Multi-Criteria Decision Analysis and Land Consolidation Projects Ranking

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Abstract: Land consolidation as a power tool for land management is a resource-demanded process that requires sensitive decision-making from the beginning of the process to its finish. The beginning of the process of land consolidation starts with the decision of how to distribute the limited resources on competing projects of land consolidation. Since its numerous benefits and the natural process of land property fragmentation land consolidation should be provided permanently but it is not possible because of limited resources including finance. This implies that decision-making about the distribution of a limited budget on competing projects (or which project should be realized) is the first decision-making before starting with land consolidation project realization. This is not an easy decision because land consolidation is long long-lasting projects and resources captured for the realization of one project could not be utilized for another one. In this paper, multi-criteria decision-making is discussed as a model for decision-making about the ranking of land consolidation projects.

1. INTRODUCTION

Land consolidation is a complex process that is recognized for its importance and effectiveness in the domain of sustainable development but it is also expensive and long-lasting (Wójcik-Leń et al., 2019). The necessity of land consolidation also arises from the natural trend of land property fragmentation. According to Niroula and Thapa (2005), it is found the fragmentation of small landholdings and tiny land parcels is detrimental to land conservation and economic gain, thereby discouraging farmers from adopting agricultural innovations. Land fragmentation is also limiting agricultural production and more broadly rural development in many countries across the world (Jürgenson, 2016). In the research, the different types of land consolidation are defined and their potential impacts are assessed including numerous positive effects of land consolidation (Thomas, 2006). Land consolidation is used as a tool for rural development in several countries in Europe, with main utilization (at the moment of research conducted) in Germany, the Netherlands, France, Belgium, Luxembourg, Austria and Switzerland as well as Finland, Norway and Sweden (Vitikainen, 2004). The fragmentation of land properties is an important aspect of farm structure resulting from population pressure and partible inheritance (Burton & King, 1982). In their research, Crecente et al. (2002) stated that arable area is declining and that “a high population density, a large number of scattered settlements, a dominant traditional agricultural economy and a historical tradition of property inheritance by sub-division within families, have produced a high degree of land fragmentation, with a mean cadastral parcel of 2500 m².”

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This research stresses two important facts: land fragmentation is a natural and inevitable process that decreases the effective utilization of land and land consolidation is the main tool for solving problems of effective utilization of arable land including the problems of sustainable development.

The decision-making process about land consolidation project ranking i.e. about the decision on how to determine the priorities between competing land consolidation projects could be generally divided into qualitative and quantitative methods. Qualitative methods are based on analyzing different factors that could not be accurately explicated in numbers and the decisions are made according to experts’ preferences (for example SWOT and DELPHI methods). Quantitative methods are based on factors explicated in numbers and the ranks of competing projects are obtained by using certain algorithms of multi-criteria decision-making methods (for example: AHP, TOPSIS, VIKOR, etc.).

2. LITERATURE REVIEW

The multi-criteria decision-making analyses (MCDMA) are based on the definition of alternatives, factors and their weights for decision-making and choice of algorithm. Among different approaches, some methods are most known and researched. One of the first methods for multi-criteria decision-making analysis was the active hierarchy process (AHP) introduced by Saaty (1990, 2008). After that, numerous methods were developed as follows: Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Hwang et al., 1981); Multicriteria Optimization and Compromise Solution (VIKOR) (Opricović, 2009), simple additive weighting (SAW) (Sembiring et al., 2019). The different research proved the applicability of MCDMA methods in land consolidation projects ranking (Marinković et al., 2016). In their research, Marinković et al. (2019) proposed an integrated assessment for land consolidation projects. Combining different methods and their analysis by statistical methods to determine the ranking of competing land consolidation projects should lead to better reliability in the process of decision-making (Marinković et al., 2022).

3. PROBLEM DEFINITION AND PROPOSED SOLUTION

The development of different methods for multi-criteria decision-making analysis implies that there is no one best method for utilization in the process of decision making and utilization of different methods can make one decision. This fact inspired the authors to research the possibilities for combining different MCDMA methods in order to check the ranking of competing land consolidation projects.

In this research, fifteen alternatives and ten factors were analyzed. The alternatives were the cadastral municipalities in the municipality of Zrenjanin, Vojvodina region, Republic of Serbia (competing land consolidation projects): Banatski Despotovac, Elemir, Ečka, Jankov most, Klek, Lazarevo, Lukičevo, Mihajlovo, Orlovat, Slovački Aradac, Srpski Aradac, Srpski Elemir, Stajićevo, Taraš and Tomaševec.

The chosen factors were as follows:
F1: The participation of arable land related to the total area of the cadastral municipality;
F2: Average area of the parcel in the cadastral municipality;
F3: Number of parcels per participant;
F4: The average area per participant in land consolidation;
F5: The percent of farmers with property over 5 hectares;
F6: The participation of public land in the cadastral municipality;
F7: Active farmers;
F8: The cost of the land consolidation project;
F9: The state of survey;
F10: The area of State-owned land for rent.

The ranking results are given in the following table.

Table 1. The prioritization of land consolidation projects

<table>
<thead>
<tr>
<th>Alternative/Method</th>
<th>AHP</th>
<th>TOPSIS</th>
<th>VIKOR</th>
<th>SAW</th>
<th>Av. Rank</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taraš</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Orlovat</td>
<td>2.0</td>
<td>3.2</td>
<td>2.0</td>
<td>3.0</td>
<td>2.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Tomaševac</td>
<td>3.2</td>
<td>3.8</td>
<td>3.6</td>
<td>3.2</td>
<td>3.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Mihajlovo</td>
<td>4.2</td>
<td>4.4</td>
<td>4.0</td>
<td>4.4</td>
<td>4.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Jankov Most</td>
<td>5.2</td>
<td>5.2</td>
<td>4.8</td>
<td>5.4</td>
<td>5.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Elemir</td>
<td>7.2</td>
<td>6.4</td>
<td>6.4</td>
<td>5.8</td>
<td>6.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Srpski Elemeir</td>
<td>7.6</td>
<td>6.6</td>
<td>8.2</td>
<td>7.2</td>
<td>7.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Slovački Aradac</td>
<td>7.8</td>
<td>7.6</td>
<td>8.4</td>
<td>7.6</td>
<td>7.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Banatski Despotovac</td>
<td>8.2</td>
<td>8.2</td>
<td>8.8</td>
<td>8.4</td>
<td>8.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Lazarevo</td>
<td>8.8</td>
<td>9.6</td>
<td>8.8</td>
<td>9.4</td>
<td>9.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Srpski Aradac</td>
<td>12.0</td>
<td>10.4</td>
<td>10.6</td>
<td>10.6</td>
<td>10.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Lukičevo</td>
<td>12.4</td>
<td>13.2</td>
<td>11.6</td>
<td>12.2</td>
<td>12.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Stajićevo</td>
<td>12.6</td>
<td>13.4</td>
<td>13.6</td>
<td>13.4</td>
<td>13.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Klek</td>
<td>13.4</td>
<td>13.4</td>
<td>13.6</td>
<td>13.6</td>
<td>13.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Ečka</td>
<td>14.4</td>
<td>13.6</td>
<td>14.6</td>
<td>14.8</td>
<td>14.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Source: Authors

According to the obtained results, the maximal standard deviation of ranking obtained by different MCDMA methods is $\sigma_{\text{max}} \leq 0.7$ and it could be concluded that in this case, the decision about land consolidation projects ranking is reliable. Further analysis, in this case, is not necessary but in other cases, it might be necessary if a larger difference appears.

4. CONCLUSION

Land consolidation in theory and practice is recognized as a power tool for the improvement of arable land management including arable land sustainable development. The inevitability of land fragmentation and caused declining effectiveness of land utilization requires consideration of the projects of land consolidation. On the other hand, the budgeting of land consolidation is limited by available resources and lack of resources causes the necessity of land consolidation projects prioritization. The reliable auxiliary tool in the process of prioritization of land consolidation projects are MCDMA method. Bearing in mind that MCDMA methods also could be limited and that there is no one best MCDMA method, the authors proposed the utilization of multiple MCDMA methods and their statistical analysis to increase the reliability of land consolidation projects prioritization.

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References


