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Prioritization and Evaluation of Land Consolidation Projects—Žitava River Basin in a Slovakian Case

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Abstract: Experience shows that existing selections (particularly in Slovakia) of cadastral areas for land consolidation (LC) projects have been overwhelmingly subjective based on diverse sources of information, particular interests and the degree of LC's popularity in different regions. Multi-criteria evaluation and clustering may be an adequate, universal and yet an inexpensive solution as a semi-objective approach for selection and evaluation of land consolidation projects. Based on an analysis of parameters and data from 74 cadastral areas in the Žitava River basin in Slovakia, a set of criteria (geometrical, ownership/social, environmental, erosion, and morphology) and weights for them have been identified and combined into composite indices/criteria for designing a ranking system for LC prioritization and evaluation. However, they are universally applicable/adaptable, and are not limited to a particular territory or country. Presented results for finished projects in the case study area also verify that the selection process has been deeply unsatisfactory.

Keywords: multi-criteria evaluation; land consolidation; project tenders; ecology; benefits; landscape

1. Introduction

A general notice announces the start of land consolidation (LC) in a cadaster, leading to several questions, especially concerning what benefits land owners are going to receive and why LC is beginning in their cadaster and not in neighboring ones. This paper attempts to answer these questions and outline solutions so the selection of a cadastral area for LC becomes as objective as possible and ensures that LC project mainly occur in those cadastral areas which would get the most benefits from it. There should be no preferred cadastral areas benefiting someone that happened to have bought "worthless" properties and is taking advantage of LC to lump them into ideal land suitable for operating a business, pushing other aspects such as landscaping, the environmental and erosion issues into the background.

In most countries that have instituted LC, it is understood to be a multifunctional rural development tool. The basic definition that appears in references [1,2] describes LC as having a wide-ranging impact which involves the redistribution of land in order to eliminate fragmentation, although the objective of LC reaches far beyond this. Reference [3] also shares this understanding, arguing the outcome of LC is more than merely the settlement of property relations. He considers LC a means for creating a landscape, too. In addition, reference [4] considers LC as a land management tool that can reduce land fragmentation and other disturbances in land use. LC is an excellent tool for the implementation of rural development projects [5,6] and, according to reference [7], LC can even minimize the disparity between rural and urban areas. Furthermore, there have been claims that LC's main objective is to improve land structure, while encouraging land owners and users to construct

new road infrastructure that will promote rural development. References [8,9] emphasize land consolidation's improved organization of agricultural land, water management and irrigation network. LC comprises a group of activities concerned with improving productivity and working conditions in rural areas, with a proposed reconstruction plan for rural settlement and rural life generally [10]. References [11–13] summarize that LC can resolve conflicts in areas such as infrastructure, nature, environment, rural public demand, consolidation of ownership, sustainable land management and improving the quality of life in rural areas. Reference [14], defines LC as a change in real estate implemented in order to create integrated units and optimal land management according to the needs of individual landowners, carried out with their consent and in response to common demands on the landscape, environment and construction. Research has shown benefits from LC including environmental protection, improved soil protection, better water management and a more ecologically stable countryside, [15,16]. LC is intended to be playing inherently the same role in the Slovak Republic (SR) [17] as well as mentioned above, although the mechanism for consolidating land varies.

In general, implementing an LC project should provide the most benefits to rural areas. But how can be the optimal quantity and quality determined? This issue is becoming more urgent as LC is a process supported and co-funded by the EU [2]. The EU monitors the effective utilization of funds, so it is logical for control not to be subjective, yet it should be possible to have objective indicators representing the eligibility of LC implementation in the field. LC is a forward-looking process and it is assumed that its popularity is going to eventually rise, with demand LC becoming greater than the financial coverage and capacity available. Therefore, objective criteria need to be established for selecting cadastral areas whose land is going to be consolidated.

How are cadastral areas selected for an LC project? It is impossible for all cadastral areas to start implementation simultaneously due to limited resources. This research examined the question with the conclusion that a number of countries select properties at random. From the available literature, particularly reference [18], contribution defines a so-called allotment barometer, where urgency and benefits of land consolidation is evaluated on the basis of the quality of the agricultural parcel structure per area (average percentage of plots of land with farm buildings, average percentage of parcels at a distance, average number of parcels at a distance, average size of parcels at a distance) and an indication of financial benefits after improvement. However, the referenced barometer, in our opinion, reflects only ownership and economic parameters, and lacks environmental and landscape considerations and the benefits derived from them. In most cases, rankings are not necessarily based on an objective assessment. Many countries report only pilot projects looking for optimal procedures related to land consolidation. For example, reference [19] describes the indicators presenting selected barriers in the productivity of agricultural areas (soil quality, land fragmentation, parcel shape and area, farm structure, roads accessibility, and terrain difficulty). Prioritization of land consolidation which takes into account the geographic location of an area is described in reference [20]. Three thematic factors connected with the risk of water and wind erosion in arable land, water management, and water retention in the landscape for preferential implementation of land consolidation are mentioned in references [21,22]. Another approach using the "COPRAS" methodology [23] suggested criteria involving the share of arable land related to the total agricultural land, average parcel size in and out-of-construction areas, number of parcels per real estate folio, average property size in and out-of-construction areas, percentage of individual agricultural manufacturers with property size larger than 5 hectares, state property share in the total out-of-construction areas, size of the state property land given in lease, areas under the channel network, active agricultural population and state of land consolidation. 7 indicators were used to determine land consolidation suitability (share of agricultural land, average size and shape of agricultural parcel, number of agricultural holdings and their fragmentation index, share of state owned agricultural land, and regional development index) by [24]. Approaches based on multiple criteria are also used e.g., references [25,26] to solve the problems associated with landscape planning in somewhat easier and faster way.

In Slovakia, cadastral areas are currently being chosen for LC projects with no coordination and based, among other things, on local analysis, resident opinions, available data and the urgency to invest in construction. There is no procedure to clearly estimate and quantify the urgency of implementation in place. Interpretation of surveying, landscaping, environmental issues and aspects of ownership prevails. In the absence of an objective system, everyone endeavors to reinforce their own issue as the top priority.

This research seeks to investigate a possibility of an easy to implement and semi-objective procedure for evaluation and prioritization of land consolidations to achieve a balance of benefits in a particular area based on multiple clearly determined and interpretable criteria (indices). Identifying problematic regions and areas can have an economic, social and environmental impact.

2. Material and Methods

The case study area for the evaluation and prioritization of land consolidations is the Žitava River watershed in Slovakia e.g., references [27–29]. A total of 74 cadastral areas lie within on 91,759 hectares divided into three administrative regions (Nitra, Banská Bystrica and Trenčín), comprising seven districts (Levice, Nitra, Nové Zámky, Partizánske, Topoľčany, Zlaté Moravce and Žarnovica). The average cadastral area is 1027 hectares, of which 59.4% is agricultural (46.3% arable) land, 32.4% is forested, 1.2% is water, 4.9% is built up and 2.1% is classified as "other".

Available, measurable characteristics (that are recorded for cadastral areas and used in land consolidation processes) were gradually taken into consideration (originally around 70), which have been systematically reduced to a (easily interpreted) selection, as a basis for further research [30]. Correlation analysis using Kendall rank correlation coefficient and divisive hierarchical clustering have been applied [31].

Finally, the following sets of variables for the multi-criteria evaluation e.g., from reference [32] have been selected:

- Geometrical criteria (measured in hectares):
    - Total cadastral area (TA);
    - Area devoted to agriculture (AL—arable land and permanent grassland);
    - Area devoted to permanent cultures (PCA—total area of hop gardens, orchards and vineyards);
    - Forest (FA).
- Owner and community criteria:
    - Plots recorded on deed kept in the E Register (PER), i.e., properties with unknown boundaries which are part of large agricultural units the owners usually rent; a historical remnant from socialist times when ownership was only registered. Each plot is usually shared among several owners. The co-owners may have been people who died many years ago and determining the legal disposition of the land has been challenging.)
    - Average number of co-owners (NCO) per plot; there can be hundreds of owners)
    - Number of unknown owners (NUO) defined as historically registered not updated ownership, where the owner's residence remains unknown even though they are alive, so the public authorities usually represent the owner
    - Population (P) of the particular cadastral area;
    - Socially sensitive communities' population (SCP)—there is quite a number of settlements on plots whose ownership is unsettled, which is a serious problem in Slovakia.
- Erosion criteria: average level of water erosion (SEOP—the average value of the degree of erosion vulnerability).

- Morphological criteria: elevation in the case study area (DMR expresses the difference between maximum and minimum elevation in a cadastral areas).

74 diverse cadastral areas located in a single watershed were divided into clusters according to similarities amongst them in above mentioned criteria. For the clustering, two methods were applied, namely divisive hierarchical clustering to narrow the estimates for the number of possible groups and fuzzy analysis clustering into a predefined number of clusters [31].

A point value has been calculated as a sum of composite indices (criteria) in order to rank, e.g., from reference [32], the territories for land consolidation priority. The higher value meaning the higher priority assigned to a land consolidation project. Weights in composite indices have been adapted from initial range-estimates by a bisection method, e.g., from reference [33], with main constraint being similar index values for close cluster members. Clusters have also been used to identify classification/prioritization thresholds.

3. Results and Discussion

When clustered, eight prominent groups were identified that seem to be linked by size, property, community, environment, erosion and relief in the model area. Table 1 shows the average values of individual criteria for these clusters.

The largest group is Cluster 1, which includes 13 cadastral areas averaging 503 hectares. It is characterized as flatland with most of the cluster used for agriculture, minimal forested land and permanent cultures. The mean number of Register E plots is 2403 (close to the Slovak average), the mean number of co-owners is 24,942, and the mean number of unknown owners is 541 (also the average for Slovakia). Ecological stability is low in this area; it has no cases of water erosion, is less well represented by socially sensitive communities, and has a population density less than Slovakia's average. Significant benefit from LC for these cadastral areas might be increasing for ecological stability. Territories in this cluster can be classified as areas with a very low priority for LC selection.

12 cadastral areas averaging 758 hectares per cadaster form Cluster 2. It is characterized as high elevation land, much of it used for agriculture, with minimal permanent cultures and it is slightly more forested. All property parameters are below the national average. The area has a low ecological stability with minimal water erosion, smaller socially sensitive communities and a low population density. LC can only provide a significant benefit for ecological stability. Territories in the cluster can be described as low priority areas for LC.

12 cadastral areas in Cluster 3, with an average area of 401 hectares, can be characterized as mainly low-lying hills, with a balanced proportion of agricultural land and forest, and minimal special crop coverage. All property parameters are well below national averages. The area is ecologically stable, with few symptoms of water erosion, has a higher incidence of socially sensitive communities and a population density less than the national average. LC can provide some benefits when dealing with social issues and erosion here. Cadastral areas in the cluster can be described as having the lowest priority for LC projects.

Cluster 4 contains 10 cadastral areas averaging 1543 hectares and is characterized by plains. A majority of the land is used for agriculture, with minimal forested land and permanent cultures. These regions have well above the national average number of Register E plots, with an average number of co-owners and a lower number of unknown owners. The area is ecologically fragile, with minimal symptoms of water erosion, a higher presence of socially sensitive communities and a high population density compared to the national average. A LC project in this cluster could bring significant benefits in addressing ownership, ecological stability and social issues. Territories in this cluster can be classified as areas with very high priority for land consolidation.

Table 1. Average values of individual criteria for clusters.

Cluster l	Number of Cadastral Areas	Average Size of a Cadaster	Average Area of Agricultural Land	Average Area of Permanent Cultures	Average Area of Forested Land	Average Number of Parcels in E Registry	Average Number of Co-Owners	Average Number of Unknown Owners	Average Area of Ecologically Fragile Areas	Average Erosion Endangerment Value	Average Elevation	Average Population
1	13	503	463	47	17	2403	24942	541	447	1.2	68	428
2	12	758	547	46	170	1431	14088	296	517	2.0	147	563
3	12	401	259	21	127	1626	17921	238	232	4.3	131	254
4	10	1543	1340	108	107	2770	22131	436	1290	1.0	99	2844
5	9	1045	834	68	158	2595	11417	269	798	1.4	155	860
6	8	807	748	63	31	2592	18256	391	703	1.8	92	484
7	7	2066	729	72	1270	2750	12710	244	625	4.3	367	1313
8	3	3092	727	74	2259	1339	7020	304	450	13.4	572	1079

Nine cadastral areas averaging 1045 hectares are in Cluster 5. It can be characterized as low-elevation highlands, with much of the land used for agriculture and minimum permanent cultures and forest. Compared to the national average, the cadastral areas have an average number of E Register plots while co-owner and unknown owner numbers are slightly below the national average. The area is ecologically fragile, with minimal symptoms of water erosion, minimal presence of socially sensitive communities and a population density below the national average. LC might provide average benefits for ownership, very high benefits when addressing environmental issues and minimal solutions for erosion and social problems. Cadastral areas in the cluster can be described in terms of being consolidated as having medium priority.

Cluster 6 contains eight cadastral areas averaging 807 hectares and is characterized as lowland plains. Almost the entire territory consists of intensively utilized agricultural land, with minimal permanent cultures and hardly any forested areas. These cadastral areas have an average number of E Register plots, and the numbers of both co-owners and unknown owners are much lower. The area is ecologically fragile with minimal symptoms of water erosion, a population density below the national average and no socially sensitive communities. LC could bring very important benefits when addressing environmental issues and potential solutions to erosion and social problems here. Cadastral areas in the cluster can be described as having average to medium priority for LC.

Cluster 7 contains seven areas, averaging 2066 hectares. It is a very rugged area, where forests dominate the land. The representation of special cultures is minimal. The area is ecologically very stable with a significant presence of sites endangered by erosion. The population density is low, with minimal socially sensitive populations. There is a major need for resolving ownership issues. An LC project for the cadastral areas in this cluster will be of significant benefit, when addressing both ownership and erosion endangerment. Territories in the cluster can be described as a high priority area for LC.

Cluster 8 contains three cadastral areas which are large and features a very rugged, indented relief. The population density is below average with no significant socially sensitive population. There is a specific need in this cluster to resolve both ownership and erosion issues. The territories grouped in this cluster can be considered an urgent priority area for LC.

Geometrical criteria were combined into a composite weighted sum index:

$$K_{geometrical} = [0.42(FA) + 0.29(PCA) + 0.29(AL)] \quad (1)$$

The weights have been determined by refining initial interval estimates (in this case, provided by the authors based on their expertise in the field, available data and cluster membership), repeatedly halving the range until the index values for most of close cluster members were as similar as possible (did not start to drift apart). Initial estimates for weights as well as composition of indices provide a way to incorporate expertise and policy goals into the evaluation procedure.

The combined ownership and social criteria index is defined as follows (weights determined as above):

$$K_{ownership\_social} = [0.10(P) + 0.10(SCP) + 0.25(NCO) + 0.25(PER) + 0.30(NUO)] \quad (2)$$

Unknown owners were highlighted in comparison to the other criteria in the group due to the segregation of unknown from known owners. The existence of unknown owners would negatively affect LC, as experience has already shown.

Environmental criteria (KES) are kept separate because low ecological stability is a very important factor which should influence the ranking list of urgency itself. Relief criteria (DMR) are assessed similarly. It is understood that relief of an area determines the activities that are planned in it. Erosion criteria (SEOP) are used in the same way as relief and environmental criteria.

The sum of composite indices and standalone criteria forms a ***POINT VALUE*** that indicates urgent land consolidation need (Table 2). Higher point value means a higher priority for LC. Priority thresholds are mentioned and given below (Table 3).

$$\textbf{\textit{POINT VALUE}} = K_{geometrical} + K_{ownership\_social} + KES + SEOP + DMR \quad (3)$$

This evaluation procedure was applied to all 74 cadastral areas (Table 2). The result is a ranking in terms of priority and expected benefits an implementation of LC project would bring to a particular area. The resulting value is points scored in each territory, which in this case ranges from 22 to 533 points.

As previously mentioned, different cadastral areas have been divided by fuzzy clustering into eight clusters, according to the similarity of the examined parameters. It has been presumed that the difficulty in any cluster, whether cost or time related, is similar. Clusters allowed for determining ranges of values for classification/prioritization (Table 3, Figure 1).

Table 2. Ranking of cadastral areas in the case study area (territories where LC projects have already been completed are highlighted).

No	Cadaster Name	Cluster	POINTS	No	Cadaster Name	Cluster	POINTS
1	Vráble	4	533	38	Vajka nad Žitavou	6	183
2	Trávnica	4	489	39	Mlyňany	2	177
3	Jelenec	7	441	40	Beša	2	172
4	Zlaté Moravce	4	437	41	Vlkas	2	170
5	Velčice	8	416	42	Telince	2	169
6	**Veľká Maňa**	**4**	**400**	**43**	**Melek**	**2**	**160**
7	Topoľčianky	7	390	44	Volkovce	2	158
8	Obyce	8	360	45	Veľké Chrašťany	2	157
9	Jedľové Kostoľany	8	332	46	Prílepy	2	156
10	Tehla	7	321	47	Machulince	2	152
11	Čifáre	4	318	48	Neverice	2	152
12	**Klasov**	**4**	**303**	49	Lovce	2	151
13	Kolíňany	4	294	50	Červený Hrádok	1	140
14	Dolné Sľažany	4	294	51	Babindol	1	140
15	Hul	4	293	**52**	**Malé Vozokany**	**1**	**139**
16	Čeľadice	4	271	53	Veľké Chyndice	1	131
17	Tesáre nad Žitavou	5	263	54	Kmeťovo	1	129
18	Hostie	7	258	**55**	**Vieska nad Žitavou**	**1**	**129**
19	Hosťovce	7	256	56	Pustý Chotár	1	128
20	Kostoľany pod Tribečom	7	254	57	Hosťová	1	127
21	**Ladice**	**5**	**251**	58	Beladice	1	123
22	Nová Ves nad Žitavou	5	243	59	Iňa	1	123
23	Nevidzany	5	238	60	Opatovce	3	115
24	Čierne Kľačany	5	237	61	Martinová	1	115
25	**Veľké Vozokany**	**5**	**235**	62	Horné Sľažany	1	115
26	Dolné Obdokovce	5	232	63	Panský Diel	3	113
27	Žikava	5	219	64	Choča	1	112
28	Slepčany	5	217	65	Martin nad Žitavou	3	108
29	Michal nad Žitavou	6	208	66	Mankovce	3	101
30	**Pozba**	**6**	**202**	67	Malá Maňa	3	96
31	Žitavce	6	201	68	Rohožnica	3	94
32	Malé Chyndice	6	201	69	Čakýň	3	84
33	Zlatno	7	200	70	Belek	3	79
34	Horný Ohaj	6	200	71	Jesenské	3	76
35	Lula	6	200	72	Malé Chrašťany	3	74
36	Dyčka	6	198	73	Závada	3	52
37	Tajná	2	185	74	Hoňovce	3	22

Table 3. Thresholds of priorities.

Priority	Values	Cluster
Highest priority	over 321	Predominantly 8
High priority	271–320	Predominantly 4
Medium/high priority	252–270	Predominantly 7
Medium priority	209–251	Predominantly 5
Little/medium priority	186–208	Predominantly 6
Little priority	141–185	Predominantly 2
Very low priority	110–140	Predominantly 1
No important	under 110	Predominantly 3

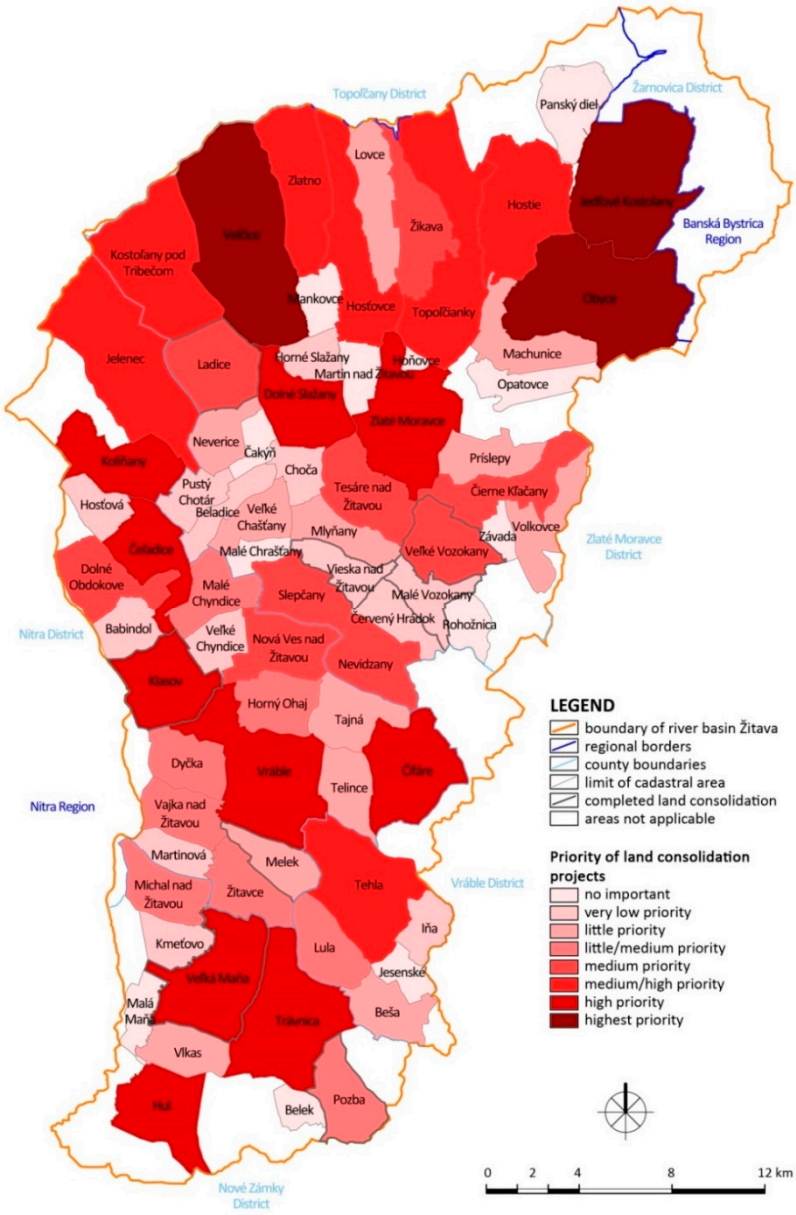

Figure 1. LC project priorities for 74 cadastral areas in Žitava watershed.

Territories with settlements of socially sensitive communities have a sufficiently high ranking to be considered a priority for LC projects. Resolving ownership problems there may clear the way for implementation of much needed social measures. The ranking of cadastral areas obtained in this study

seems to highlight well the ones with known issues that could be addressed by LC. Only 8 LC projects have been finished so far in selected 74 cadastral areas. Table 4 shows the time consumed and financial demands of the finished projects, ordering them by how they were entered by the land administrative authority for consolidation.

Table 4. Basic characteristics of completed projects.

Cadaster Name	Project Started	Project Ended	Duration [months]	Cost [EUR]	Order of Entry
Melek	01/07/2003	18/01/2011	91	91,373.56	1–2
Vieska nad Žitavou	01/07/2003	24/11/2010	89	61,954.46	1–2
Veľká Maňa	01/03/2004	15/08/2012	101	394,670.38	3
Veľké Vozokany	03/03/2004	12/12/2011	93	154,519.68	4
Malé Vozokany	31/01/2005	27/08/2012	91	87,450.71	5
Pozba	11/05/2005	16/01/2014	106	188,308.94	6
Ladice	02/05/2006	09/03/2012	45	197,829.32	7–8
Klasov	02/05/2006	06/09/2012	76	170,253.89	7–8

Completed projects were subsequently assigned priorities (Table 5) using the information in Table 3.

Table 5. Ranking of finished projects.

Cadaster Name	POINTS	Cluster	Priority	Position on Waiting List	Number of Cadastral Areas with Greater Priority
Veľká Maňa	400	4	Highest priority	1	5
Klasov	303	4	High priority	2	11
Ladice	251	5	Medium priority	3	20
Veľké Vozokany	235	5	Medium priority	4	24
Pozba	202	6	Little/medium priority	5	29
Melek	160	2	Little priority	6	42
Malé Vozokany	139	1	Very low priority	7	51
Vieska nad Žitavou	129	1	Very low priority	8	54

Experience shows that existing selections of cadastral areas for LC projects have been overwhelmingly subjective based on diverse sources of information, particular interests and the degree of LC's popularity in different regions. This is evident from our ranking of cadastral areas where LC projects have been completed. A comparison of the rankings with projects already started shows that the decision process probably does not match urgencies, meaning projects were selected with no accumulating benefits and so in some cases their real priority was in fact very low. Moreover, as reference [34] finds, many people are surprised when expected benefits fail to materialize after a LC is completed. Existing projects that have been completed evoke the view that LC is more a means to solve the problems created in the past (revising property ownership and correcting inheritance rights). Merging properties is indeed an important benefit that comes from LC, but it provides no significant return in responses from owners. On the contrary, there is a universal belief that LC wastes EU funds and that such projects are essentially useless.

At the current level of knowledge and experience with LC projects, it is obvious that the way to unlock the potential of an area is to fully exploit LC while balancing all possible benefits the project can provide, putting emphasis on the particular area's future and increasing the overall project's value in the long term. This also affects the population's positive perception of LC. This paper tries to outline the procedure in order to implement LC projects precisely in such cadastral areas with a balance of benefits. This contribution provides the primary basis for defining the criteria and algorithm. The quantifying and inclusion of various weights and criteria in the formulas should be a subject for further discussion and consensus by a range of experts in fields involved in an LC project.

4. Conclusions

An approach ranking cadastral areas (74 cadastral areas in the Žitava watershed) according to land consolidation urgency and potential project benefits (from highest priority to a very low one) has been presented in this article. The procedure allows for setting policy goals and incorporation of experience (with an expert help) and easy (re)evaluation of criteria by decision support staff. It also seems to be able to highlight the areas with (known) issues that could be addressed by land consolidation projects. It has been also pointed out that the current practice of selection of territories for land consolidation projects in Slovakia is subjective and directly evokes suspicion of a solution sought by particular interests for public money, leading to disappointed expectations by communities and public authorities. Use of multi-criteria approaches can contribute to the elimination of voluntary selection, randomness and solutions for particular interests in LC. This is a universal procedure not limited to a particular territorial unit or country. It can be adapted or refined from available data and analytical outputs of research to clarify and "explain" meaningful values of individual indicators.

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