Environ Monit Assess (2023) 195:1045
https://doi.org/10.1007/s10661-023-11712-w

RESEARCH

Prioritization of land consolidation projects using the multi-criteria Best-Worst Method: a case study from Poland

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Received: 8 June 2023 / Accepted: 11 August 2023 / Published online: 17 August 2023

Abstract In order to balance the needs of ecology, environment, and agricultural productivity with the aim of revitalizing rural areas, every local government unit that plans to implement a land consolidation (LC) project should decide where to start these projects as a priority. Traditionally, some of these decisions are made by groups of people connected to the consolidated area, while the others are made by groups of people from government departments, all trying to make the best possible decision. However, one of the most important conditions for the successful implementation of these projects, requiring large investment costs is, determining the priority areas for LC projects and allocating the investments to the appropriate areas meticulously. This study proposed a new model for determining priority areas for LC projects. In this study, by determining a set of criteria according to the parameters taken from 75 villages (Malopolska region, Poland), a model was developed for prioritizing LC projects using the Best-Worst Method (BWM), a multi-criteria decision-making (MCDM) method. The proposed model enables the transparent identification and prioritization of villages for land consolidation by national and local authorities, effective management of resources, and equitable allocation of financial assistance.

Keywords Agriculture · Decision-making method · Land management · Priority · Project ranking

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Introduction

Increasing population growth makes the relationship between land resources and humans more complex, demonstrating the necessity for sustainable land management. Hence, more efficient land management and use are required. Land management refers to implementing different types of management practices on financial land use institutions or rational land utilization by a country through legal and administrative measures (Long & Qu, 2018). Essentially, it is a comprehensive activity of decision-making, planning, regulation, coordination, and control undertaken by a country under specific conditions, aimed at increasing socio-economic and ecological benefits, maintain the dominance of social land ownership system, regulate land-based relationships, and supervise land use activities (Liu & Peng, 2005). Land management is aimed at ensuring efficient use of land, environmental protection, preservation of soil quality, promotion of sustainable agricultural practices, and management of other land uses. Land consolidation (LC) projects are effective land management tools. These projects are essential tool required for governments to develop rural areas in a sustainable manner, especially in regions with unfavorable land fragmentation parameters (Colombo & Perujo-Villanueva, 2019). Accordingly, LC projects have various benefits, such as reducing land fragmentation (Ertunç et al., 2021; Huu Quynh & Peter, 2018; Molnárová et al., 2023), making better efficiency of agriculture (Li et al., 2021), water management, and irrigation network organization (Jurík et al., 2019); protecting the environment and natural resources (Pašakarnis & Maliene, 2010); reducing the average cost of crops on farms (Hiironen & Riekkinen, 2016); increasing crop productivity (Nilsson, 2019); using machinery and technology in agricultural production (Zeng et al., 2018); and significantly changing the spatial structure of land use (Janus & Markuszewska, 2017). LC consists of a set of activities related to improving working conditions and productivity in rural areas, along with a proposed restructuring plan for rural settlements and life in general (Long, 2014). For these reasons, LC projects are commonly considered important tool for modernizing agriculture and rural development (Gonzalez et al., 2007; Kolis et al., 2017; Wu et al., 2005).

Further, the importance and benefits of LC projects for the development of agricultural regions and limited financial resources to realize projects raise the question of what criteria should be used to identify areas for this type of treatment. LC projects are comprehensive projects that involve large workloads and require large financial investments. Therefore, it is impossible to start these projects simultaneously in all rural areas that need to be carried out. This shows that determining priorities and choosing appropriate models for correct decision-making is inevitable. Some studies also support this view. Hua and Fubao (2015) proposed an algorithm with site selection model of land consolidation projects based on multi-objective particle swarm optimization (PSO). Marinković et al. (2018) addressed the ranking problematic of municipalities for land consolidation by applying the COPRAS method. Karásek et al. (2018) determined priority areas to initiate land consolidation with regard to erosion and water retention in the Czech Republic. Tomić et al. (2018) used different multi-criteria methods to rank cadastral municipalities (cadastral areas) in LC projects. Leń (2018) tried to develop a universal algorithm for choosing factor groups for the prioritization of land consolidation. Muchová and Petrovič (2019) designed a ranking system for LC prioritization and assessment using a multi-criteria decision-making method (MCDM) based on the analysis of parameters and data from 74 cadastral areas in the Žitava River Basin in Slovakia. Pašakarnis et al. (2021) presented a decision-making structure based on the MCDM, which lets for the ranking and prioritization of municipalities with the highest potential for land consolidation in the western part of Lithuania. Marinković et al. (2022) carried out a priority ranking for fifteen cadastral municipalities (cadastral areas) to realize their land consolidation projects using a multi-criteria analysis approach with eight criteria. Kilić Pamuković et al. (2023) proposed a model for a priority ranking of cadastral parcels using the COPRAS method to plan the implementation of urban consolidation.

Poland is one of the countries with a great need for the implementation of land consolidation projects, which is connected with equally great needs in terms of the correct identification of the appropriate areas for this type of activity. Land consolidation in Poland was carried out with varying intensities throughout the period of its application, formally beginning in 1923 with the adoption of the first act on this subject. The scale of project implementation reached 400,000 hectares per year before World War II. Another period of intensification of land consolidation, similar to the interwar period, covered the 1960s and was followed by a rapid decline. Currently, the number of projects is increasing with the emergence of financing sources from the European Union (EU), but the average annual area covered by land consolidation projects is slightly greater than 20,000 ha. One of the key problems is still considered to be the lack of correct project location selection criteria, which is a common problem in many other countries.

The Polish Act on Land Consolidation and Exchange of Land does not contain any indications regarding the process of selecting project locations. Therefore, the guidelines contained in the regulations on financing land consolidation projects in Poland from EU funds play a leading role. Each of the 16 voivodships in which Poland is divided receive a specific pool of funds that should be allocated to projects with the highest urgency. The ranking list was compiled based on the following criteria: the percentage of farm owners interested in implementing the project is the highest rated criterion, for which a maximum of 100 points can be awarded. For factors such as demonstrating a positive impact on the environment, improvement of landscape conditions, designation of land for public utility purposes, and improvement of water retention conditions, the project may receive additional 10 points (for each category). At the maximum possible score (140 points), the local community's positive attitude toward the implementation of the project is dominant, and the objective does not need to improve the parameters of land fragmentation or other spatial problems in the countryside. The current rules have been criticized many times. Research has also been conducted to identify alternative proposals for new solutions in this area. The main problem with the current approach is the selection and subsequent implementation of such projects, where no significant effects are achieved in terms of improving the land fragmentation parameters. There is also a discrepancy between the most important goal of LC projects set out at the level of the relevant act (which is to improve the spatial arrangement of farmland, i.e., in practice, the parameters of land fragmentation) and the criteria for selecting objects where the stated statutory goal is not possible to implement.

According to Janus and Markuszewska (2017), an inappropriate method of selecting land consolidation projects in Poland during the EU financial term of 2007–2013 had an effect on the efficiency of land consolidation. This requires a decision on where LC projects should be implemented, primarily to maximize their impact. To avoid subjective decision-makers' preferences, using multi-criteria decision-making methods is the most convenient solution for the prioritization step. MCDM methods are used in several areas of life and science. MCDM methods have also been employed in various LC project steps (Demetriou et al., 2012; Ertunç & Uyan, 2022; Uyan et al., 2013).

This study presents an easy-to-implement and objective method (model) for prioritizing land consolidation projects in a specific area based on universal criteria. The criteria determined for the ranking or prioritization of priority LC project areas were assessed using the Best-Worst Method (BWM) one of the MCDM methods. Compared with alike methods, BWM requires less data because it does not require a full pairwise comparison matrix and ensures more coherent conclusions owing to its structured pairwise comparison system. The proposed method should make possible local and national authorities to better manage their funds and land consolidation processes more effectively.

Materials and methods

Study area

The study area is located in southern Poland, where unfavorable land fragmentation parameters strongly reduce the profitability of agriculture. This region of Poland has a great need to implement land consolidation projects; however, the number of possible project implementations depends on the funds allocated for this purpose. The analysis covered 75 villages located in the Dabrowski poviat in the north-eastern part of the Malopolska region, the main city of which is Krakow. The area of the poviat is 530 km^2, and it has a typical agricultural character with an average population density of 111 people per km^2. Individual villages in the study area are diverse because of the features that affect the need to implement land consolidation projects. Therefore, the use of multi-criteria analysis methods to obtain a reliable ranking of the desirability of implementing these projects appears to be the optimal approach. The location of the research area, along with examples of the spatial arrangement of plot borders, is presented in Fig. 1. The data used for this research are from poviat cadastral databases that contain all the necessary data on plot boundaries, land use, and land ownership structure.

Methodology

In this study, a model for prioritizing LC project areas in a selected region of Poland was applied. First, criteria were determined for the prioritization of LC projects by conducting a literature review (Janus & Markuszewska, 2017; Mika et al., 2019; Muchová & Petrovič, 2019; Pašakarnis et al., 2021; Tomić et al., 2018; Wójcik-Leń et al., 2020) and obtaining

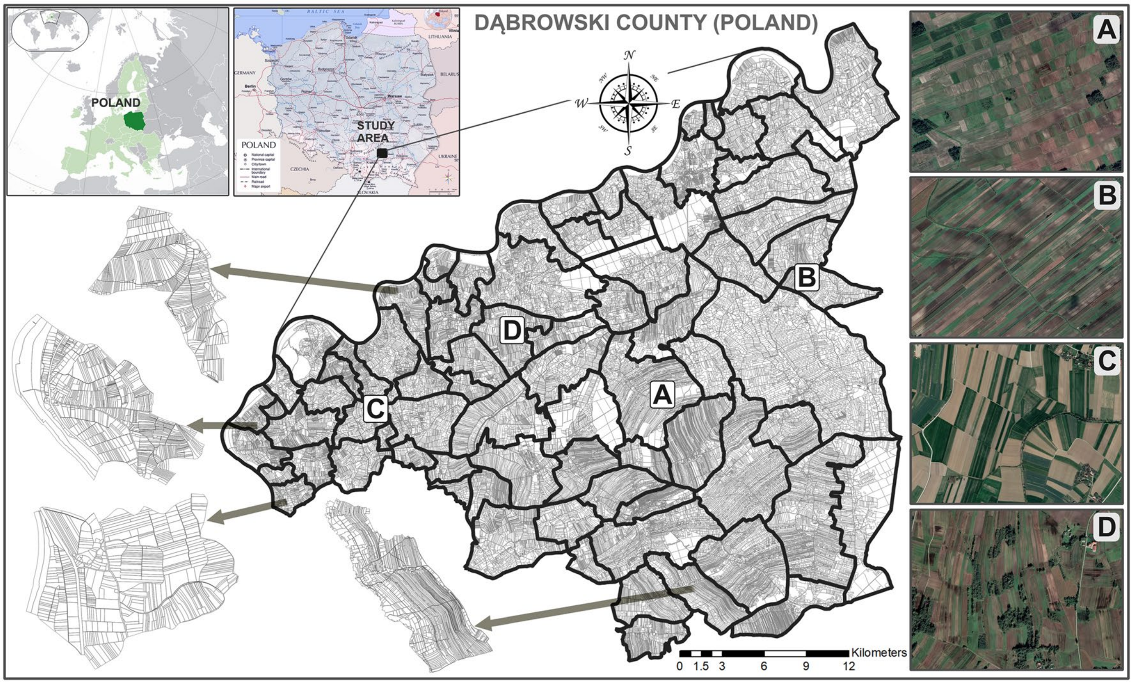

Fig. 1 Study area

expert opinions. After this stage, many criteria determined depending on the region's characteristics were weighted with the BWM that is one of the MCDM methods which enables decision-makers to conduct systematic evaluations. Priority areas for LC projects were determined by spatial modeling using GIS. Figure 2 illustrates the methodology used in this study.

Description of evaluation criteria

Multiple criteria that require implementation of LC projects can be defined. In this study, the most basic criteria for LC projects are considered.

Average plot area (C1) The average area of a plot significantly influences the operating costs of the farms. One of the aims of LC is to increase the average plot area. In LC project ranking, priority should be given to vilagges in which the average plot size is small.

Number of plots in farm (C2) One of the most important aims of land consolidation is to reduce the number of plots of landowners who participate in land consolidation, in other words, to ensure that participants own property in the least possible number of locations after the land consolidation project is realized. The potential effects of land consolidation have also increased with the increasing number of plots per farm (Marinković et al., 2018).

Average farm area (ha) (C3) Average farm area is an important factor that influences the potential benefits of land consolidation projects. In Poland, this factor varies and ranges from 4.28 ha (southern Poland) to over 2–3 ha (northeastern Poland). However, locally (at the commune or poviat level) this diversity can also be very large. A larger area of farms (usually also meaning more plots of land) usually means greater opportunities to improve the parameters of land fragmentation and a more favorable attitude of farmers with large farms to the proposed changes.

Average distance of hectares index (C4) One factor that influences the need to implement land consolidation projects is the spatial dispersion of plots belonging to individual farms. Among the many existing methods for measuring land fragmentation parameters (Postek et al., 2019), some accurately reflect the intensity of this unfavorable phenomenon.

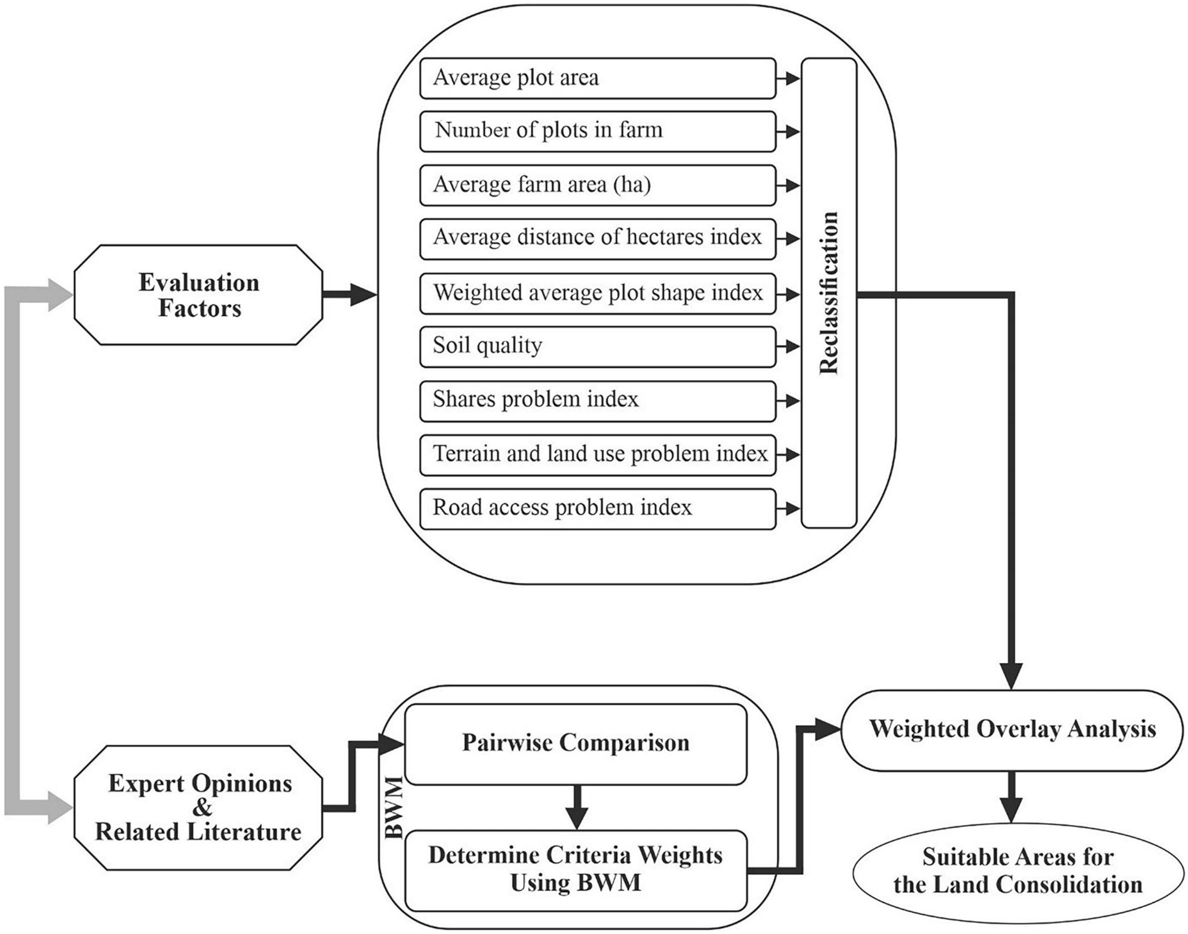

Fig. 2 General framework of the methodology used in the research

In this study, the average distance per hectare index (Latruffe & Piet, 2014) was used.

$$avdha_i = \frac{1}{A_i}\sum_{k=1}^{K_i} a_k * d_{i,k} \tag{1}$$

where A_i is the total farm area with the subscript "i," a_k is the plot field of the farm with the subscript "k," where k=1 … K_i (area of parcel k), K_i is the number of parcels belonging to the farm with the subscript "i," a_i is the area of the land parcel with the subscript "i" (applies only to the rectangular index ($rect_i$) calculated for parcels), and $d_{i,k}$ is the distance between plot with subscript "k" and center of farm with subscript "I." Distance was calculated using the following two variables: d_a is the distance roads, and d_r is the rectilinear distance.

Weighted average plot shape index (C5) With land consolidation projects, plot shapes improve; thus, the possibility of applying modern agricultural techniques increases. Therefore, plot shapes are an important criterion for LC projects. In this current study, the "weighted average plot shape index" was used.

$$wshsq_i = \frac{1}{A_i}\sum_{k=1}^{K_i} a_k \frac{p_k}{4\sqrt{a_k}} \tag{2}$$

where p_k is perimeter of the plot with "k" index.

This indicator shows the correctness of the shape of the plots belonging to a given farm (or larger area). Unfavorable form of the plots, deviation from the rectangle, or their excessive elongation (this applies particularly to plots with small areas) reduces the profitability of their cultivation. However, this feature of the plots can be significantly improved through land consolidation projects.

Soil quality (C6) The soil quality indicator represents the average soil quality from the perspective of agricultural crop productivity. The calculation of the indicator is based on soil quality data, which is an obligatory thematic layer in the cadastral database of Poland. Arable land, meadows, and pastures were divided into categories I–VI, respectively. Based on this research, these categories were assigned a score defining the differentiation of productivity of individual categories, ranging from 18 to 100 points for arable land and from 15 to 90 points for meadows and pastures. This division is the basis for determining the agricultural tax in Poland and is widely accepted by farmers. From this perspective, a higher value of the indicator indicates an area of better suitability for agriculture, which means that its value should have a positive impact on the desirability of implementing a land consolidation project in a given area.

Shares problem index (C7) The share indicator indicates the severity of the problem of excessive fragmentation of land ownership in terms of the number of owners of individual farms. Too many co-owners, who are usually associated with complicated land inheritance rules, may cause farm management problems. Another problem is the hidden fragmentation of land, which manifests as the use of a single cadastral plot by two or more farms belonging to individual co-owners. As the land consolidation process also places ownership issues in order, a higher value of this indicator indicates a greater need to implement the land consolidation project.

Topography and land use problem index (C8) The indicator covering the assessment of conditions related to topography and land use was intended to assess objective obstacles that may be associated with these conditions during project implementation. In particular, the occurrence of terraced land use due to large height differences, a large amount of mid-field afforestation, windbreaks, high escarpments, ravines, and a dispersed settlement system significantly reduced the chance of significant changes in the arrangement of ownership boundaries. At the other extreme, there is a situation in which practically no obstacles are mentioned earlier in most areas, which provides great opportunities for designing a new, favorable arrangement of arable fields.

Road access problem index (C9) The last of the discussed indicators is aimed at assessing the need for the reconstruction and expansion of the agricultural transport network, owing to the need to ensure access to each agricultural field. It is calculated by considering the share (in the number of plots and their area) without direct access to public roads. A high value of this indicator indicates a greater need for implementation of the land consolidation project.

BWM criteria weights

Decision-making is defined as the process of choosing one or more of the most appropriate or possible solutions among the available alternatives (Ertunç & Uyan, 2022). The use of traditional selection methods distracts the solution from reality because there are multiple conflicting criteria in the decision-making process. Therefore, the use of multi-criteria decision-making techniques is necessary where such decision-making is important. BWM is a favored multi-criteria technique (Kheybari & Ishizaka, 2022; Xiaomei et al., 2019). BWM does pairwise comparisons to calculate the weights. Fewer pairwise comparisons and high consistency put BWM ahead of other weighting methods (Rezaei, 2015). Because the BWM uses a nonlinear model to calculate weights, a more optimal weight range is possible (Rezaei, 2016; Rezaei, 2020). In practice, this method has been used in many different areas, such as assessing external forces that affect supply chain sustainability (Sadaghiani et al., 2015), supplier selection (Rezaei et al., 2016), risk assessment for the supply chain (Mohaghar et al., 2017), selection of the most suitable eco-industrial park (Zhao et al., 2017), choosing of wagons in the internal transportation of the logistics firm (Stević et al., 2017), sustainability evaluation of urban wastewater treatment technologies (Ren et al., 2017), green supplier choice (Gupta & Barua, 2017), logistics station establishment (Rezaei et al., 2017), evaluation of logistics performance index criteria (Rezaei et al., 2018), airport evaluation and ranking (Shojaei et al., 2018), roundabout location selection (Stević et al., 2018), evaluation of airline service quality (Gupta, 2018), and selection of a 3PL service provider (Boakai, 2016; Pamucar et al., 2019).

The five steps of BWM are as follows:

Step 1. A series decision-making criteria is defined.
Step 2. Selection of the best and the worst criteria.
Step 3. In this step, preference of the best criterion across other criteria using a number between 1 and 9 is determined. This creates the Best-to-Others vector which is

$$A_B = \left(a_{B1,}a_{B2,} \ldots ., a_{Bn,}\right) \tag{3}$$

where a_{Bj} demonstrates the best criterion which is B over criterion j. The number should always be 1 when the best criterion is compared to itself (Gökkaya, 2022).
Step 4. The preferences of the other criteria to the worst criterion are determined by using a scale from 1 to 9. This results in the Others-to-Worst vector which is

$$A_w = \left(a_{1W};a_{2W}; \ldots ., a_{NW}\right)^T \tag{4}$$

where a_{jw} demonstrates the preference of criterion j over the worst criterion which is W.
Similar to the best criterion, when the worst criterion is compared to itself, the number should always be 1 (Gökkaya, 2022).
Step 5. Finding optimum weights $\left(w_1^*, w_2^*, \ldots, w_n^*\right)$. For each pair of w_B / w_j and w_j / w_W, the optimal weight should provide $w_B / w_j = a_{Bj}$ and $w_j / w_W = a_{jW}$. For satisfying them, the maximum differences of $\left|\frac{W_B}{W_j} - a_{Bj}\right|$ and $\left|\frac{W_j}{W_W} - a_{jW}\right|$ for all j should be minimized, which is translated to the following mathematical model:

$$\min \max_j \left|\frac{W_B}{W_j} - a_{Bj}\right|, \left|\frac{W_j}{W_W} - a_{jW}\right| \tag{5}$$

Under the following constraints,

$$\sum_j w_j = 1$$

$w_j \geq 0$ (for all j values)
The equation can be transformed to linear:

$$\min\ \xi \tag{6}$$

Under the following constraints:
$\left|\frac{W_B}{W_j} - a_{Bj}\right| \leq \xi$ (for all j values)
$\left|\frac{W_j}{W_W} - a_{jW}\right| \leq \xi$ (for all j values)

$$\sum_j w_j = 1$$

$w_j \geq 0$ (for all j values)
By solving this model, optimal criterion weights $(w_1^*, w_2^*, \ldots, w_n^*)$ and ξ^* are obtained.
Step 6. The consistency ratio is calculated to check the consistency of the comparisons and to see if the results are reliable. The smaller the consistency ratio, the higher the consistency of comparisons. The consistency index is given in Table 1.

The consistency ratio of the BWM can be calculated by combining the obtained ξ and the relevant consistency index (Table 1) as follows:

$$\text{Consistency ratio} = \xi^* / (\text{consistency index}) \tag{7}$$

The consistency index in the formula is the maximum possible value of ξ^*. Here, the consistency ratio is ∈ [0, 1]. The closer the consistency ratio is to zero, the more consistent the resulting vector will be, and the reverse is also true. In general, a consistency ratio ≤ 0.1 showes that resulting vector is reasonable.

Results and discussions

A multi-criteria analysis method was employed to decide the priority ranking for implementing LC projects in 75 villages in the Malopolska region. Expert opinions were evaluated to determine and classify the nine criteria determined within the scope of this study. Determining the criteria for consolidation is important

Table 1 Consistency index used in the BMW

$a_{(best-worst)}$	1	2	3	4	5	6	7	8	9
Consistency index	0.00	0.44	1.00	1.63	2.3	3.0	3.73	4.47	5.23

in terms of the reliability of the study results. The number of criteria can be increased or reduced according to the feature of the study area, or different criteria can be included in the evaluation because the objectives and methodology of LC can be impacted by the special conditions of different countries and regions, their political and social developments, and natural conditions (Sklenicka, 2006). Spatial analysis maps of the criteria used to determine priority areas in LC were prepared using ArcGIS software (Fig. 3).

The process of weighting the determined criteria using the BWM was performed with the support of experts in the field. Weighting of each criterion according to the BWM was performed using an BWM-Solver-4 that excel file developed by Rezaei et al. (2016). Table 2 presents the calculated weight values. These weights were used to evaluate the priority areas for consolidation with the help of GIS and enabled us to produce map results using weighted overlay analysis. Creating a weighted overlay in ArcGIS involves combining multiple raster layers to produce a single output raster layer, where each input layer is assigned a weight that reflects its relative importance in the analysis. Nine weighted criteria using the BWM for this study were used as input data for the overlay process. The output of the weighted overlay is a new raster layer that represents the combined effect of all the input layers, considering their assigned weights. Areas with higher values in the output raster indicate more suitable or preferred locations based on weighted criteria. As a result of the weighted overlay made for eighty villages using

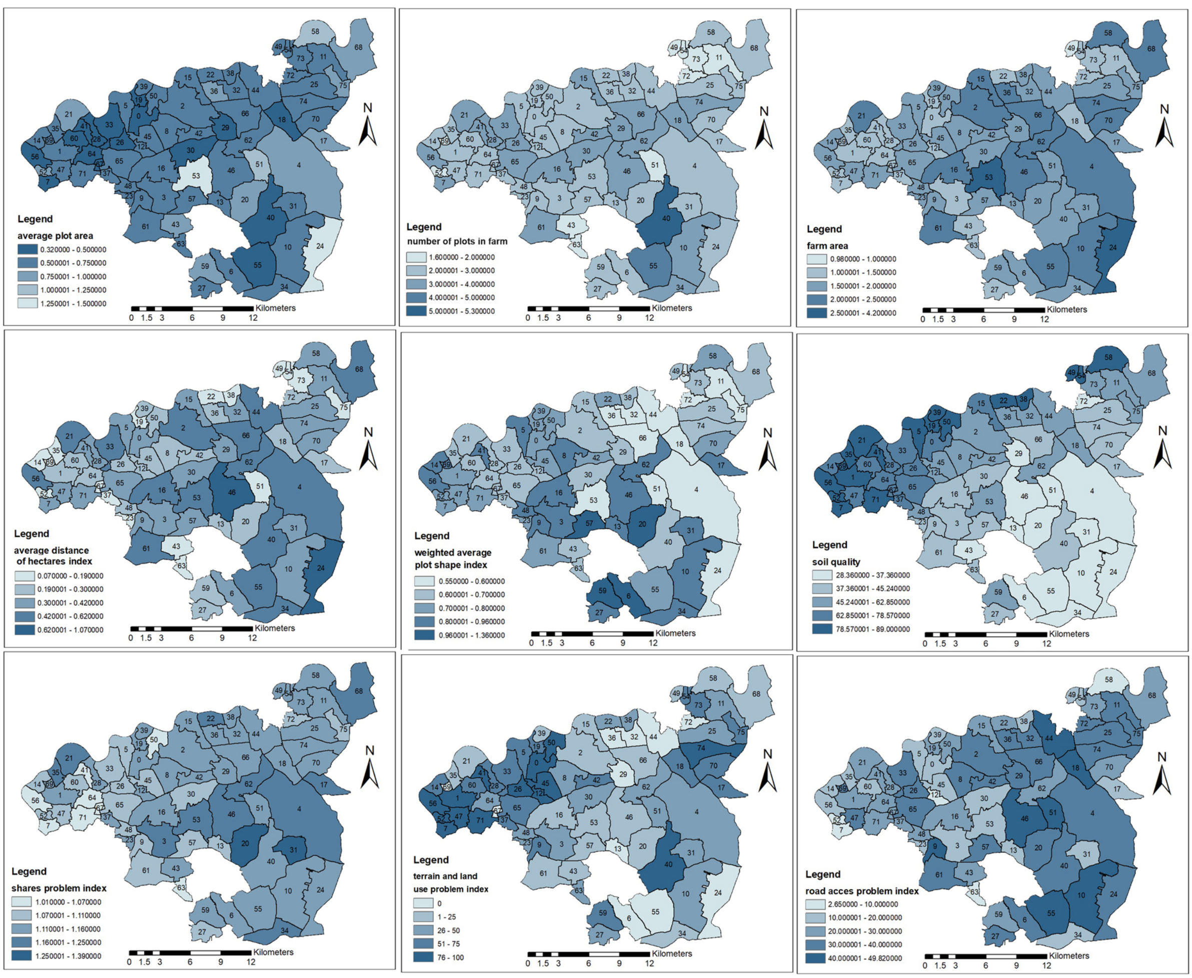

Fig. 3 Spatial differentiation of the criteria values used in the analysis

Table 2 Calculated weights of all criteria using the BWM

Criteria number = 9	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6	Criterion 7	Criterion 8	Criterion 9
Names of criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
Select the best	C2								
Select the worst	C7								
Best to others	C1	C2	C3	C4	C5	C6	C7	C8	C9
C2	1	1	5	5	6	5	8	4	5
Others to the worst	C7								
C1	8								
C2	9								
C3	5								
C4	5								
C5	4								
C6	5								
C7	1								
C8	6								
C9	5								
Weights	C1	C2	C3	C4	C5	C6	C7	C8	C9
	0.270	0.295	0.067	0.067	0.056	0.067	0.025	0.084	0.067
CR	0.067416								

ArcGIS software, three classes between 5 and 7 were formed. These values were optionally reclassified into five categories (lowest priority, low priority, medium priority, high priority, and very high priority) (Fig. 4). Table 3 shows the villages with the lowest and highest priorities according to the weighted overlay results.

The CR value of pairwise comparisons in the weighting process for each criterion was determined as 0.067416, as shown in Table 2. A value less than 0.10 gives the result that the pairwise comparisons are consistent. As a result of the pairwise comparisons, it was determined that the most important criterion for the study was C2 (number plots in farm), with a weight value of 0.295 (29.5%). LC studies carried out in areas with a high number of plots are important in terms of achieving the objective of the project and observing the results. The C1 (average plot area) criterion, with a weight value of 0.27 (27%), affected the study at least as much as the C1 criterion. The small size of the plots does not support rational land use or mechanization in agriculture. This makes farming efficiency problematic. C7 (shares problem index) is the criterion that affects the study the least, with a weight value of 0.025 (2.5%). The reason for this is the low ratio of shared problems in the study area. However, share problems in LC projects in Poland are generally observed at high rates, and sometimes agricultural lands may become unusable due to the problem of shareholders operating agricultural lands. The weights of the other criteria (C3, C4, C5, C6, C8, and C9) vary between 6 and 8%, and their effects on the study were almost the same. Figure 4 shows the priority map of LC fields, created by combining raster criteria maps weighted by BWM analysis with overlay analysis and reclassified according to priority levels. The classification was divided into five categories: lowest, low, medium, high, and very high. According to the map created, the most suitable region for LC is Nieczajna Gorna village, represented by number 40. High-priority regions were concentrated in the central part of the research area. Thanks to such maps, local authorities will be well equipped to select possible project areas and decide on financing allocations.

Assessing the correctness of the algorithms leading to the creation of a ranking of the needs for the application land consolidation projects is difficult. It is often impossible to verify these indications using an alternative method, the results of which can be

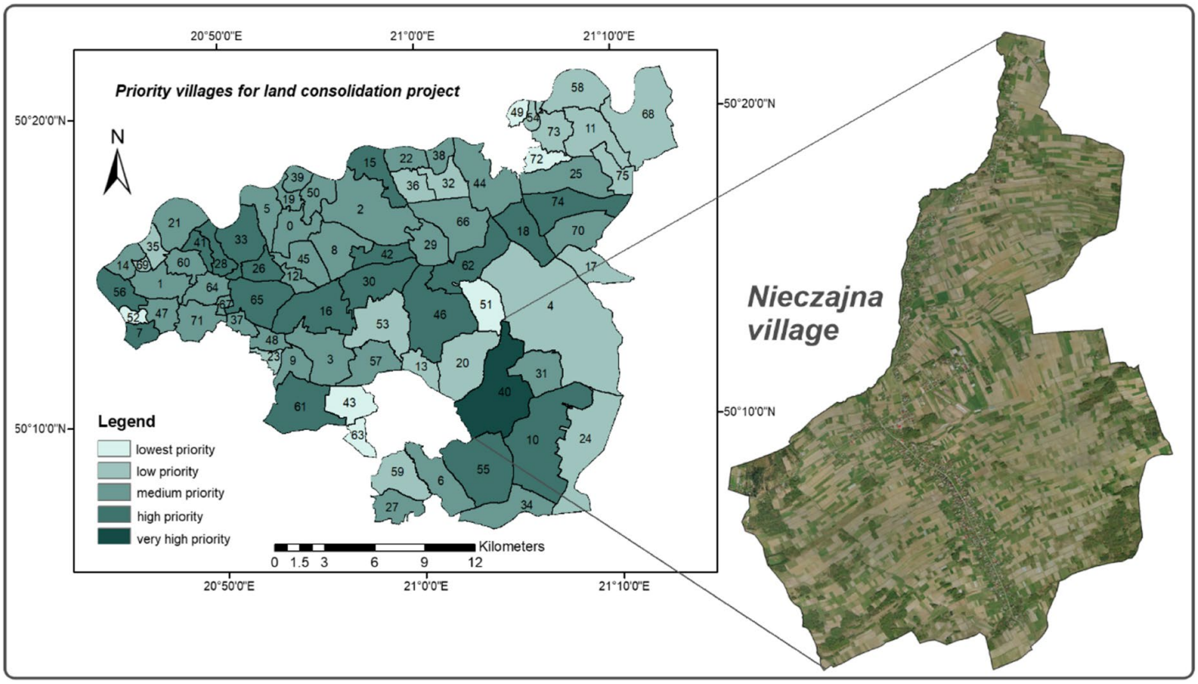

Fig. 4 LC project priorities for 75 cadastral areas in the Dąbrowski poviat in Poland

considered objective. Moreover, known algorithms for solving this problem (Janus & Taszakowski, 2018; Leń, 2018; Tomić et al., 2018; Wójcik-Leń et al., 2019) can be parameterized. This allowed us to obtain different results depending on the assumptions made or the adopted weights of the individual factors considered in the analysis.

Based on the analysis, the village of Nieczajna was indicated to have the highest potential for the implementation of the land consolidation project (Fig. 4), meeting all the conditions necessary in Polish legal and practical conditions to achieve the high efficiency of these projects (Janus & Markuszewska, 2017). The key parameters of land fragmentation (number of plots, average area, and dispersion captured by the avdhai index) are among the most unfavorable (from the point of view of land cultivation economics) (Di Falco et al., 2010; Heinrichs et al., 2021; Rahman & Rahman, 2009) in the entire analyzed dataset. Within the analyzed area, lots of plots have not got a direct connection to the road network. At the same time, in the area of the village of Nieczajna, there are no significant obstacles hindering the effectiveness of designing a new layout of plots in the form of escarpments, trees, rivers, drainage ditches, or dispersed farm buildings. Under these conditions, it is possible to achieve a significant improvement in all land fragmentation parameters, which should significantly improve the economic aspects of farm functioning in such areas.

The results should also be considered in terms of the set of criteria used and their weights. Among the criteria used, no environmental or landscape factors are increasingly (He et al., 2020). However, the

Table 3 The villages with the lowest and highest priority for LC projects according to the weighted overlay result

ID	Village name	Score	Priority
51	Sutków	5	Lowest
52	Okręg	5	Lowest
49	Łęka Szczucińska	5	Lowest
72	Świdrówka	5	Lowest
63	Morzychna	5	Lowest
62	Radwan	7	Very high
46	Smęgorzów	7	Very high
10	Luszowice	7	Very high
55	Szarwark	7	Very high
40	Nieczajna	7	Very high

proposed approach was aimed at creating a ranking from the perspective of the potential to improve the economics of agriculture in a given area. This is still the most important goal of land consolidation projects in Poland. However, in other countries, both the set of factors used and their weights should be changed accordingly.

In LC projects, the use of this decision-making model ensures the basis for objective decision-making and notably decreases optional decision-making in the LC ranking process (Marinković et al., 2022; Muchová & Petrovič, 2019). Furthermore, according to Muchová and Petrovič (2019), the use of multi-criteria methodes can contribute to eliminating optional choice, casualness, and solutions for special interests in LC. Pašakarnis et al. (2021) showed that assistance in identifying potential land consolidation areas was satisfied by both land owners/users and authorities, particularly in Finland and the Netherlands. In Balkan countries, such as North Macedonia and Croatia, there are initiatives to implement MCDA methodologies to help in the land consolidation projects (Pašakarnis et al., 2021).

Conclusions

The design and aplication of land consolidation projects in a planned manner create conditions for more economical and efficient agricultural production in rural areas, which in turn directly impacts the development and well-being of local communities. Hence, it is necessary to establish objective criteria for the determination or prioritization of cadastral areas whose lands will be consolidated.

In the current study, a new model was presented in which potential land consolidation projects were ranked according to the priority in which they would be carried out. In this model, the BWM (Best-Worst Method) has been used. The advantage of the method is that it clearly determines the relative importance. Instead of ranking the alternatives, it focuses on identifying the best and worst aspects of each alternative, making the relative importance among alternatives more evident. However, the disadvantage is that it solely focuses on determining the best and worst aspects of the alternatives, neglecting other characteristics of the alternatives. Hence, some details may be overlooked. BWM is a useful method for determining preferences and can be applied in various fields. The study showed that it could significantly help decision makers in selecting cadastral municipalities (cadastral areas) to initiate land consolidation projects. The possibility of choosing the right set of factors to be considered depending on local needs and their weighting based on the opinion of experts makes this method universal. Therefore, the proposed method can be used on an international scale, not only in a particular country or region. The suggested model ensures the transparent determination and prioritization of regions for land consolidation by national and local authorities, effective management of funds, and equitable allotment of financial support. Furthermore, implementing LC areas after prioritization will increase the success of these projects.

Author contribution Ela Ertunç: conceptualization, methodology, validation, investigation, formal analysis, writing—original draft, writing—review and editing, visualization, and resources. Jarosław Janus: conceptualization, validation, data curation, formal analysis, resources, writing—original draft, writing—review and editing, resources, visualization, and resources. Mevlut Uyan: methodology, formal analysis, software, writing—review and editing, and visualization.

Data availability Data will be made available on request.

Declarations

Ethics approval All authors have read, understood, and have complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the Instructions for Authors.

Conflict of interest The authors declare no competing interests.

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