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Decision-making models using the Analytical Hierarchy Process in the urgency of land consolidation works

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Abstract

Poland is characterized by a number of factors which adversely affect the agricultural economy, so this paper will aim to present the possibilities of using multi-criteria decision-making methods of Analytical Hierarchy Process (AHP) in the analysis of the spatial structure of rural areas. AHP is a widely used tool for making complex decisions based on a large number of criteria, such as, for example, land consolidation works on fragmented agricultural land. The first step is to formulate the decision-making process, then the assessment criteria and the solution variants guided by expert knowledge are determined.

A ranking, according to which the order of land consolidation and land exchange works in the studied area should be determined, will be defined by using decision-making models of the AHP method. The basis for calculations will be the weights received for the factors/parameters defined for the five thematic groups. Calculations for individual villages will be made, and then the obtained results will allow creating a ranking for the studied commune, allowing for the effective (in terms of economic and socio-economic) spending of funds for this purpose. The presented method can be successfully used to conduct analogous analyses for any area.

Key words: *AHP method, decision-making process, land consolidation works, ranking of urgency*

INTRODUCTION

The picture of the contemporary village has been shaped by individual needs of society, and depends, first and foremost, on historical, cultural, economic and social factors. The important role in that process has been land use issues, especially a high level of fragmentation of land farms. Fragmentation is mainly due to the enforcement of inheritance law [HUNG *et al*. 2007; TAN *et al*. 2006]. The most common defects of the spatial structure of private agricultural land in Poland are: the small area and the large number of land parcels forming the farm, in particular in the territory with differentiated terrain relief. This is mainly the case in southern and south-eastern Poland. Land in the eastern and central regions of Poland is characterized by other defectiveness which is also very considerable. Land parcels in the lowlands are very narrow and significantly elongated. In addition, they are hardly accessible with having no access to roads and, most importantly, the land is scattered inside and outside the limits of the village. Such a state of affairs has a negative effect on building a full-featured real property cadastre [LEŃ, MIKA 2016;

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NOGA, LEŃ 2010]. The factors mentioned above generate a range of similar problems related to excessive land fragmentation in numerous countries of central Europe [VAN DIJK 2003]. The negative effects of land scattering are also felt in other parts of Europe and the world [LATRUFFE, PIET 2013]. Faulty land use structure poses a problem not only to rural areas, but also to suburban areas, thus endangering the spatial order of these areas [MIKA, SALATA 2015; SOBOLEWSKA-MIKULSKA 2015]. One chance to improve this situation in rural areas is to carry out land management and land readjustment operations aimed at consolidation of parcels. The policy of the European Union, including Poland, proclaim land consolidation works as geodesic procedures in which new plots are formed in a configuration different from that of original plots in order to reduce the number of small, scattered plots constituting a single farm and to increase their average size [Regulation (EU) No 1305/2013]. The consolidation works also include works related to post-consolidation management of land such as creating a functional system of roads to agricultural land and forestland and regulation of the water regime in the consolidated area. In Poland, from the moment it joined the European Union, the processes of land consolidation and land exchange has been targeted at economic development as a factor in increasing the attractiveness of rural areas to their inhabitants, and at fostering economically and environmentally sustainable development of the agriculture sector [DUDZIŃSKA *et al*. 2014].

Land management and land consolidation are an investment which pays off, because of removing defects in the spatial structure of lands. In Poland, it is estimated that there are around 3 mln ha of poorly structured agricultural space. This means that effective land management and effective land consolidation and exchange require that priorities be established for performing these tasks. In connection with this, statistical methods, including the ranking methods, are becoming increasingly useful in empirical research on the land use structure of rural areas. The advantage of using ranking methods is that they provide means for multi criteria analysis of the spatial structure of villages [LEŃ *et al*. 2016].

The aim of this study was to establish the priority schemes for land consolidation works by using decision-making models of AHP method. The study encompassed 34 villages of Sławno municipality, located in central Poland, in the district of Opoczno, Łódź Voivodeship (Fig. 1). As it was mentioned, a characteristic feature of agriculture in central Poland is excessive land fragmentation and land scattering, as well as disadvantageous geometry of land parcels. Above mentioned factors impede profitable agricultural production. Additionally, the existing network of roads does not ensure the direct access to all land parcels, therefore, does not allow for the usage of modern agricultural machines. These facts combined all together, show that villages of central Poland are one of the best examples that require consolidation works aimed at improving the spatial structure of land.

Calculations were based on twenty factors representing five groups of parameters characterizing the land use structure of the villages studied. The results from analysis of the AHP method, allowed determining priority hierarchies for consolidation works and establishing the ranking of urgency of this kind of works for each village.

The method of multicriteria ordering of decision-making variants of AHP (Analytic Hierarchy Process) and Hellwig's synthetic measure method were applied in the research. In the first stage of the analysis, the AHP method enabled determining weights, and then in the second stage, using Hellwig's method, individual villages were assessed due to the urgency of land consolidation works.

The actions using the AHP procedure are focused on the allocation of a standardized final assessment (set in the vector of scale) to each decision-making variant, which can be interpreted as the usefulness of the *i*-th variant. The scale vector is obtained on the basis of comparisons between pairs of criteria and decision variants due to subsequent criteria. These activities are carried out using the nine-point Saaty scale by assigning a numerical and verbal description to individual comparisons [SAATY 2006].

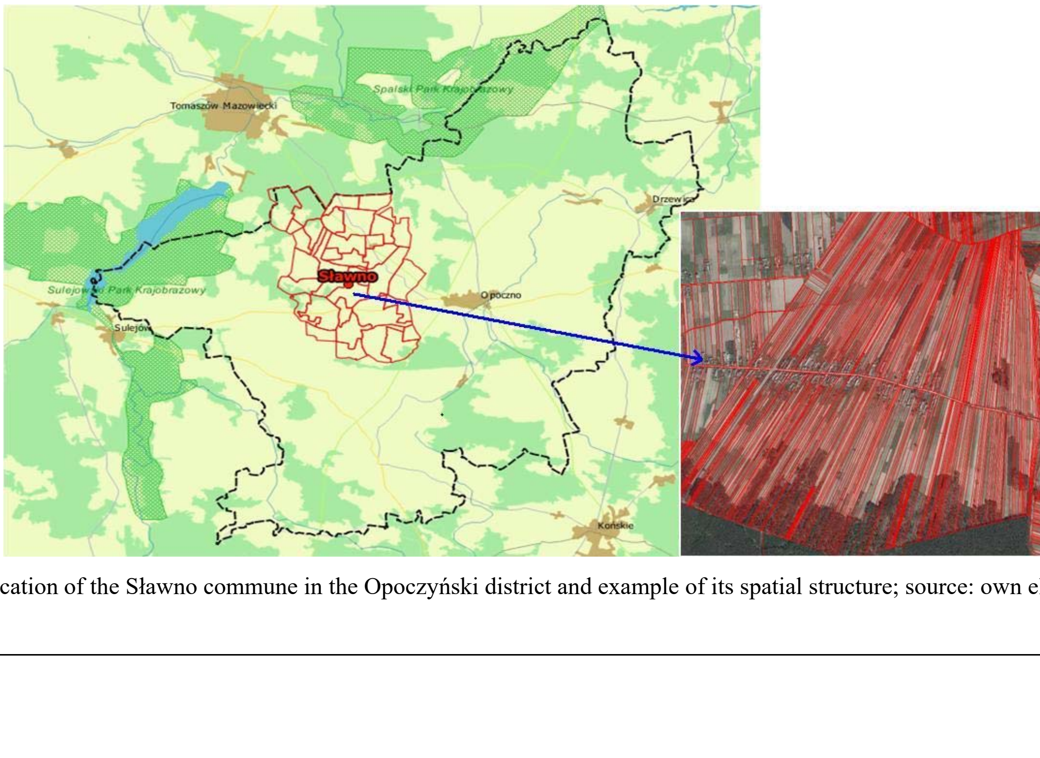

Fig 1. Location of the Sławno commune in the Opoczyński district and example of its spatial structure; source: own elaboration

The AHP method takes into account the specificity of psychological valuation processes, primarily having hierarchical and relational character. Numerous applications of this method in supporting socio-economic, financial or technical decisions confirm its usefulness, especially in cases where a significant part of the assessment criteria is qualitative and the assessor's experience is the main source of evaluations [DOWNAROWICZ *et al*. 2000].

THE ANALYTIC HIERARCHY PROCESS METHOD

The Analytic Hierarchy Process (AHP) is a technique for organizing and analysing complex decisions and is used to derive ratio scales from paired comparisons. These comparisons may be taken from actual measurements (such as area, density of population, other factors that can be measured) or from a fundamental scale which reflects the relative strength of preferences (feelings and opinions for example). The AHP method [SAATY 1977; 1980] is used to rank decision variants and indirectly to support their selection. The method is used to solve decision-making problems, especially in situations where the criteria are qualitative, and the assessments are subjective and result from the analyst's knowledge and experience. An analytical hierarchical process, that can be presented in the form of a multi-level hierarchical structure, consists of: the superior goal, main criteria, partial criteria (attributes) and the analysed variants (objects, decision alternatives), and is used to solve decision problems. The levels are ordered in the direction of decreasing importance, and the elements are compared in pairs at each level of the hierarchy. In this way, the predominance of one element over the other is determined in relation to the elements located above [ADAMUS, ŁASAK 2010]. Aggregation of assessments in the AHP method takes place according to the additive utility function, synthesizing the shares of weights of the criteria and the value of the fulfilment degree of the fractional target function by each of the criteria. The assessment of the fulfilment of these criteria for the considered decision-making variants is obtained by the pairwise comparison method [DOWNAROWICZ *et al*. 2000].

The pairwise comparison is the fundamental component of the AHP process. The experts provide their judgment of the relative importance of one indicator against another. For each pairing within each criterion, the better option is awarded with a higher score, on a scale between 1 – equally good, and 9 – absolutely better [SAATY 1980], while the opposite option in the pairing is assigned with a rating equal to the reciprocal of this value. There could be some difficulties with expressing consistent evaluations by the decision maker. This may lead to determining an inconsistent matrix of pairwise comparisons which will therefore lack the assumed properties, so the results of pairwise comparison are normalized and examined with the consistency ratio (*CR*) test. When the *CR* value is less than 0.20, consistency of the comparison is appropriate [LEE *et al*. 2012]. Some of the authors accept only 0.10 for the upper *CR* limit.

Generally, the AHP consists of a few steps [PIRES *et. al*. 2011; SAATY 1980].
1. Defining the problem.
2. Creating the structure of decision hierarchy from top to bottom.
3. Construction of the pair-wise comparison matrix:

matrix $M = (m_{ij})$ is said to be consistent if $m_{ij} \cdot m_{ik} = m_{ik}$ and its principal eigenvalue ($\lambda_{\max}$) is equal to *n*. The general eigenvalue formulation is (Eqs. 1–3):

$$M \cdot w = \begin{vmatrix} 1 & \frac{w_1}{w_2} & \frac{w_1}{w_3} & & \frac{w_1}{w_{n-2}} & \frac{w_1}{w_{n-1}} & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \frac{w_2}{w_3} & \cdots & \frac{w_2}{w_{n-2}} & \frac{w_2}{w_{n-1}} & \frac{w_2}{w_n} \\ \frac{w_3}{w_1} & \frac{w_3}{w_2} & 1 & & \frac{w_3}{w_{n-2}} & \frac{w_3}{w_{n-2}} & \frac{w_3}{w_{n-2}} \\ & \vdots & & \ddots & & \vdots & \\ \frac{w_{n-2}}{w_1} & \frac{w_{n-2}}{w_2} & \frac{w_{n-2}}{w_3} & & 1 & \frac{w_{n-2}}{w_{n-1}} & \frac{w_{n-2}}{w_n} \\ \frac{w_{n-1}}{w_1} & \frac{w_{n-1}}{w_2} & \frac{w_{n-1}}{w_3} & \cdots & \frac{w_{n-1}}{w_{n-2}} & 1 & \frac{w_{n-1}}{w_n} \\ \frac{w_n}{w_1} & \frac{w_n}{w_1} & \frac{w_n}{w_3} & & \frac{w_n}{w_{n-2}} & \frac{w_n}{w_{n-1}} & 1 \end{vmatrix} \cdot \begin{vmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_{n-2} \\ w_{n-1} \\ w_n \end{vmatrix} \quad (1)$$

Where *w* are weights and *i, j* = 1, 2, 3, …, *n*

$$M \cdot w = n \cdot \begin{vmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_{n-2} \\ w_{n-1} \\ w_n \end{vmatrix} = \lambda_{\max} \cdot w \quad (2)$$

$$\lambda_{\max} = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{(M \cdot w)_i}{w_i} \quad (3)$$

4. Applying the consistency test (Eg. 4).

For measure consistency index (*CI*) adopt the value (4):

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad (4)$$

The *CR* is obtained by comparing the *CI* with an average random consistency index *RI* (Eq. 5).

$$CR = \frac{CI}{RI} \quad (5)$$

Where: *RI* is the random index; for purposes of this work *RI* values are 0.90, 1.12 and 1.24 for 4, 5 or 6 compared parameters respectively. For 2 compared parameters calculation of *CR* is unavailable.

5. Calculation of relative local and global weights of factors.
6. Obtaining the principal eigenvector and largest eigenvalue.

MATERIALS AND METHODS

The study area is 34 villages located in central Poland, with a total number of 27 733 cadastral parcels and total area of 12 540 ha. In order to develop the rankings of the urgency of land consolidation and land exchange work in the area of research 20 indicators describing the full spatial structure of the surveyed villages was designated. These factors represent the five criteria of issues and served as diagnostic indicators used for further research. All elements under each criterion were set based on literature and expert knowledge.

A three-level AHP model consisting of 20 indicators for the five criteria was proposed (Fig. 2). There are three levels in the decision hierarchy. The overall goal of the decision process, which is defined as the ranking of villages for urgency of land consolidation and land exchange works, is in the first level of the hierarchy. The criteria are on the second level and the indicators are on the third level of the hierarchy.

The first group of indicators – K_1 included those which described the land tenure structure: K_{11} – percentage share of lands belonging to the State Treasury, K_{12} – percentage share of lands belonging to the commune, K_{13} – percentage share of lands belonging to individual agricultural holdings, K_{14} – percentage share of lands belonging to the district.

The second group of indicators – K_2, were related to land use: K_{21} – percentage share of agricultural lands, K_{22} – percentage share of grasslands, K_{23} – percentage share of pastures, K_{24} – percentage share of agricultural built-up land, K_{25} –- percentage share of forests, K_{26} – percentage share of transportation areas. The factors, expressed as a percentage, were calculated on the basis of data obtained from the Land and Building Register, in relation to the total area occupied by each particular locality.

The third group of indicators – K_3 associated with the demographic conditions of the investigated district: K_{31} – number of inhabitants and K_{32} – number of inhabitants per square kilometer. Information on the number of inhabitants was obtained from the Sławno municipal office.

The fourth group of indicators – K_4, regarding land fragmentation, included six indicators determined on the basis of data obtained from the Land and Building Register: K_{41} – total area of a village, K_{42} – total number of plots, K_{43} – average area of a plot in the village, K_{44} – number of privately owned parcels, K_{45} – average area of privately owned parcels and K_{46} – land fragmentation coefficient. This indicator has been calculated based on the formula presented in NOGA and LEŃ [2010].

The fifth group of indicators – K_5 is associated with plots without road access were: K_{51} – percentage of plots without road access and K_{52} – percentage of plot area without road access. In this part of the study, tools available in the "QGIS 2.18" software were used to quickly and easily calculate numerical results as well as their graphical representation.

By using the AHP and Helwig's methods, the preference of 34 given villages corresponding to each criterion and a final ranking can be evaluated. Past experience is utilized in determining the criteria and 20 important indicators to be used for destination selection are established. After forming the structure for the decision problem, the weights of the criteria to be used in the evaluation process are calculated by using the AHP method. In this phase, the experts are given the task of forming an individual pairwise comparison matrix by using scale proposed by Saaty. The questionnaire was answered by ten experts from academia and practice of consolidation works. They were asked to compare the criteria at a given level to identify their relative significance. Geometric means of the expert's choice values are used to obtain the pairwise comparison matrix on which there is a consensus. Based on the matrix of comparison, a different weight has been attributed to the criteria of urgency of the consolidation works. The overlay technique to determine the weights was also repeated also for all indicators in the particular criteria. A detailed numerical example, illustrating the application of our approach to criteria evaluation and final ranking is given. The calculations were made using an MS Excel spreadsheet. The importance of the integration work is in Tables 1–3.

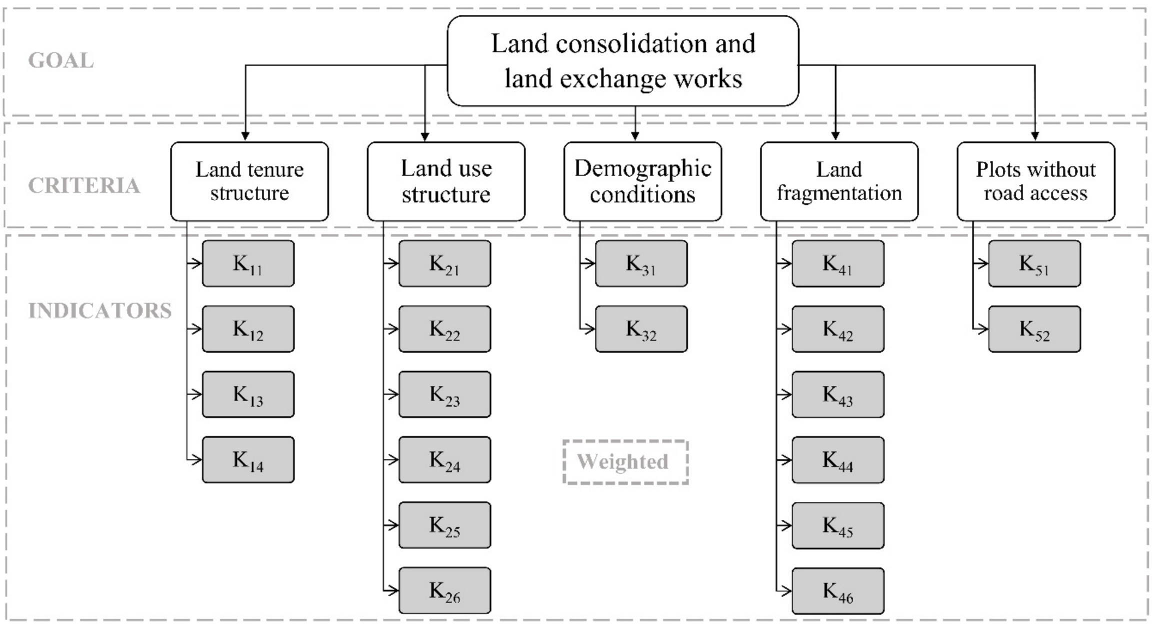

Fig. 2. Hierarchy of land consolidation works decision model; K_{11}–K_{14}, K_{21}–K_{26}, K_{31}–K_{32}, K_{41}–K_{46}, K_{51}–K_{52} as in p. 147; source: own elaboration

Table 1. Criteria matrix – *M*

Criteria	K_1	K_2	K_3	K_4	K_5
K_1	1.000	3.003	0.200	0.125	0.500
K_2	0.333	1.000	0.333	3.030	0.333
K_3	5.000	3.000	1.000	0.111	3.003
K_4	8.000	0.330	9.000	1.000	0.500
K_5	2.000	3.000	0.333	2.000	1.000
Total	16.333	10.333	10.866	6.266	5.336

Explanations: K_1 = land tenure structure, K_2 = land use structure, K_3 = demographic conditions, K_4 = land fragmentation, K_5 = plots without road access.
Source: own elaboration.

Table 2. Normalization of criteria matrix and values of weights

Criteria	K_1	K_2	K_3	K_4	K_5	Weight w
K_1	0.061	0.291	0.018	0.020	0.094	0.097
K_2	0.020	0.097	0.031	0.484	0.062	0.139
K_3	0.306	0.290	0.092	0.018	0.563	0.254
K_4	0.490	0.032	0.828	0.160	0.094	0.321
K_5	0.122	0.290	0.031	0.319	0.187	0.190
Total	1.000	1.000	1.000	1.000	1.000	1.000

Explanations as in Tab. 1.
Source: own elaboration.

Table 3. The general eigenvalues and consistency ratio test for analysed criteria

Products of matrix $=M \cdot w$	$\frac{(M \cdot w)_i}{w_i}$
0.699366	7.226
1.290611	5.039
1.760212	2.755
3.519824	2.181
1.525707	3.681
Consistency ratio *CR* test	0.092

Explanations: M = matrix, w = weights, i = row index.
Source: own elaboration.

Table 4. Resulting weights and consistency ratio – values of criteria and indicators obtained with AHP method

Indicators / Criteria		Weight	Consistency ratio
K_{11}	percentage share of lands belonging to the State Treasury	0.423	0.038
K_{12}	percentage share of lands belonging to the commune	0.216	
K_{13}	percentage share of lands of individual agricultural holdings	0.218	
K_{14}	percentage share of lands belonging to the district	0.143	
K_{21}	percentage share of agricultural lands	0.399	0.065
K_{22}	percentage share of grasslands	0.137	
K_{23}	percentage share of pastures	0.093	
K_{24}	percentage share of agricultural built-up lands	0.206	
K_{25}	percentage share of forests	0.085	
K_{26}	percentage share of transportation areas	0.080	
K_{31}	number of inhabitants	0.546	–
K_{32}	number of inhabitants per km^2	0.454	
K_{41}	total area	0.196	0.038
K_{42}	total number of plots	0.169	
K_{43}	average plot area in the village	0.176	
K_{44}	number of privately owned parcels	0.154	
K_{45}	average area of privately owned parcels	0.152	
K_{46}	land fragmentation coefficient	0.153	
K_{51}	percentage of plots without road access	0.496	–
K_{52}	percentage of plot area without road access	0.504	
K_1	land tenure structure	0.097	0.092
K_2	land use structure	0.139	
K_3	demographic conditions	0.254	
K_4	land fragmentation	0.321	
K_5	plots without road access	0.190	

Source: own study.

RESULTS AND DISCUSSION

The results obtained from the computations based on the pairwise comparison matrix are presented in Table 4.

The "land use structure", "land fragmentation" and "plots without road access" are determined as the three most important criteria in the ranking of village on consolidation land work in the selection process by AHP. Consistency ratios of the pairwise comparison matrixes are calculated as less than 0.1. So the weights are shown to be consistent and are then used in the ranking process.

Finally, Hellwig's method is applied to rank the village in priority of land consolidation land and land exchange works. The values of the weights with respect to criteria, calculated by AHP and shown in Table 4 can be used with Hellwig's method. The use of Hellwig's method was described by LEŃ *et al*. [2016]. The results for particular villages generated from Table 4 and by using Hellwig's method are shown graphically in Figures 3 and 4.

The use of the AHP method can enable one to create the ranking of urgency of land consolidation and land exchange works. The results obtained in the present study show that consolidation should be first performed in the areas of Gawrony and Kunice. However, the lowest final grade was recorded in the case of Olszewice village. The obtained results were influenced by many factors, among which the statistical material, the composition of the criteria adopted in the study and the analyst's preferences regarding these criteria should be mentioned.

AHP is an effective decision-making method, especially when subjectivity exists, and it is very suitable to solve problems where the decision criteria can be organized in a hierarchical way into sub-criteria. The use of the AHP method in performing a ranking of priority of consolidation works will make it possible to follow a multifunctional and sustainable development scheme combining the conditions of land management and environmental and landscape protection and also improving the agrarian structure of farms and implementation of multifunctional development of rural areas. The abovementioned activities include works related to improving the status of water management within the object of consolidation works.

The results obtained are convergent with the findings of previous studies about using other methods by ranking of villages for consolidation land work, and which were presented in literature [LEŃ *et al*. 2016]. However, the decision-making models and systems should be used for data processing, with the supervision of the user (selecting proper data sets and organising the data analysis process), and the preparation of the information in a clear and understandable form for the user. Decision makers are response-

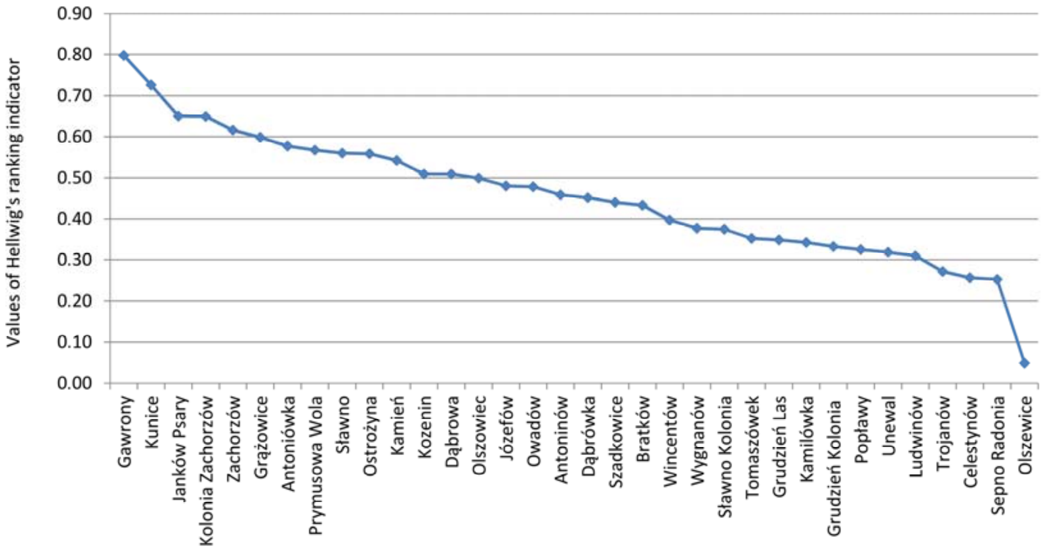

Fig. 3. The Hellwig's method ranking with AHP weights; source: own study

ble for receiving the information, and based on it, understand the analysed issue and make a final decision [KAZAK, VAN HOOF 2018].

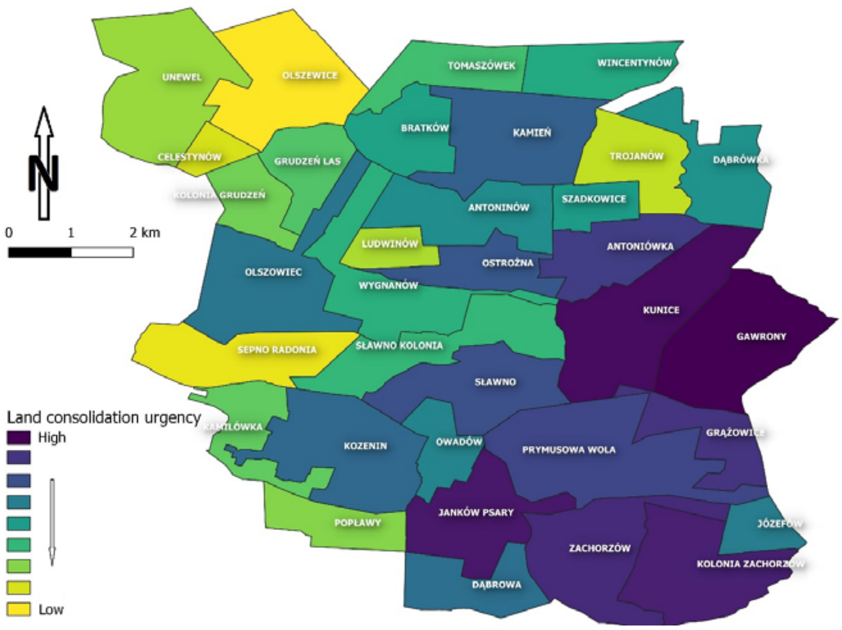

Fig. 4. The land consolidation urgency in Sławno municipality; source: own study

CONCLUSIONS

This paper presents a multi-criteria decision making process for evaluation of most urgent villages, to perform land consolidation works on given area, by implementing the AHP method. The ranking of urgency for land consolidation and land exchange works is strategic information for all the players in the agricultural sector. Several alternatives must be considered and evaluated in terms of different criteria and indicators, leading to a large set of quantitative and qualitative data. Due to this, decision making for selecting the hierarchy of processes of land consolidation and land exchange targeted at economic development as a factor in increasing the attractiveness of rural areas is of special importance.

The integrated AHP and Hellwig's method approach is proposed as an efficient and effective methodology to be used by decision makers in the agricultural sector in terms of its ability to deal with all measures influencing decision process. The results acquired from numerical examples determine that this model could be used for decision making optimization in village ranking of land consolidation works urgency. The evaluation provides representative results for the entire region, characterized by significant defects in terms of the spatial structure of land and could be used as a support in the decision-making process by strategy makers of the agricultural sector, local municipalities, management of agricultural agencies, etc. However, the final solution should be selected by humans based on their knowledge and considering the costs of land consolidation works for effective spending of public funds. This methodology can be successfully applied to another area of research, also to any other selection problem involving multiple and conflicting criteria.

REFERENCES

ADAMUS W., ŁASAK P. 2010. Zastosowanie metody AHP do wyboru umiejscowienia nadzoru nad rynkiem finansowym [The application of the Analytic Hierarchy Process to deciding about the location of financial market supervision]. Bank i Kredyt. Vol. 41. No. 4 p. 73–100.

DOWNAROWICZ O., KRAUSE J., SIKORSKI M., STACHOWSKI W. 2000. Zastosowanie metody AHP do oceny i sterowania poziomem bezpieczeństwa złożonego obiektu technicznego. W: Wybrane metody ergonomii i nauki o eksploatacji [Application of AHP method for evaluation and safety control of a complex technical system. Selected methods of ergonomics and exploitation science]. Gdańsk. Wydaw. Politechniki Gdańskiej p. 7–42.

DUDZIŃSKA M., JASIŃSKA E., KOCUR-BERA K., LEŃ P., PREWEDA E., SAJNÓG N., SOBOLEWSKA-MIKULSKA K., STEINSHOLT H., WALACIK M., WÓJCIK J. 2014. Directions for land management in rural areas. Zagreb–Olsztyn–Katowice. Croatian Information Technology Society, GIS Forum, University of Warmia and Mazury in Olsztyn, University of Silesia. ISBN 978-953-6129-40-9 pp. 74.

HUNG P.V., MACAULAY G., MARSH S.P. 2007. The economics of land fragmentation in the north of Vietnam. The Australian Journal of Agricultural and Resource Economics. Vol. 51 p. 195–211. DOI 10.1111/j.1467-8489.2007.00378.x.

KAZAK J.K., VAN HOOF J. 2018. Decision support systems for a sustainable management of the indoor and built environment. Indoor and Built Environment. Vol. 27(10) p. 1303–1306. DOI 10.1177/1420326X18799812.

LATRUFFE L., PIET L. 2013. Does land fragmentation affect farm performance? A case study from Brittany, France [online]. Working Papers Smart – LERECO. No. 13-04 p. 1–27. [Access 05.05.2019]. Available at: https://hal.archives-ouvertes.fr/hal-01133262/document

LEE S., KIM W., KIM M. Y., OH K.J. 2012. Using AHP to determine intangible priority factors for technology transfer adoption. Expert Systems with Applications. Vol. 39. Iss. 7 p. 6388–6395. DOI 10.1016/j.eswa.2011.12.030.

LEŃ P., MIKA M. 2016. Determination of the urgency of undertaking land consolidation works in the villages of the Sławno municipality. Journal of Ecological Engineering. Vol. 17. Iss. 4 p. 163–169. DOI 10.12911/22998993/64827.

LEŃ P., OLENIACZ G., SKRZYPCZAK I., MIKA M. 2016. The Hellwig's and zero unitarisation methods in creating a ranking of the urgency of land consolidation and land exchange work. 16th International Multidisciplinary Scientific GeoConference SGEM 2016, www.sgem.org, SGEM2016 Conference Proceedings. June 28–July 6, 2016. Book 2. Vol. 2 p. 617–624. DOI 10.5593/SGEM2016/B22/S09.080.

MIKA M., SALATA T. 2015. The use of local databases of spatial information for the preservation of spatial order on example of selected units of local government in Poland. 15th International Multidisciplinary Scientific GeoConference SGEM 2015, Informatics, Geomatics and Remote Sensing, Conference Proceedings. Vol. 2. Cartography & GIS p. 1163–1173, Bulgaria 2015. DOI 10.5593/SGEM2015/B22/S11.145.

NOGA K., LEŃ P. 2010. Analiza rozdrobnienia gruntów indywidualnych we wsiach powiatu Brzozów [Analysis of the fragmentation of private land in the villages of the district Brzozow]. Infrastruktura i Ekologia Terenów Wiejskich. Nr 3 p. 55–64.

PIRES A., CHANG N.B., MARTINHO G. 2011. An AHP-based fuzzy interval TOPSIS assessment for sustainable expansion of the solid waste management system in Setubal Peninsula, Portugal. Resources, Conservation and Recycling. Vol. 56. Iss. 1 p. 7–21. DOI 10.1016/j.resconrec.2011.08.004.

Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005.

SAATY T.L. 1977. A scaling method for priorities in hierarchical structures. Journal of Mathematical Psychology. Vol. 15 (3) p. 234–281.

SAATY T.L. 1980. The analytic hierarchy process. New York-London. McGraw-Hill International Book Co. ISBN 0070543712 pp. 287.

SAATY T.L. 2006. Rank from comparisons and from ratings in the analytic hierarchy, network processes. European Journal of Operational Research. Vol. 168. Iss. 2 p. 557–570. DOI 10.1016/j.ejor.2004.04.032.

SOBOLEWSKA-MIKULSKA K. 2015. The importance of planning documents for the land validation process in Poland. In: 15th International Multidisciplinary Scientific GeoConference SGEM 2015, www.sgem.org, SGEM2015 Conference Proceedings. 18–24 June 2015. Book 2. Vol. 2 p. 515–522. DOI 10.5593/SGEM2015/B22/S9.064.

TAN S., HEERINK N., QU F. 2006. Land fragmentation and its driving forces in China. Land Use Policy. Vol. 23. Iss. 3 p. 272–285. DOI 10.1016/j.landusepol.2004.12.001.

VAN DIJK T. 2003. Scenarios of Central European land fragmentation. Land Use Policy. Vol. 20. Iss. 2 p. 149–158. DOI 10.1016/S0264-8377(02)00082-0.

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Modele decyzyjne z wykorzystaniem Analytical Hierarchy Process w ustalaniu pilności prac scaleniowych gruntów rolnych

STRESZCZENIE

Obszar Polski charakteryzuje się występowaniem wielu czynników wpływających niekorzystnie na gospodarkę rolną, dlatego celem pracy jest przedstawienie możliwości wykorzystania wielokryterialnej metody podejmowania decyzji Analytical Hierarchy Process (AHP) w analizie struktury przestrzennej obszarów wiejskich. AHP jest powszechnie stosowanym narzędziem do podejmowania złożonych decyzji na podstawie znacznej liczby kryteriów, a takim procesem są prace scaleniowe dotyczące rozdrobnionych gruntów rolnych. Pierwszy krok to sformułowanie procesu decyzyjnego, następnie ustala się kryteria oceny oraz warianty rozwiązania, kierując się wiedzą ekspercką.

Model procesu decyzyjnego dla metody AHP zostanie wykorzystany do określenia wag poszczególnych czynników wpływających na pilność przeprowadzenia prac scaleniowych na badanym obszarze. Uzyskane wyniki umożliwią stworzenie rankingu pilności prac scaleniowych dla badanej gminy, pozwalającego na efektywne pod względem ekonomicznym i społeczno-gospodarczym wydatkowanie środków na ten cel. Zaprezentowana metoda może zostać z powodzeniem wykorzystana do przeprowadzenia analogicznych analiz dla dowolnego obszaru.

Słowa kluczowe: *metoda AHP, podejmowanie decyzji, ranking pilności prac scaleniowych, scalenie i wymiana gruntów*