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To cite this article: Zanna Strek *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **221** 012066

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# Hierarchization of Land Consolidation Works in the Rural Areas of Central Poland

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**Abstract.** According to studies carried out by the authors, the development of agricultural production space in the analyzed area resulted in a highly defective spatial structure of agricultural land. The resulting defective spatial structure must be urgently rearranged in line with the achievements of the 21st century. However, land consolidation and exchange cannot be performed in such an extensive area, primarily for economic reasons. In connection with this fact, a hierarchy of needs for land consolidation and exchange works and their urgency must be established using objective methods of assessment. Therefore, this paper aims to determine the needs for land consolidation and exchange in the villages of the gmina of Drzewica, in the powiat of Opoczno, Łódź voivodeship. In administrative terms, the analyzed gmina consists of 17 villages and Drzewica – a town with powiat rights that was not included in the study. The total area covered by the study is 10600.1851 ha. The analyses were based on 24 features describing each of the villages, split into 4 thematic groups. First of the groups (general features) includes the total area of the village, total number of plots, number of inhabitants, average area of plots owned by private owners in respective precincts. The second group, referring to private land, comprises features connected with land owned by private farmers, including: number of registration units in the group of farms, number of plots and average area of plots in those units. The third group is productivity ratios for cropland and grassland. Group four comprises plots without access to roads where the number and area of real properties without access to roads was determined. In the last group the ratios of fragmentation, their average value and percentage of the area of plots covered by orchards and forestland were determined along with the average value of and the synthetic elongation ratio for plots within the precinct. The used features describe the spatial structure of the analyzed villages in detail. The rankings of urgency of land consolidation and exchange works for respective villages were developed using the zero unitarization method and Hellwig's method. Both, for Hellwig's calculations and the zero unitarization method the values of synthetic measures fall within the range [0;1]. These rankings were created by means of synthetic measures of the urgency of consolidation. The measures can be used to classify objects according to the size of multi-theme and multi-feature phenomenon, that is, the analyzed spatial structure of land in the presented community (gmina).

## 1. Introduction

The current status of spatial structure in Polish rural areas is a result of many factors including human activity continuing for many centuries as well as social and economic conditions. People living in specific areas took control over the natural environment and changed the land they cultivated.



Settlement had a decisive impact on those changes. It stimulated the development of cropland. Changes in the forms of land use were connected in the first place with the type and quality of soil and terrain relief [7]. Factors accompanying settlement were soil, terrain relief and conditions for development of the specific areas. In many regions of Poland, inheriting of farms by farmers' children and arranged marriages were important for agriculture. They decreased the agricultural usefulness of land and led to fragmentation and scattering of land both within the village and outside its limits. One of solutions which could improve the spatial structure of land is the possibility of consolidation and exchange of land. According to the review of literature, land consolidation works are carried out in many countries of Central and Eastern Europe, for example in Poland [17], [11], Slovakia [3], [4], Latvia [2], Croatia [15], [18], in the south of Europe: in Spain [16], Greece [12], Turkey [19] and in many other countries in Europe and around the world. These works are rural management procedures aiming to rearrange the spatial layout of cropland. They contribute to rationalization of the spatial structure of very fragmented land. It is understood as the consolidation of plots of land that constitute farms and that are often distant from one another. They are situated in neighbouring villages and are excessively elongated. Land consolidation and exchange works as a governmental administration task provide an opportunity of alternative management of less favoured areas and have an indirect effect on the construction of a full-featured real property cadastre in Poland [14], [20], [13], [1].

This publication aims to identify the areas in which land consolidation works should be carried out in the first place. It is impossible to carry out land consolidation processes in all precincts where they are required, especially when the spatial structure is unfavourable. Such goals require considerable financial expenditure and human resources. Thus, it is necessary to carry out analyses which can establish a specific hierarchy and urgency of land consolidation works.

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

## 2. Materials and methods

Statistical analyses are aimed to design so-called rankings of objects which should contain characteristics describing specific objects. Rankings should be designed based on quantitative features, so the variables should be made uniform and deprived of labels. Such works can be supported by methods for standardizing quantitative features. [6]

The study area covers 17 precincts situated in the gmina of Drzewica in central Poland, powiat of Opoczno, Łódź voivodeship. The total area of all precincts is 10600.1851 ha. Features characterizing respective precincts were determined for the purposes of studies connected with the rankings of urgency of land consolidation works in the gmina of Drzewica (Table 1).

For the purposes of analysis values of respective variables must be determined and characterized and they should be expressed as descriptive statistics. Every variable is described in terms of necessity and urgency of consolidation works. It is labelled as either a larger-the-better (LTB) characteristic or a smaller-the-better (STB) characteristic. 19 features were classified as LTB characteristics, while the remaining 5 features are STB characteristics (Table 2).

Prior to developing a synthetic ranking, the general selection of values of diagnostic variables is a very important and significant thing. The criterion applied in the analysis often excludes variables for which the value of V ratio was less than 20%. Another criterion is rejection of features that are highly correlated. It is connected with the fact that they represent similar values and information about the order of objects [10]. In this case, all the variables were adopted for analyses and testing without determining the degree of their correlation.

**Table 1.** List of features characterizing the analyzed area

General	Information concerning private land	Productivity ratio	Plots without access to road	STB characteristics
Total area [ha]	Number of registration units 7.1	% of cropland	% number of plots without access to roads	Fragmentation ratio
Total number of plots	% of registration units 7.1	% of grassland	% area of plots without access to roads	% of orchards
Number of residents	Number of plots per registration unit 7.1			% of forests
Number of residents per 1km <sup>2</sup>	Area of plots per registration unit 7.1			Average elongation ratio
% of the area of land owned by individual farmers	% of the number of plots in subgroup 7.1 in relation to group 7			Synthetic ratio of plot elongation for the precinct
% of the number of plots owned by individual farmers	% of the area of plots in relation to group 7			
Average plot area in group 7	Average number of plots per registration unit			
	Average area of a registration unit			

**Table 2.** Summary of the adopted variables

Selected features	Mean	Median	Min.	Max.	V
LTB characteristics					
Total area of the village	623.54	515.1	77.66	1854.29	69.52
Total number of plots	1713.29	1325	531	4921	61.33
Number of residents	393.35	420	47	754	46.8
Number of residents per 1km <sup>2</sup>	102.13	59.25	20.31	561.4	125.98
% of the area of plots owned by individual farmers	88.56	94.81	43.83	98.1	16.42
% of the number of plots owned by individual farmers	87.88	87.58	78.68	99.52	7.7
Average plot area [group 7]	0.38	0.39	0.03	0.7	38.53
Number of registration units 7.1	283.53	291	114	593	45.43
% of registration units 7.1	79.19	81.22	58.14	93.66	12.12

Selected features	Mean	Median	Min.	Max.	V
LTB characteristics					
Number of plots per registration unit 7.1	1369.88	1114	487	4171	64.57
Area of plots per registration unit 7.1	516.67	457.58	120.97	1245.9	55.56
% of the number of plots in subgroup 7.1 in relation to group 7	90.73	92.81	77.79	98.38	6.43
% of the area of plots in subgroup 7.1 in relation to group 7	93.43	94.29	84.21	98.82	4.06
Average number of plots per registration unit	3.77	3.49	2	6.17	30.57
Average area of a registration unit	1.45	1.57	0.47	2.43	32.25
Productivity ratio of cropland	36.96	36.64	19.98	56.24	23.29
Productivity ratio of grassland	35.6	34.41	21.16	45.54	18.62
% number of plots without access to roads	14.87	13.88	6.58	34.15	48.02
% area of plots without access to roads	12.71	12.19	6.73	21.25	31.93
STB characteristics					
Fragmentation ratio	3.61	3.66	2.56	4.32	11.46
% of orchards	1.34	1.14	0	3.38	73.43
% of forests	25.8	23.15	0.69	68.84	94.04
Average elongation ratio	1.07	1	0.43	2.14	44.27
Synthetic ratio of plot elongation for the precinct	2.34	2.29	1.14	3.28	27.27

The rankings of urgency of land consolidation and exchange works for respective villages were developed using the zero unitarization method and Hellwig's method. These rankings were created by means of synthetic measures of the urgency of consolidation. The measures can be used to classify objects according to the size of multi-theme and multi-feature phenomenon, that is, the analyzed spatial structure of land in the presented gmina [5]. A detailed calculation algorithm for the zero unitarization method is presented in the publication [10], and Hellwig's method – in the paper [8]. Both, for Hellwig's calculations and the zero unitarization method the values of synthetic measures fall within the range [0;1].

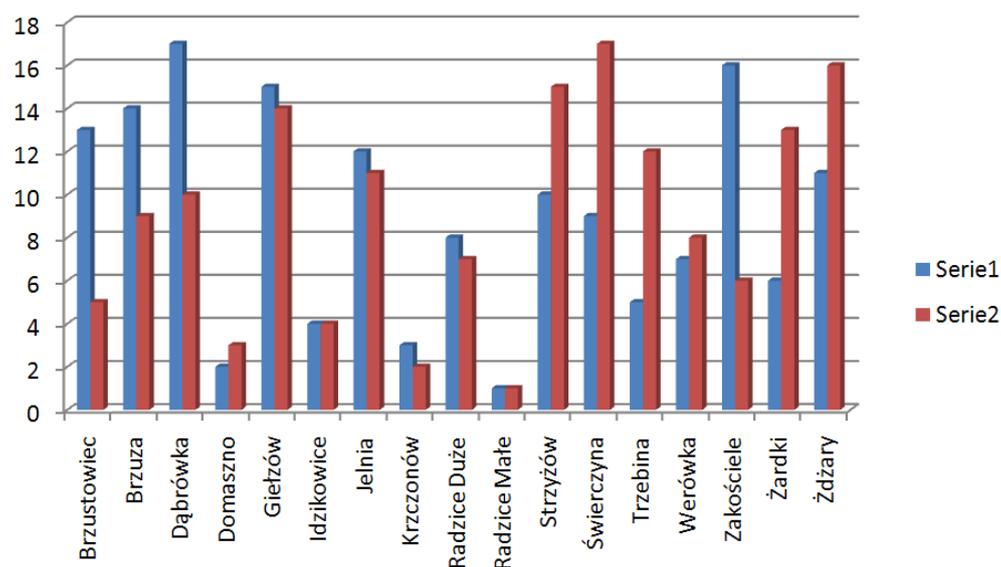
### 3. Results and discussions

Based on the calculation methods used and the resulting values, urgency rankings were created in relation to land consolidation and exchange works in the analyzed villages. The resulting measures indicate the order in which consolidation works should be carried out. The higher the value of the

measure, the higher the urgency of such works is. Table 3 and Figure 1 below present respective indicators of the urgency of consolidation works according to methods.

**Table 3.** Ranking of villages based on synthetic measure calculated using the adopted methods

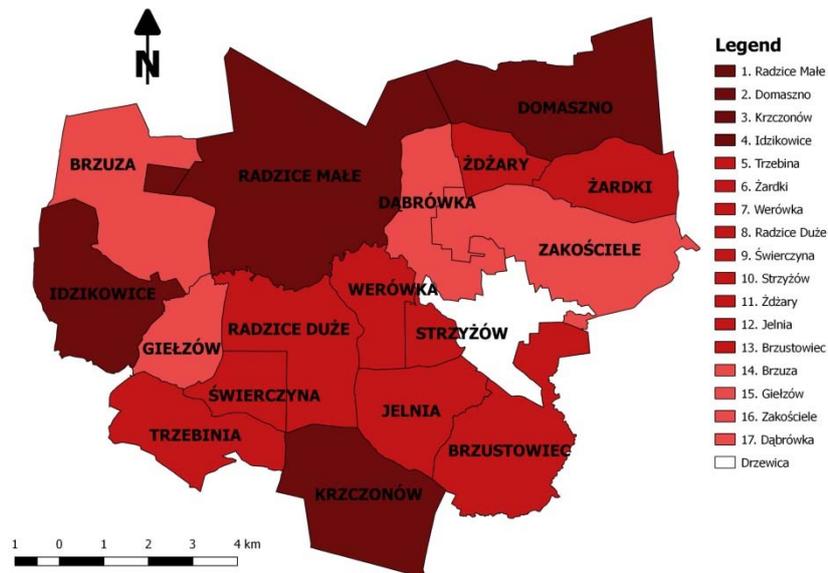
No.	Village	Zero unitarization method	No.	Village	Hellwig's method
1	Radzice Małe	0.67	1	Radzice Małe	0.92
2	Domaszno	0.61	2	Krzczonów	0.51
3	Krzczonów	0.54	3	Domaszno	0.50
4	Idzikowice	0.54	4	Idzikowice	0.49
5	Trzebina	0.49	5	Brzustowiec	0.46
6	Żardki	0.47	6	Zakościele	0.45
7	Werówka	0.47	7	Radzice Duże	0.37
8	Radzice Duże	0.46	8	Werówka	0.32
9	Świerczyna	0.46	9	Brzuza	0.31
10	Strzyżów	0.43	10	Dąbrówka	0.28
11	Żdźary	0.42	11	Jelnia	0.28
12	Jelnia	0.42	12	Trzebina	0.27
13	Brzustowiec	0.40	13	Żardki	0.25
14	Brzuza	0.39	14	Giełzów	0.23
15	Giełzów	0.39	15	Strzyżów	0.20
16	Zakościele	0.39	16	Żdźary	0.16
17	Dąbrówka	0.38	17	Świerczyna	0.15



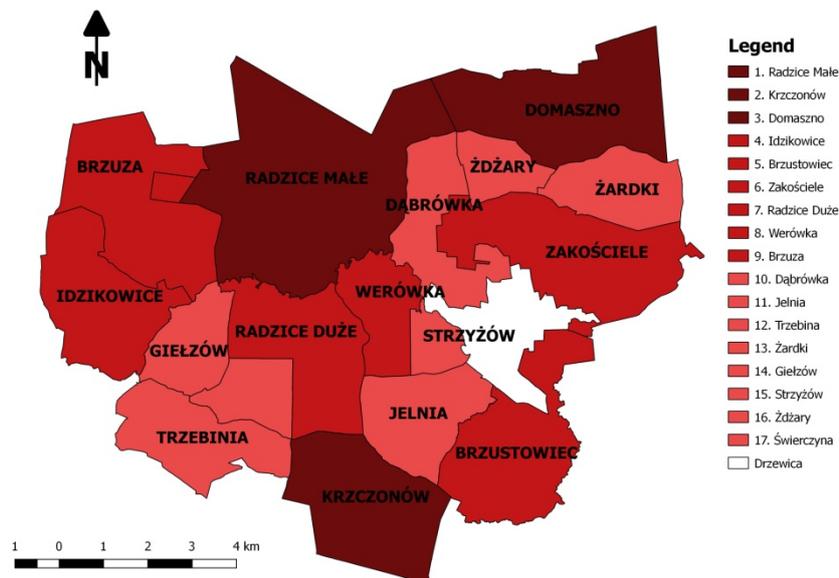
**Figure 1.** Positions of respective villages in rankings

According to surveys (Table 3), the most urgent need for land consolidation works occurs in the village of Radzice Małe, because in both rankings the village occupies the first position. In addition, the need for consolidation and exchange of land can also be noticed in Domaszno and Krzczonów

which were ranking leaders despite the fact that their position between the rankings changed. While identifying villages for consolidation, Idzikowice should be taken into account in the first place. The village was first in both rankings. The spatial location of the analyzed village is illustrated in figures 2 and 3.



**Figure 2.** Map of location of areas in need of urgent land consolidation according to zero unitarization method



**Figure 3.** Map of location of areas in need of urgent land consolidation according to Hellwig's method

It should be also emphasized that in 2 villages (Radzice Małe, Idzikowice) the precincts occupied the same position, whereas in 6 villages of the analyzed gmina their ranking position differed by one only (Domaszno, Krzczoneń, Werówka, Radzice Duże, Jelnia, and Giełzów). It should be noted that

villages with coinciding ranking positions or positions differing by one were very highly ranked precincts in both rankings. It leads to the conclusion that the methods used correctly indicate objects for which consolidation works should be undertaken with the utmost urgency.

#### 4. Conclusions

Works related to comparison of spatial geometrical structures of the specific precincts must be subject to assessment. Next, the consolidation works urgency ranking can be developed. The assessment of multiple criteria requires that the adopted variables be made uniform. As a result of such works the variables are deprived of so-called labels, and the quantities by which they are described have a similar value. This process is referred to as the method of standardization. The values of diagnostic features are consecutively aggregated, which leads to the development of synthetic features. These features describe respective precincts with respect to the purpose of study in which they were used. The final effect is rankings aiming at a hierarchical classification of the analyzed precincts with regard to the urgency of consolidation works in respective precincts. Every village is assigned synthetic values from the worst to the best one. Thanks to the calculation algorithm, the ranking of villages in the gmina of Drzewica in which such works should be undertaken as a priority could be presented clearly. Thanks to this, funds allocated to that purpose can be spent rationally, which in the future will facilitate better management of land with correctly designed new structure, thanks to which owners will be able to improve the level and comfort of work in rural areas, which is one of the priorities of the European Union.

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