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DETERMINATION OF DEMAND FOR LAND CONSOLIDATION WORKS IN VILLAGES WITH A RIBBON LAND LAYOUT

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Summary

In the European Union, the restructuring of rural areas based on the consolidation process is a common activity, and therefore Poland's membership in the EU has enabled the development of these zones through financial support for the analysed activities. The development of agriculture in Poland, as well as its production capabilities, are spatially very diverse. One of the reasons for this is the process of long-term transformations of the agricultural economy in areas with a different socio-economic situation, lasting for many years. Land consolidation works are aimed at creating more favourable farming conditions in agriculture and forestry by improving the area structure of farms, forests and forest lands, rational land layout, adapting property borders to the land drainage system, roads and land relief. The research was carried out in the rural commune of Żarnów, located in the Opoczno poviat, in the Łódź voivodship, which included 41 registration precincts with a total area of 14,106.0 hectares. In order to create a ranking of urgency of performed land consolidation and exchange works in the Żarnów commune, 32 most important factors characterizing individual villages were used previously. A ranking was made using the zero unitarisation and Hellwig's methods. The article is a continuation of research, where the authors identified spatial and technical parameters of agricultural land in the villages of Central Poland on the example of the examined commune.

Keywords

land consolidation • ranking methods • arable land • rural areas

1. Introduction

The reconstruction of the spatial structure of rural areas is necessary for sustainable development of these areas [Sobolewska-Mikulska and Stańczuk-Gałwiaczek 2018]. Land consolidation, which is a tool organizing the space, leads to the desired structural changes, but must be systematically implemented and become a permanent element of the long-term policy of voivodship self-governments in the field of arranging rural areas. Consolidating and exchange works should be carried out comprehensively, in

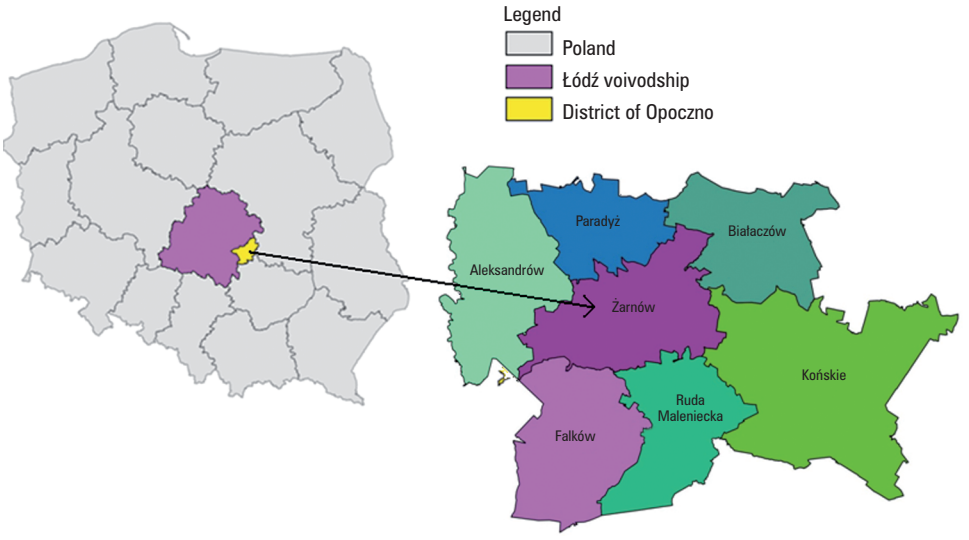
conjunction with post-consolidation development. Only then can they serve the multifunctional development of rural areas. These works are effective tools for improving the identified defects, and also provide opportunities for alternative development of adverse, useless agricultural areas, the so-called problem areas of agriculture [Wójcik-Leń and Sobolewska-Mikulska 2017a, 2017b, Wójcik-Leń and Stręk 2017].

The problem of the unfavourable structure of arable land concerns many countries in Europe and the world. It results from historical, social or economic transformations that have often lasted for decades [Gonzalez et al. 2004, Cay et al. 2010, Pašakarnis and Maliene 2010, Hudecová 2016, Leń 2017, Stręk 2017, Kurowska and Kryszk 2017]. Land consolidation and exchange works are a tool enabling improvement of the spatial structure. Considering the fact that funds for the abovementioned activities are limited, it becomes necessary to select objects where these works should be carried out first. The current spatial structure of land in Poland is caused by such factors as: demographic relations, socio-economic and legal relations, marriage matching, and divisions of great landed properties before and after World War II, agriculture, regulation of farm ownership.

The purpose of this article is to determine the demand for land consolidation works in the municipality of Żarnów. The most important stage of the work was the creation of an urgency ranking for undertaking the consolidation and exchange works of lands in 41 villages of the examined commune, using methods of multivariate statistics. Studies have shown that the spatial structure in the Żarnów commune requires an improvement of a defective spatial structure. The conducted analyses showed that the methods of multivariate statistics used for research constitute a very good basis for establishing the urgency ranking of undertaking the consolidation and exchange works of land in the Żarnów commune.

2. Location of the study area

The commune of Żarnów is located in the Opoczno poviat, which is located in the south-eastern part of the Łódź voivodship. The commune's area is 14,106 ha, which is 13.56% of the total area of the Opoczno poviat and 0.77% of the area of the Łódź voivodship. As shown in the Figure 1 below, the Żarnów commune is adjacent to the Paradyż commune from the north, and to the commune of Białaczów from the north-east. From the east it borders with the Końskie commune. The southwestern part of Żarnów borders with the Falków commune, while the southern border belongs to the Ruda Maleniecka commune. From the west, Żarnów is adjacent to the Aleksandrów commune. The Żarnów commune is divided into 30 village administrative units: Adamów (together with Malenie and Siedlów), Afryka, Antoniów, Bronów, Budków, Chełsty, Dąbie (including Ławki and Młynek), Dłużniewice, Grębenice, Jasion, Klew, Klew-Kolonia, Malków, Marcinków (with Kamieniec), Miedzna Murowana, Myślibórz (with Widuch), Nadole, Niemojowice, Paszkowice, Pilichowice, Ruszenice (with Ruszenice-Kolonia), Sielec (with Nowa Góra), Skórkowice (including Chorzew, Poręba and Skumros), Soczówki, Staszowa Wola, Topolice, Trojanowice, Wierzchowisko, Zdyszewice and Żarnów [Nawrocki 2000].



Source: Authors' own study

Fig. 1. Spatial distribution of the Żarnów commune on the map of Poland, the Łódź voivodship and the Opoczno poviat

3. Methodology for developing the hierarchy of land consolidation works

32 calculated factors characterizing the examined objects were used to rank the hierarchy of land consolidation works. The first group includes factors describing general information about the studied precincts in the commune, such as: x_1 – total area, x_2 – total number of plots, x_3 – number of inhabitants, x_4 – number of inhabitants per km^2, x_5 – % of the area of individual farms, x_6 – % of the number of plots of individual farm lands, x_7 – average plot area (group 7). The second group consists of factors concerning individual farm lands such as: x_8 – number of registration units 7.1, x_9 – % of registration units 7.1, x_{10} – number of plots of a registration unit 7.1, x_{11} – area of plots of a registration unit 7.1, x_{12} – % of the number of plots 7.1 in relation to group 7, x_{13} – % of the plot area in relation to group 7, x_{14} – average number of plots in a registration unit, x_{15} – average area of a registration unit, x_{16} – fragmentation index. The next group concerns the productivity index, which consists of the following factors: x_{17} – of arable lands, x_{18} – of grasslands. The fourth group belongs to factors concerning the ownership structure, in which we distinguish: x_{19} – % of land owned by the Agricultural Property Agency of State Treasury, group 1.1, x_{20} – land owned by the communes. In the fifth group, regarding plots without road access, the following factors are included: x_{21} – % of the number of plots without road access, x_{22} – % of the plot area without road access. Group 6 consists of factors concerning the structure of land use, which includes the following factors: x_{23} – % of the share of orchards, x_{24} – % of the share of forests. The last group of factors is: x_{25}– % of the number of plots below the elongation index

Table 1. Features adopted for research as stimulants and destimulants

	Selected features	Average	Min.	Max.	Median	Variance	Standard deviation	Coefficient of variation
Stimulants	x_1 – total area [ha]	344.07	27.89	962.33	279.27	49990.59	223.59	64.98
	x_2 – total number of plots	681.17	62.00	2275.00	534.00	289530.20	538.08	78.99
	x_3 – number of inhabitants	157.15	7.00	1149.00	105.00	39045.98	197.60	125.74
	x_4 – number of inhabitants per 1 km^2	41.31	2.92	144.34	36.88	1001.13	31.64	76.59
	x_5 – % of individual farm lands	78.93	25.58	98.39	86.06	380.30	19.50	24.71
	x_6 – % of the number of plots of individual farm lands	81.79	35.19	96.53	86.35	194.33	13.94	17.04
	x_7 – Average plot area (group 7)	0.63	0.19	2.77	0.51	0.19	0.43	68.65
	x_8 – number of registration units of group 7.1	127.49	21.00	542.00	111.00	9991.16	99.96	78.40
	x_9 – % of registration units of group 7.1	74.34	53.49	88.52	76.32	90.97	9.54	12.83
	x_{10} – number of plots of a registration unit of group 7.1	519.39	46.00	1480.00	384.00	152447.54	390.45	75.17
	x_{11} – area of plots of a registration unit of group 7.1	253.87	27.89	727.91	217.71	30500.18	174.64	68.79
	x_{12} – % of the number of plots of group 7.1 in relation to group 7	94.80	72.31	133.14	94.23	185.07	13.60	14.35
	x_{13} – % of area of plots in relation to group 7	96.43	83.46	117.04	96.50	43.95	6.63	6.87
	x_{14} – average number of plots in a registration unit	4.27	1.57	9.91	3.89	3.83	1.96	45.83
	x_{15} – average area of a registered unit	2.13	0.77	4.22	2.07	0.43	0.66	30.88
	x_{16} – arable lands	32.92	20.03	48.60	32.67	50.16	7.08	21.51
	x_{17} – grasslands	35.77	15.00	45.34	38.04	52.19	7.22	20.20

Stimulants	x_{18} – % of the lands owned by the Agricultural Property Agency of State Treasury, group 1.1	0.75	0.00	2.37	0.57	0.48	0.69	91.71
	x_{19} – % of the lands owned by communes	2.41	0.00	10.03	1.94	4.23	2.06	85.41
	x_{20} – % of the number of plots without road access	16.78	1.39	58.99	13.08	199.53	14.13	84.19
	x_{21} – % of the area of plots without road access	11.57	0.35	62.44	10.39	138.37	11.76	101.64
	x_{25} – % of the number of plots with the value of the elongation index below 1.00	20.49	0.00	55.88	17.50	199.67	14.13	68.95
	x_{26} – % of the area of plots with the value of the elongation index below 1.00	16.25	0.00	52.09	12.21	200.07	14.14	87.07
	x_{27} – % of the number of plots with the value of the elongation index of 1.01–2.00	22.29	3.08	49.12	23.53	82.38	9.08	40.72
	x_{28} – % of the area of plots with the value of the elongation index below 1.01–2.00	23.81	2.78	61.99	24.90	173.90	13.19	55.38
	x_{29} – % of the number of plots with the value of the elongation index of 2.01–3.00	16.45	9.52	24.84	16.26	19.11	4.37	26.57
	x_{30} – % of the area of plots with the value of the elongation index below 2.01–3.00	17.33	8.28	26.47	16.70	21.44	4.63	26.72
Destimulants	x_{31} – synthetic plot elongation index for precinct	3.34	1.82	4.95	3.48	0.72	0.85	25.34
	x_{32} – average value of the elongation index	2.93	1.53	5.04	2.86	0.58	0.76	25.87
	x_{22} – fragmentation index	3.88	2.63	4.74	3.90	0.20	0.45	11.56
	x_{23} – % of the share of orchards	0.84	0.00	3.56	0.71	0.65	0.81	96.11
	x_{24} – % of the share of forests	24.43	0.20	85.08	17.51	376.86	19.41	79.45

Source: Authors' own study

of 1.00, x_{26} – % of the area of plots below the elongation index of 1.00, x_{27} – % of the number of plots with the elongation index value of 1.01–2.00, x_{28} – % of the area of plots with the elongation index of 1.01–2.00, x_{29} – % of the number of plots with the elongation index value of 2.01–3.00, x_{30} – % of the area of plots with the elongation index value of 2.01–3.00, x_{31} – synthetic plot elongation index for the precinct, x_{32} – average value of the elongation index.

The initial analysis concerned the characteristics of the distribution values of individual variables presented in the form of descriptive statistics (Table 1). 27 factors were used as stimulants, while 5 factors were used as destimulants.

Before the synthetic ranking is prepared, a general selection is usually performed based on the diagnostic output values. A frequently used criterion excludes variables taken into account in the analysis whose coefficient of variation V is less than 20%. Based on the factors examined, in terms of the coefficient of variation, the adopted criterion is not met by: % of the number of plots of individual farm lands (V = 17.04), % of registration units of group 7.1 (V = 12.83), % of the number of plots of group 7.1 in relation to group 7 (V = 14.35), % of the plot area in relation to group 7 (V = 6.87), and the fragmentation index of the plots (V = 11.56). Despite this fact, it was decided to accept all variables regardless of their correlation level, due to the extreme importance of the analysed variables.

4. Development of the demand ranking for land consolidation works

The zero unitarisation method and the Hellwig's method were used to compile the urgency ranking of consolidation works and land exchange in the villages of the commune of Żarnów. These methods have measures that allow classification of objects by characteristics and subject matter of the examined object in terms of the analysis of spatial structure of lands carried out in the work [Jędrzejczyk et al. 2002].

The zero unitarisation method allows to order diagnostic variables characterizing the studied area. Diagnostic variables describing the examined object are divided into three groups [Leń and Mika 2016, Leń et al. 2016, Leń et al. 2017]:

1. Stimulants – variables whose increase in value causes an increase in assessment of characteristics of the examined object, then normalized variables are calculated according to the formula:

$$Z = \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

2. Destimulants – variables whose increase in value causes a decrease in assessment of characteristics of the examined object, then normalized variables are calculated according to the formula:

$$Z = \frac{x_{\max} - x}{x_{\max} - x_{\min}}$$

3. Nominates – variables that have the highest assessment (optimum) only for a certain value or range of values; as you move away from the optimum, the assessment of the phenomenon decreases, then normalized variables are calculated according to:

$$Z = \frac{x - x_{\min}}{x_{\text{opt}} - x_{\min}}, \text{ for } x < x_{\text{opt}}$$

$$Z = \frac{x - x_{\max}}{x_{\text{opt}} - x_{\max}}, \text{ for } x > x_{\text{opt}}$$

where:

Z – normalised variable,
x – variable before normalization,
$x_{\max}$ – maximum value of the variable in a given set,
$x_{\min}$ – minimum value of the variable in a given set,
x_{opt} – optimal value of the variable in a given set.

The ordering of diagnostic features is the first step in order to obtain a multi-criteria assessment of each examined object. Thus, their total assessment is obtained by means of aggregation. The synthetic measure is obtained on the basis of the following formula [Pluta 1986], which is used to calculate average values of sets presenting individual features [Leń and Mika 2016, Leń et al. 2016, Leń et al. 2017].

$$Z_i = \frac{1}{p}\sum_{j=1}^{P} X_{ij} (i = 1, \ldots, m)$$

Normalized measures are in the range <0; 1>. The results obtained can be interpreted as the average values of the optimal features of each object. It follows that the object's position in the ranking depends on the synthetic measure, which is higher the higher the position in the ranking.

The Hellwig's method sums up information from a number of diagnostic variables and assigns one measure to the analysed phenomenon. Identical groups of indicators were used to determine synthetic measures of the urgency of consolidation works in the study area. The following formula was used to calculate the examined indicator:

$$W_k = \sum_{k=1}^{5} (Czn_k w_k)$$

where:

Czn_k is the normalization of features to simplify the comparison of values between departments, calculated from the formula:

$$Czn_k \left(\frac{s_j}{s_{\max}} \right) k$$

where:

k is the next factor characterizing the analysed phenomenon (k = 1, 2, 3, 4, 5).

The value of weighted average features (s_j) in span ranges is calculated according to the formula:

$$s_j = \frac{1}{\sum w_i} \sum c_i w_i,\ j = (1, 2, 3, 4)$$

where:

c_i – the value of a particular feature in the j-th span range,
w_i – the weight assigned to it.

As a result of calculations with the method of zero unitarisation and the Hellwig's method, for which the values of synthetic measures in the range <0; 1> were obtained, the degree of the synthetic measure allowed to determine which precincts require the most urgent consolidation works. The consolidation works should be carried out first in the precincts shown in Table 2.

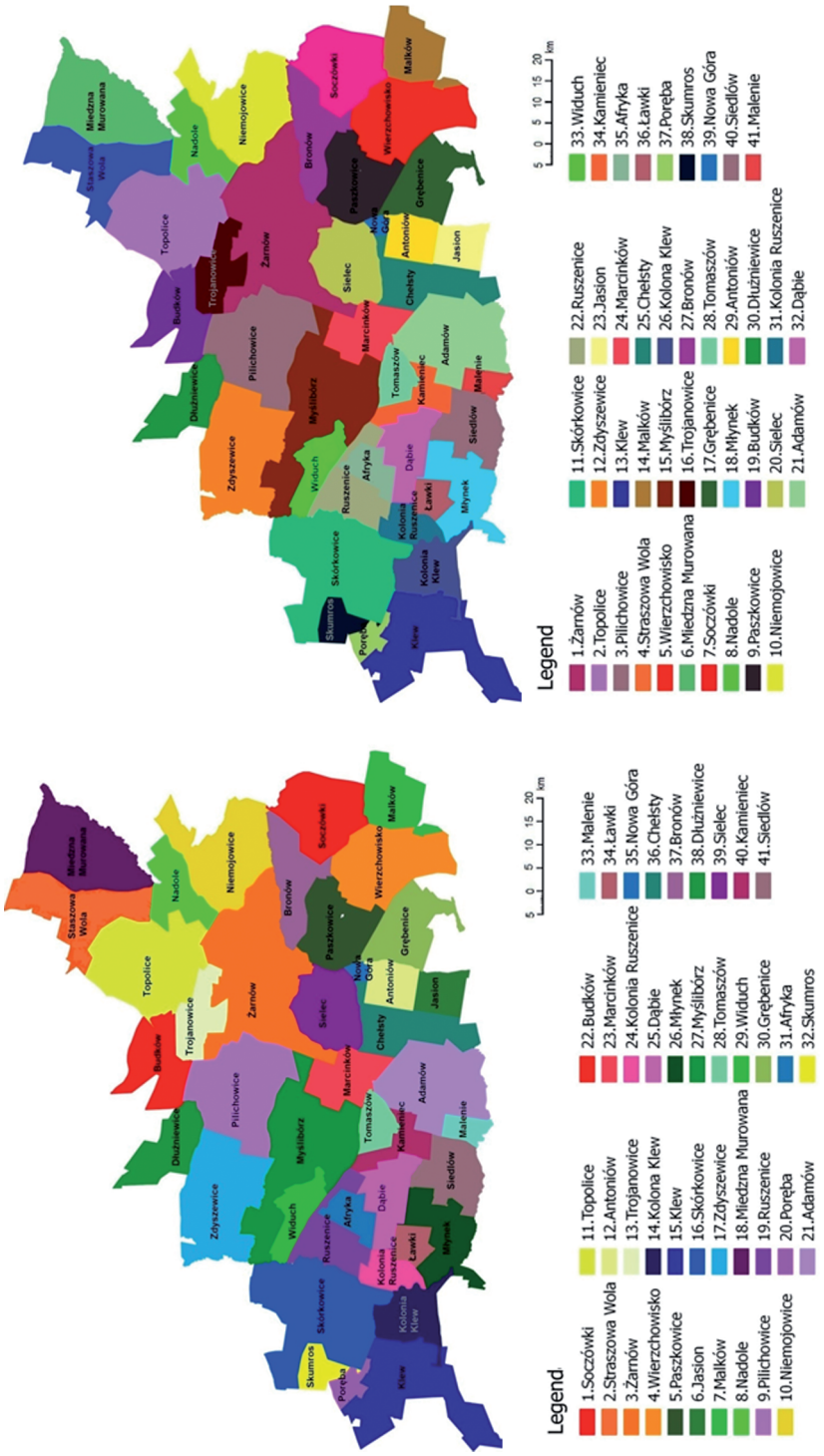
Table 2. Ranking of villages based on the calculated synthetic measure using the zero unitarisation and the Hellwig's methods

Rank	Zero unitarisation method		Hellwig's method	
	Synthetic meter	Precinct name	Synthetic meter	Precinct name
1	0.542	Soczówki	0.960	Żarnów
2	0.536	Straszowa Wola	0.652	Topolice
3	0.528	Żarnów	0.647	Pilichowice
4	0.519	Wierzchowisko	0.645	Straszowa Wola
5	0.500	Paszkowice	0.636	Wierzchowisko
6	0.498	Jasion	0.559	Miedzna Murowana
7	0.490	Malków	0.517	Soczówki
8	0.487	Nadole	0.507	Nadole
9	0.486	Pilichowice	0.506	Paszkowice
10	0.484	Niemojowice	0.498	Niemojowice
11	0.484	Topolice	0.479	Skórkowice
12	0.477	Antoniów	0.471	Zdyszewice
13	0.444	Trojanowice	0.394	Klew
14	0.444	Kolonia Klew	0.373	Malków
15	0.436	Klew	0.362	Myślibórz
16	0.433	Skórkowice	0.356	Trojanowice

17	0.431	Zdyszewice	0.349	Grębenice
18	0.423	Miedzna Murowana	0.346	Młynek
19	0.420	Ruszenice	0.343	Budków
20	0.418	Poręba	0.317	Sielec
21	0.409	Adamów	0.307	Adamów
22	0.404	Budków	0.286	Ruszenice
23	0.401	Marcinków	0.286	Jasion
24	0.400	Kolonia Ruszenice	0.282	Marcinków
25	0.395	Dąbie	0.264	Chełsty
26	0.384	Młynek	0.262	Kolonia Klew
27	0.379	Myślibórz	0.249	Bronów
28	0.369	Tomaszów	0.247	Tomaszów
29	0.367	Widuch	0.243	Antoniów
30	0.366	Grębenice	0.234	Dłużniewice
31	0.362	Afryka	0.227	Kolonia Ruszenice
32	0.356	Skumros	0.211	Dąbie
33	0.356	Maleni	0.210	Widuch
34	0.354	Ławki	0.186	Kamieniec
35	0.343	Nowa Góra	0.185	Afryka
36	0.333	Chełsty	0.182	Ławki
37	0.329	Bronów	0.173	Poręba
38	0.327	Dłużniewice	0.168	Skumros
39	0.322	Sielec	0.156	Nowa Góra
40	0.250	Kamieniec	0.156	Siedlów
41	0.171	Siedlów	0.135	Malenie

Source: own study based on the data form the Land and Property Register

According to the conducted research, the use of two separate methods allowed the separation of two different rankings of the urgency for consolidation works and exchange of lands. Four out of forty-one villages studied were in the same position in the ranking, constituting 10% of all villages. The difference of one place in the examined rankings by two methods covers 3 precincts, which constitute 7% of the entire analysed commune. Four villages differ by 2 places in the ranking. The next 3 villages



Source: Authors' own study

Fig. 2. Ranking of villages made with the zero unitarisation method and the Hellwig's method

converge in the rankings by 3 places. In terms of difference of 4 places, there are 4 villages, which is 10% of the whole commune. The next two villages differ by 5 places in the analysed rankings. Four villages shifted 6 places in the ranking. The remaining 17 villages are distinguished by 7, 8, 9, 10, 11, 12, 13, 17 and 19 places in the ranking. The biggest difference in the synthetic measure is for Sielec, which moved 19 places in the compared rankings for both methods.

As a result of the ranking analysis (Table 2, Fig. 2), it should be stated that the consolidation works should be carried out first in the villages of Adamów, Nadole, Niemojowice and Tomaszów. The surveyed precincts are characterized by a relatively large percentage of plots in the individual sector in relation to the total number of plots, namely: Adamów (87%), Nadole (81%), Niemojowice (85%), and a much smaller one for the village of Tomaszów (39%). In Adamów, Nadole and Tomaszów, over 34% of the plots have no road access.

In terms of the largest average plot area in the individual sector, Adamów stands out, with an average area of 1.0507 ha for 442 plots. Whereas the smallest average plot area in the individual sector falls to the village of Nadole – 0.1878 ha, where there are 1013 plots.

The analysis showed that the results obtained are the basis for determining the order of consolidation works and land exchange in the examined commune.

5. Summary

The Łódź voivodship is characterized by worse than average conditions for the development of agriculture in the country, but at the same time this form of activity is, next to industry, the main economic specialization of the region. Small and very small farms with low productivity dominate in the discussed voivodship. Rural areas are characterized by insufficient economic activity and poor social activation, an unfavourable situation in terms of equipping with network devices or difficult access to social services. That is why the restructuring of agricultural production and raising its qualitative values aiming at increasing economic efficiency as well as improving the living conditions of the inhabitants is so important for rural areas. The specificity of agricultural farms in the Łódź voivodship and environmental conditions point to the possibility of building a strong agricultural sector oriented towards eco-farming, which will improve the ecological situation of the voivodship.

The reconstruction of the agrarian structure of rural areas is necessary for the sustainable and balanced development of these areas. Land consolidation, which is a tool organizing the space, leads to the desired structural changes, but must be systematically implemented and become a permanent element of the long-term policy of voivodship self-governments in the field of arranging rural areas.

Studies have shown that the spatial structure in the Żarnów commune requires an improvement of a defective spatial structure. This applies to both the removal of small and narrow plots and the improvement of road network infrastructure. Therefore, it is necessary to carry out the process of land consolidation and exchange in this area. The

conducted analyses showed that the methods of multivariate statistics used for research constitute a very good basis for establishing the urgency ranking of undertaking the consolidation and exchange works of land in the Żarnów commune. The consolidation and exchange of lands throughout the entire area under study in the same time is impossible, which is why the work order specified in the paper is a very important determinant for creating a new spatial order and improving agriculture in the Żarnów commune.

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