DIFFERENCES IN SPATIAL STRUCTURE OF VILLAGES OF COMMUNE KSIEZPOL WITH REGARD TO PARCEL SHAPE INDEX

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Abstract. The spatial structure of rural areas in eastern Poland is characterized by large fragmentation of privately owned farmland, as well as the scattering of parcels across villages and beyond their boundaries. An important defect is also the unfavourable shape of land parcels, which hampers and sometimes even makes impossible rational management of land in a given area. Shape analysis has been the focus of numerous publications in fields such as geography and ecology, and, more recently, also geodesy. Previous studies show that both the shape and the size of parcels can be improved by consolidation of land. This process allows the creation of new plots with regular shapes, which translates into increased profits and improved living conditions of the farmers. From this angle, it seems necessary to conduct detailed studies of the unfavourable geometry of parcels, because the economic output of a farm is significantly influenced by the width, length, and elongation of the parcels, as well as their shape. These parameters affect both the efficiency of field work and the harvest. The research area encompassed 17 villages of the Księżpol commune, located in the Biłgoraj District in the Lubelskie Voivodship, occupying a total area of 1125.82 ha and divided into 17513 registered plots. The types of villages identified in the study differ in terms of their parcel geometry index, which may be used as one of the criteria for determining the order, in which villages should be subjected to land consolidation and exchange.

Keywords: shape index, land consolidation, GIS.

Introduction

Excessive fragmentation of plots owned by a farm is one of the major factors adversely affecting the profitability of agricultural production [1]. The spatial arrangement of land owned by individual farmers in the rural areas of southern and southeastern Poland, developed by historical processes, is characterized by farms covering a small area of land and made up of fragmented and dispersed plots. Fragmentation of plots is presented both in domestic literature [2-8] and international references [9-13]. In reference literature four types of land fragmentation are distinguished depending on the type of use, form of ownership and the geometric structure of plots (area, number of plots per farm, plot shape, plot elongation, lack of access to the plot and distance from the farmer's dwelling). All the above-mentioned defects have a very negative influence on agricultural production and income derived from such production. They also indirectly affect the establishment of a full-featured real property cadastre [14-19].

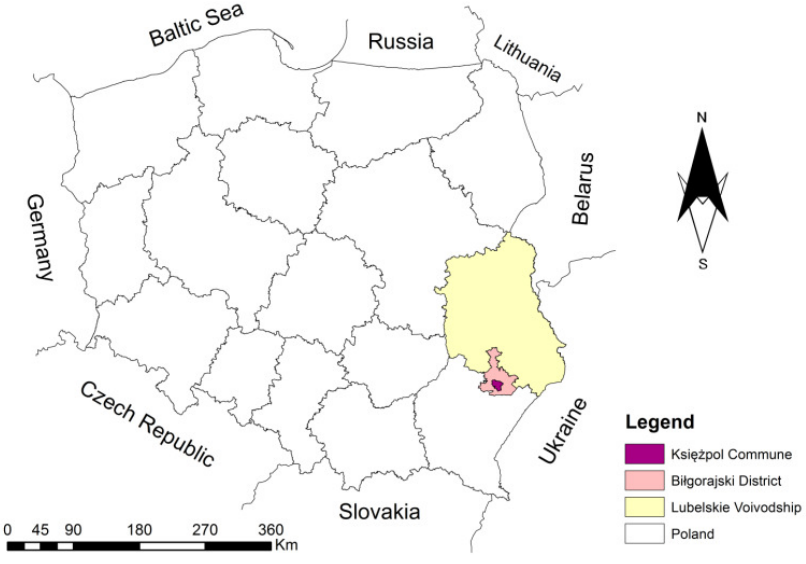

Fig. 1. **Map location of Księżpol commune**

The conditions for agriculture can be improved as a result of reconstructing the defective spatial structure through the consolidation and exchange of land, which is a recommended solution. This

process facilitates alternative development of disadvantaged areas of no use for agriculture, the so called agricultural problem areas [8; 20; 21].

This paper aims to calculate the value of the parcel shape index and verify the areas with the worst plot shapes in the villages of the Księżpol commune, Lubelskie Voivodship (Fig. 1).The study area comprises 17 villages of the Księżpol commune (Fig. 1), in the Biłgoraj District, Lubelskie Voivodship, covering an area of 1125.82 ha, split into 17513 plots. The identified types of villages differ in terms of the parcel shape index, which can be one of the criteria for determining the priority of villages in undertaking land consolidation and exchange works.

Materials and methods

A significant element of hierarchization of land consolidation works is calculation of the factor referring to the plot elongation ratio. The elongation ratio can be determined by dividing the length of the plot by its width. However, in real conditions plots are rarely well-formed rectangles. In comprehensive computer analyses of a large number of plots with irregular shapes, regular geometric forms must be used. These studies used a circle as a theoretical model for calculating plot elongation (Fig. 2). Based on the Area and Circumference, we can calculate the parcel shape index from the formula (1). A simplified formula for calculating the parcel shape index, as proposed by experts from realexperts.pl, was adopted for the purposes of this study

$$W_k = 40 \cdot \pi \cdot \frac{P}{O^2}, \tag{1}$$

where W_k – parcel shape index
P – area of the plot
O – perimeter of the plot

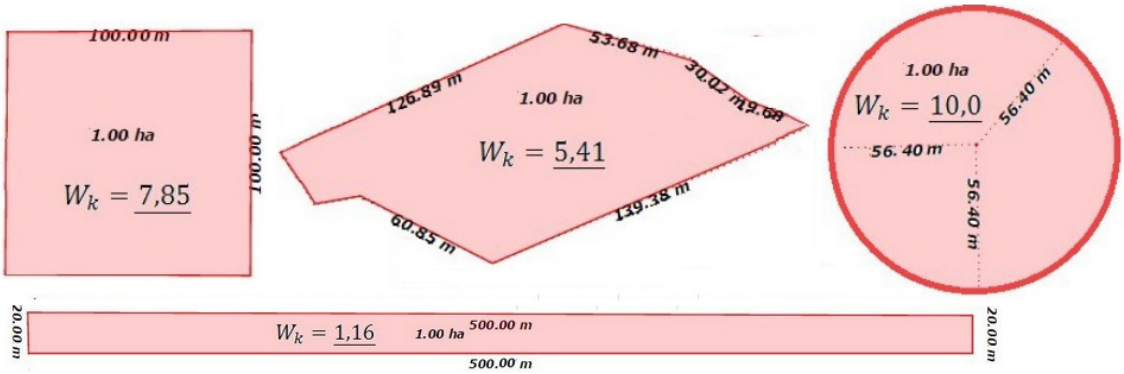

Fig. 2. **Example of index calculated for selected geometric figures [22]**

The spatial structure of the analyzed area was studied by means of the Geographic Information System (GIS) tools implemented in ArcGIS software. GIS tools were used to perform the calculations and analyses of the plot elongation ratio. ArcGIS makes use of spatial information and attributes data to generate relevant queries to database in order to select objects with specific characteristics or spatial relations.

The presented spatial arrangement of plots in the analyzed commune (Fig. 3) has numerous defects. The analyzed area is characterized by large fragmentation and negative elongation of plots that, in addition, are intersected by roads. The system of agricultural transport roads shown in Fig. 3 is incorrect. Not only does it split agricultural plots into smaller parcels, but it also does not provide access to all crop fields. The system of transport plays a very important role in agricultural production. Land consolidation and exchange works can improve the shape of the plot, but also the road network, so that each plot can be accessed from the farmer's dwelling.

The organization of the farm's space and its economic results are affected by the width, length and elongation of plots as well as their shape. The width of the plot has a significant influence on the farm's income. The elongation of plots affects the time of work on the plot (recurrence) and the amount of edge losses of crops at the plot boundary. The analysis of the existing results of studies

proves that plot elongation, for which the highest work savings are achieved, should not exceed 1:5 [23].

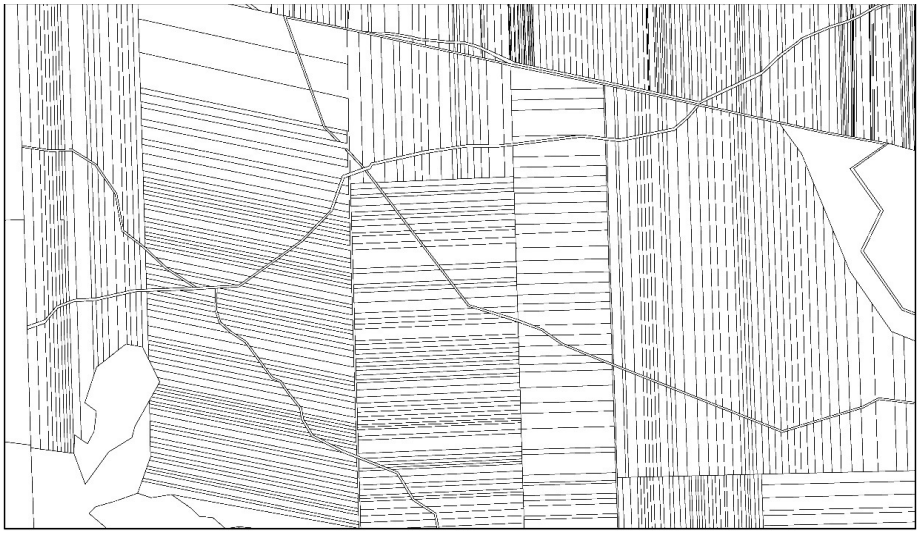

Fig. 3. **Ribbon-like pattern of plots in village of Lipowiec Duży**

Results and discussion

When the formula for the circle is used, the ratio equals 10. Specific data concerning the calculated index are illustrated in Table 1, while the graphic results of this analysis for the Księżpol commune are presented in Figure 4.

Studies have shown that the elongation ratio is considerably differentiated in respective villages. The plots, for which the ratio is below 1.00, 1.01-2.00 and 2.01-3.00, are plots characterized by the most disadvantageous elongation. The analysis reveals that plots with very defective structure cover an area of 8451.13 ha, which accounts for 60.2 % of the overall area of the analyzed commune. In administrative terms this area consists of 10234 plots, which accounts for 59.5 % of the total number of plots. Proof of very defective elongation of plots in the analyzed area is the mean value of the elongation ratio ranging from 1.77 in Borki to only 3.98 in Zanie, whereas the mean value of this ratio for the commune is 3.03. To sum up, the elongation ratio is unfavourable in the whole commune.

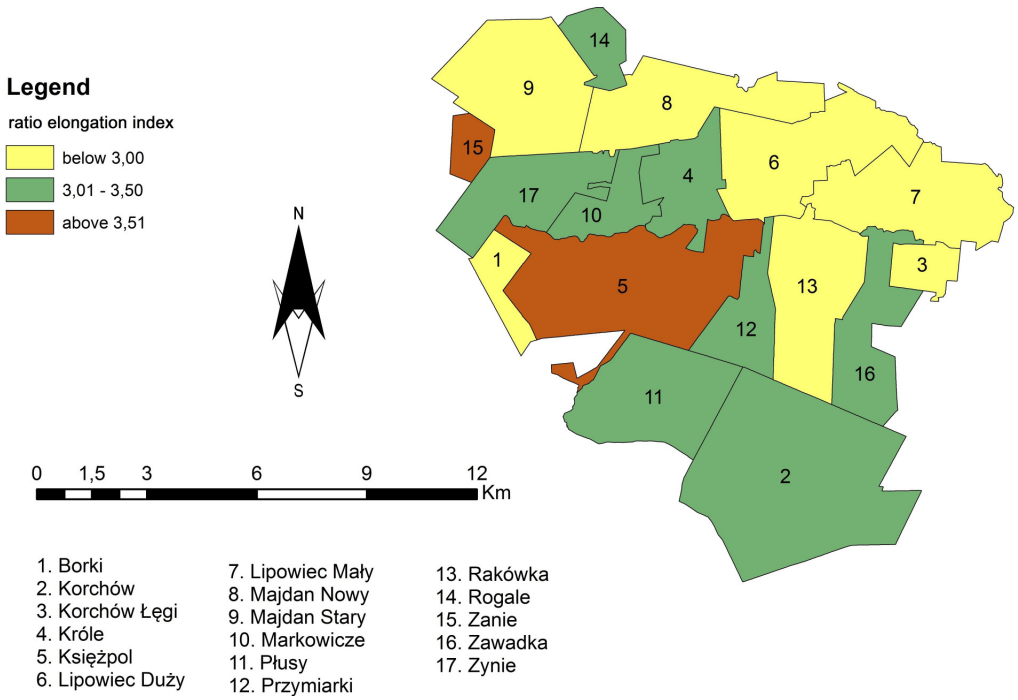

Fig. 4. **Graphical representation of plot elongation ratio in Księżpol commune**

Table 1

Elongation ratio calculations

Village	Elongation ratio values																Average elongation ratio
	below 1.00				1.01-2.00				2.01-3.00				above 3.00				
	Plots		Area		Plots		Area		Plots		Area		Plots		Area		
	Number	%	ha	%	Number	%	ha	%	Number	%	ha	%	Number	%	ha	%	
Borki	241	38.1	114	44.9	186	29.4	78.8	32.1	96	15.2	31.5	12.6	105	16.6	26.8	10.6	1.77
Korchów	153	8.6	94.3	4.1	453	25.3	586.3	25.6	352	19.7	481.3	21.1	813	45.5	1145	49.2	3.19
Korchów Łęgi	28	35	32.06	21.7	6	7.5	18.09	12.1	9	11.3	4.7	3.5	36	45	168.9	75.4	2.99
Księżpol	148	7.1	107.1	5.8	396	19.1	361.8	20.7	433	20.9	408.3	23.1	1088	52.5	920.6	51.1	3.6
Markowicze	131	23.6	89.27	25	85	15.3	85.47	23.4	55	9.9	43.76	14.7	282	50.9	151.3	39.9	3.3
Lipowiec Duży	383	22.1	207.2	18.3	459	26.5	247.8	22.1	303	17.5	144.8	13.5	580	33.4	519.7	46.1	2.64
Majdan Nowy	515	33.5	557	57.4	220	14.3	200.5	22.4	173	11.3	69.07	7.4	623	40.5	127.4	13.2	2.93
Płusy	98	9.9	55.78	5.6	241	24.5	263.7	26.3	193	19.6	266.3	27	451	45.8	411.2	41.1	3.23
Przymiarki	29	8.5	20.71	4.5	82	24.1	129.1	27.9	75	22.1	124.1	27	153	45	188.1	40.5	3.06
Rakówka	116	12.1	93.81	9.3	283	29.4	285.5	29.6	194	20.2	214.5	22.5	360	37.5	378.2	38.6	2.88
Rogale	65	12.9	37.8	13.7	120	23.9	98.9	37.8	91	18.1	63.9	24.1	222	44.2	66.8	24.8	3.25
Króle	161	23.6	86.63	16.6	145	21.3	83.02	15.4	97	14.2	91.83	17.6	276	40.5	271.3	49.9	3.02
Lipowiec Mały	141	14.9	109.7	10.7	216	22.9	205.9	20.2	186	19.7	145.4	14	392	41.5	578.2	55.3	2.93
Majdan Stary	838	31.9	498.8	43.5	715	27.3	360.5	32.1	367	14	139.9	12.2	685	26.1	141.7	12.3	2.27
Zanie	15	7.6	17.3	10.2	33	16.8	58.1	34.8	35	17.8	50.9	30.7	114	57.9	42.5	25.2	3.98
Zawadka	68	11.7	85.76	12.4	128	22	214.2	31.7	81	13.9	81.14	11.7	299	51.5	307	44.2	3.4
Zynie	227	20.8	266.7	35.7	234	21.4	255.5	35.1	135	12.4	82.46	11.5	490	44.9	134	18	3.15
Total	3357	19.5	2474.12	17.6	4002	23.3	3533.05	25.2	2875	16.7	2443.96	17.4	6969	40.5	5578.12	39.8	3.03

Table 1 was used to prepare Figure 4, which is a graphical representation of the elongation ratio of plots in the villages of the Księżpol commune. It can be noted that in the analyzed commune villages form clusters characterized by similar elongation ratio. Studies show that plots have the most

defective shape in the eastern and northern part of the commune, where the elongation ratio is below 3.0. The second village type is characterized by the ratio ranging from 3.01 to 3.50. Villages of this type are situated in the southern and western regions of the commune. One village (Rogale) is located in the north. Two villages had the best elongation ratio above 3.51. Those were Księżpol and Zanie situated in the western part of the commune.

Conclusions

1. Elongation, shape and area of the plot not only have influence on the effectiveness of field works, but they also affect the crop yield and thus income from agricultural production. The use of GIS tools for analysis of the spatial structure of agricultural land is an easy way of obtaining information such as: circumference, width, length, and area. Based on the above-mentioned information the value of the elongation ratio can be calculated, which makes it possible to obtain information about losses resulting from agricultural production in considerably elongated or irregularly shaped plots of land.
2. In detailed studies of the spatial structure of villages before land consolidation and exchange activities are undertaken, it is recommended to calculate the elongation ratio for respective villages because the average area of the plot is not always a reflection of its defects. Some plots may have a large area, but when the ratio is calculated, they may turn out to be excessively elongated.
3. For the purposes of identifying the need for consolidation works, it is important to know the plot elongation ratio for respective villages in the analyzed commune. A high ratio will clearly indicate areas, in which income from agricultural production is low. It also informs us that the geometry of plots is negative. The use of analytical tools of the Geographic Information Systems facilitates smooth calculation of the plot elongation ratio with no need for analyzing each of them in detail.

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