



ASSESSMENT OF THE SPATIAL STRUCTURE OF RURAL AREAS FOR HIERARCHISING VILLAGE CONSOLIDATION WORKS IN THE MUNICIPALITY OF TRAWNIKI

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Summary

Sustainable development of many rural areas in Poland requires actions in the field of comprehensive spatial planning, supported by agricultural management works, in particular by land consolidation and exchange. This process stimulates the development of functions performed by these areas, among others in the social, environmental or economic domains. Changes in the ownership and use structure make it possible to separate functional and spatial areas. Work on improving the agricultural production space cannot be undertaken in all villages at the same time due to, for example, economic, technical or social conditions. Therefore, work to change the flawed spatial structure of land should be carried out in the right order, starting in the villages where the need is greatest. The aim of this study is to assess the spatial structure in the villages of the municipality of Trawniki with regard to the necessity of taking measures to improve the rural spatial structure. The scope of this study covers the municipality of Trawniki, located in the Lubelskie voivodeship, Świdnik county. The municipality consists of 11 cadastral districts with a total area of 84.16 km², which accounts for 17.95% of the entire county's area. An analysis and assessment of the spatial structure of the land was carried out for all the precincts, which included: the structure of land ownership, land use and land fragmentation, accessibility of parcels to roads and an index defining the geometry of the registered parcels. In order to illustrate the problem of land fragmentation in detail, a land fragmentation index was calculated for each surveyed village. In addition, the productivity index for arable land and grassland was also determined. The analyses provided a basis for further research into determining the urgency of land consolidation and exchange work.

Keywords

land consolidation • rural areas • spatial structure

1. Introduction

The development of rural areas is strongly linked to broadly defined management and agricultural works both in Poland and in other countries. Multifunctional and sustainable rural development requires a comprehensive approach both spatially and socially [Knaap and Chakraborty 2007]. Land consolidation works play an important role in the organisation of rural spaces and in improving their functionality in the economic, social or environ-

mental domains, among others [Trystuła 2008]. Land exchange is very useful in restructuring farms, especially when there is a large number of owners involved [Corbelle-Rico et al. 2019]. Land consolidation is a process that was initiated in Poland many years ago. According to Rutkowski, this process originated already in the Middle Ages [Rutkowski 1947]. The works to improve the spatial order and functionality of villages began to develop dynamically mainly in the inter-war period and during the People's Republic of Poland. These works improved the spatial structure in the country by 1975, mainly by consolidating 1.5 million ha of land [Antoniak 1983]. In the following years, consolidation works were successively continued, but it was only after 2004 that these processes became more widespread. This was due to Poland's accession to the European Union and, consequently, to the acquisition of EU funds, which to a large extent financed land consolidation works. Land consolidation was included in the second group of measures for the sustainable development of rural areas [Przegon 2016]. Land consolidation and exchange were included in the Sectoral Programme 2004–2006 and the Rural Development Programme 2007–2013, 2014–2020 under the scope: *Improving the economic performance of all farms and facilitating the restructuring and modernisation of farms, particularly with a view to improving market participation and market orientation, and diversifying agricultural production*. The growing interest of farmers in the participation in consolidation processes of their land is the result of an increased awareness of the positive impact of such changes on the economic performance of farms [Rural Development Programme 2014]. Nowadays, the unfavourable spatial structure of farms has a negative impact on farmers' labour returns. According to Noga [Noga 2001], the spatial structure of farms is influenced by: the number of parcels in the farm, the acreage of the parcels, the shape of the parcels, the accessibility of the parcels to the road, the extension of the parcels and the distance of the parcels from the homestead. In Poland, there is a very high demand for consolidation work. This is largely due to the fact that consolidations are nowadays used not only to rationalise the land configuration and to improve the efficiency of agricultural production, but also to enable the implementation of a number of investment activities in the spatial structure of rural areas, such as small-scale retention, landscape design, nature conservation, or acquiring land for large linear infrastructure investments [Banach 2020].

Changes in the spatial structure of rural areas are necessary for the sustainable and balanced development of agricultural productive space. Land consolidation, as a tool for organising agricultural space, leads to desirable structural changes. In order for these works to bring the intended effects, they must be carried out systematically and become a permanent element of the long-term policy of voivodeship self-governments in the field of agricultural management works [Leń 2017].

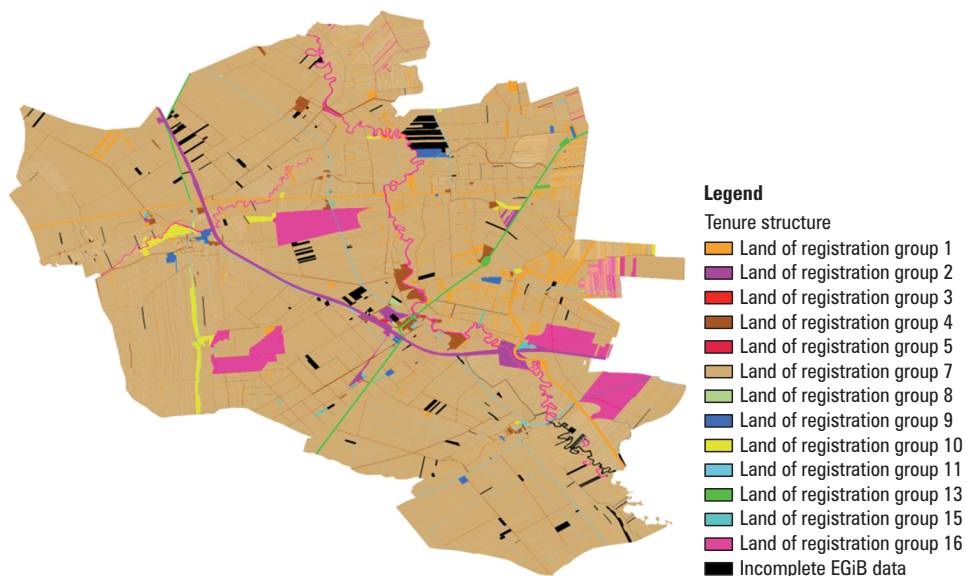
The aim of this study is to assess the spatial structure in the villages of the municipality of Trawniki with regard to the necessity of taking measures to improve the spatial structure of village. The scope of this study covers the municipality of Trawniki, located in the Lubelskie voivodeship, Świdnik county. The municipality consists of 11 cadastral districts with a total area of 84.16 km², which accounts for 17.95% of the entire county's area. An analysis and assessment of the spatial structure of the land was carried out for all the precincts, which included: the structure of land ownership, land use and land fragmenta-

tion, accessibility of parcels to roads and an index defining the geometry of the registered parcels. In order to illustrate the problem of land fragmentation in detail, a land fragmentation index was calculated for each surveyed village. In addition, the productivity index for arable land and grassland was also determined. The analyses provided a basis for further research into determining the urgency of land consolidation and exchange work.

2. Materials and methods

2.1. Land tenure structure

Ownership is both the fundamental and the broadest right in rem, which is protected by Article 12 of the Constitution of the Republic of Poland [1977]. According to the Civil Code [1964], this right allows the owner to freely use the property in accordance with its socio-economic purpose. The Trawniki municipality covers an area of 8415.17 ha. As the analysis shows, the largest part of the land (87.0%) belongs to group 7 – natural persons. They hold an area of 7,087.8737 ha. There are 6 villages in the municipality where the share of this type of land is more than 90.0% of that of the whole village. These are the villages of: Bonów Kolonia, Oleśniki, Pełczyn, Struża, Struża Kolonia, Siostrzytów. The smallest part consists of land belonging to group 5 – municipalities, inter-municipal or metropolitan associations if they coincide with perpetual usufructuaries (> 0.02%). There is no land in the municipality belonging to registration groups 6, 12 and 14. The groups following group 7 are respectively: 1, 16, 4 and 2. The remaining registration groups have a negligible (> 1%) share in the land tenure structure. The spatial picture of the land tenure structure of the studied municipality is illustrated in Figure 1.



Source: Authors' own study based on EGiB data

Fig. 1. Tenure structure in Trawniki municipality

2.2. Land use structure

The structure of land use depends on environmental conditions and the management pattern devised by man. Land use is understood as the exploitation of the land for its intended purpose. Land is defined here as a continuous portion of land used in a uniform manner. It is the smallest part of the country's land division created for the purpose of keeping land and building registers [Koniczna 2012]. There are 23 types of land use in the Trawniki municipality. According to the analysis, the largest part of the land use structure is occupied by arable land (> 58%). Their total area is 4940.61 ha. This type of land is found in every cadastral precinct of the study area. Another land use with more than 16% is permanent meadows with a total area of 1419.61 ha. The remaining types of land use occupy less than 10% of the land use structure. These are: forests (6.8%), roads (3.4%), built-up agricultural land (3.3%), permanent pasture (2.8%), wasteland (2.7%), and land under flowing surface water (1.3%). The unlisted types of land use cover less than 1% of the area of the precinct. The spatial picture of the land use structure is illustrated in Figure 2.

In order to parameterise the use structure, indicators were defined, such as the productivity index for arable land and for grassland. The adopted system of soil classification distinguishes 6 basic classes for arable land and grassland. The arable land classes III and IV are further divided into classes IIIa, IIIb, IVa and IVb, respectively [Leń 2010]. In order to calculate the index, the adopted point values for the individual land classes presented in Table 1 should be used.

Table 1. Point values of the quality classes of arable land and grassland

Land class	Arable land	Grassland
I	100	90
II	92	80
IIIa	83	65
IIIb	70	
IVa	57	45
IVb	40	
V	30	38
VI	18	15

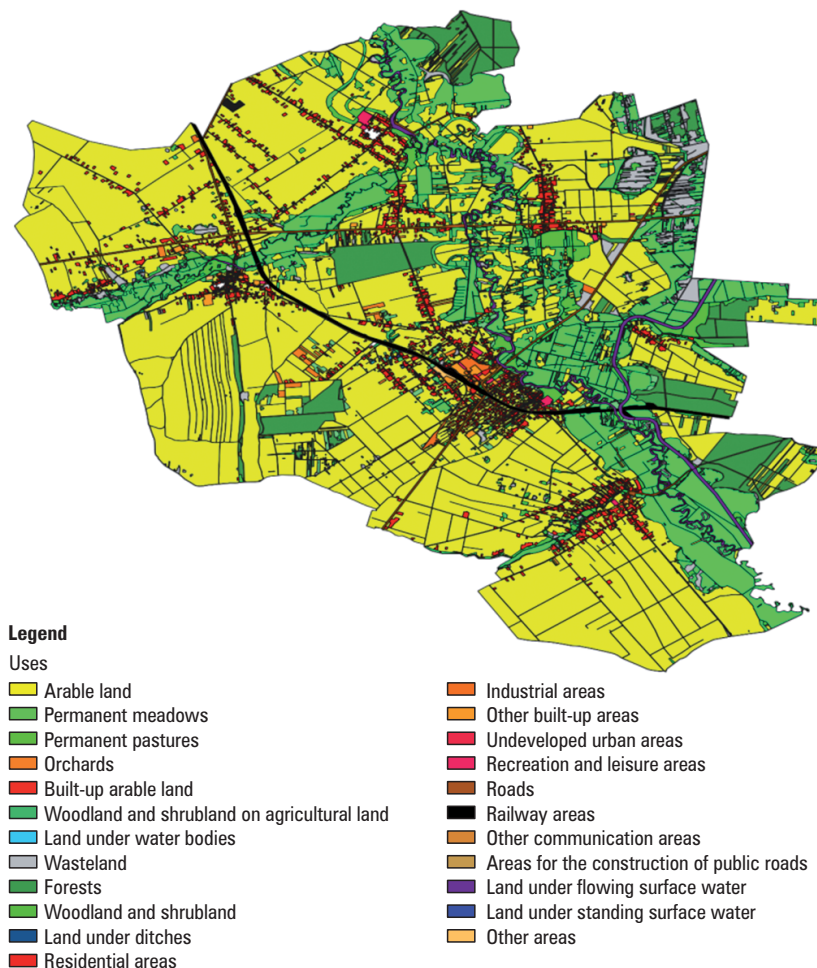
Source: Witek and Górski [1997]

The following equation was used to calculate the production value index (W_{wp}) for each precinct:

$$W_{wp} = \frac{\sum_i^n (X_n \cdot W_p)}{P}$$

where:

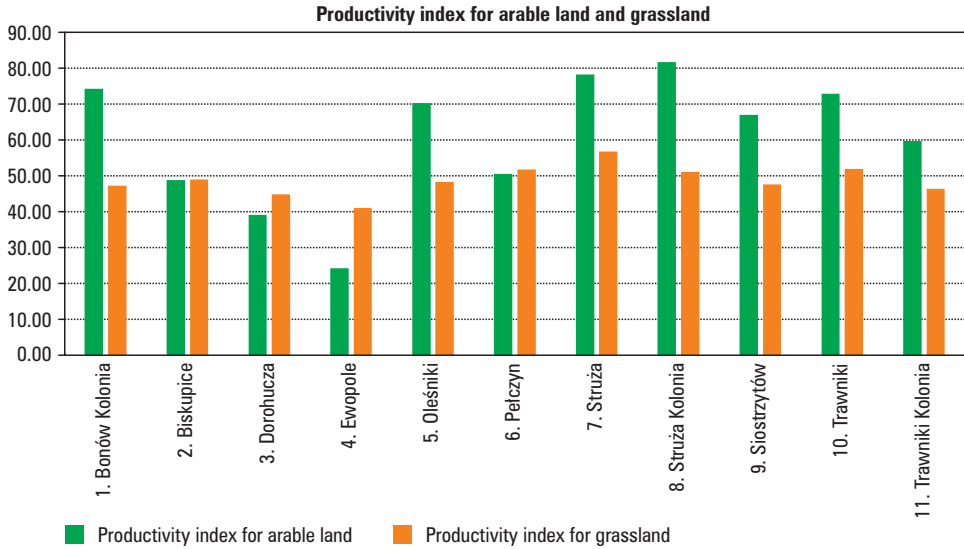
- W_p – point values for individual soil bonitation classes for arable land and grass-land,
- X_n – the area of the bonitation classes of arable land and grassland,
- P – overall bonitation area of arable land and grassland.



Source: Authors' own study based on EGiB data

Fig. 2. Land use structure in the Trawniki municipality

Table 2 shows the calculated productivity indices for arable land and grassland for the individual precincts of Trawniki municipality. Figure 3 compares the productivity index for arable land with that for grassland in the individual precincts of Trawniki municipality.



Source: Authors' own study based on EGİB data

Fig. 3. Comparison of the productivity index for arable land and grassland in individual precincts of Trawniki municipality

2.3. Land fragmentation

Land fragmentation in the municipality of Trawniki was studied in relation to individual farms, belonging to registration group 7, in which 5 area ranges were assumed (Table 2).

Table 2. Structure of land fragmentation in the villages in the municipality of Trawniki

Area ranges		Parcels number	[%]
I	0.00–0.10	5 688	28.0%
II	0.11–0.30	7 479	36.0%
III	0.31–0.60	4 300	21.0%
IV	0.61–1.0	1 811	9.0%
V	1.01 <	1 321	6.0%
Total		20 599	100.0%

Source: Authors' own study based on EGİB data

Table 3. Detailed analysis of the fragmentation of parcels in the villages of Trawniki municipality

Precinct name	Numer of parcels	Range I		Range II		Range III		Range IV		Range V		Total area	Fragmentation index
		Number	%	Number	%	Number	%	Number	%	Number	%		
Bonów Kolonia	264	10	3.8	58	22	58	22	53	20.1	85	32.2	220.7051	4.41
Biskupice	2726	770	28.2	1084	39.8	565	20.7	200	7.3	107	3.9	779.9332	3.23
Dorohucza	2883	644	22.3	1028	35.7	676	23.4	348	12.1	187	6.5	1066.532	3.51
Ewopole	901	420	46.6	285	31.6	134	14.9	38	4.2	24	2.7	238.426	3.47
Oleśniki	4858	1194	24.6	1847	38	1047	21.6	424	8.7	346	7.1	1740.776	3.55
Pełczyn	748	89	11.9	265	35.4	248	33.2	101	13.5	45	6	323.1935	3.54
Struża	1500	882	58.8	454	30.3	106	7.1	47	3.1	11	0.7	206.6319	2.57
Struża Kolonia	932	139	14.9	269	28.9	240	25.8	126	13.5	158	17	568.9366	4.1
Siostrzytów	2895	954	33	1079	37.3	541	18.7	193	6.7	128	4.4	826.0102	3.3
Trawniki	1888	488	25.8	829	43.9	383	20.3	132	7	56	3	525.0892	3.12
Trawniki Kolonia	1004	98	9.8	281	28	302	30.1	149	14.8	174	17.3	616.9845	4.06

Source: Authors' own study based on EGIB data

According to the analysis, the largest part of the parcels is within the 2nd range, their areas ranging between 0.11–0.30 ha. For the analyses, 20,599 registered parcels were adopted, representing 36% of all the total parcels located in the analysed area of the municipality. The total area of these plots is 1,392.44 ha, which constitutes 20% of the area of all privately owned parcels. The next group in terms of numbers are the parcels within the range of up to 0.10 ha, which represent 28% of all parcels. Although numerically there are quite a few parcels in this range, their area makes up only 4% of the area of all analysed parcels. The third range in the ranking, comprising 21% of all parcels, is between 0.31 ha and 0.60 ha. The area of these parcels in relation to the total area of private parcels is 26%. The next range, 0.61 ha to 1.0 ha, comprises 9% of the parcels with an area not exceeding 20% of the analysed parcels. The parcels belonging to the last range, above 1.0 ha, do not exceed 6% of the total. Although the number of parcels is the lowest, in terms of area, this is the range with the highest share of private parcels, amounting to more than 30%. In order to parameterise the land fragmentation in the adopted area ranges, i.e. 0–0.10 ha, 0.11–0.30 ha, 0.31–0.60 ha, 0.61–1.0 ha, and above 1.01 ha, the land fragmentation index was calculated according to the following equation:

$$W_R = \frac{\sum_1^n (X_n \cdot l_n)}{P}$$

where:

- X_n – the area of the registered parcels in the defined surface areas,
- l_n – weighting for each sector (1–5);
- P – the total area of individual land in the precinct [Leń and Noga 2010].



Source: Authors' own study based on EGİB data

Fig. 4. Structure of land fragmentation in Trawniki municipality

A detailed analysis of land fragmentation in the municipality of Trawniki showed that the largest number of parcels not exceeding 0.10 ha is located in the Olesniki precinct (1194 parcels). The smallest number of parcels in this range is found in Bonów Kolonia. Considering the number of total parcels in these precincts, these are the precincts with the largest and smallest number of parcels of registration group 7, respectively. Range II is the range in which the percentage of the number of parcels in relation to the total is the largest in the 7 precincts. The largest parcels, i.e. parcels with an area exceeding 1 ha, are found in the Olesniki precinct (346 parcels). The analysis of the fragmentation of the Trawniki municipality indicated that the highest fragmentation rate is found in Bonów Kolonia, while the lowest is found in Struża. The spatial picture of land fragmentation is illustrated in Figure 4.

2.4. Parcel elongation rate

According to the study, a major problem occurring in the municipality of Trawniki, relating to parcels owned by natural persons, is the unfavourable geometry of registered parcels. In order to characterise this defect in the spatial structure of the studied area, the value of the parcel elongation index was determined. It was calculated based on the following formula¹:

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

where:

- W_k – layout factor,
- P – parcel area,
- O – parcel perimeter.

The synthetic index of elongation of parcels was calculated in six ranges of values, i.e. below 1.00, 1.01–2.00, 2.01–3.00, 3.01–4.00, 4.01–5.00, and above 5.01. Each of the above ranges was given an appropriate weight in the order from 1 to 6. The area of parcels of each range was multiplied by the assigned weight and summed. In the next step, this result was divided by the total area of individual land and thus the value of the synthetic index was obtained.

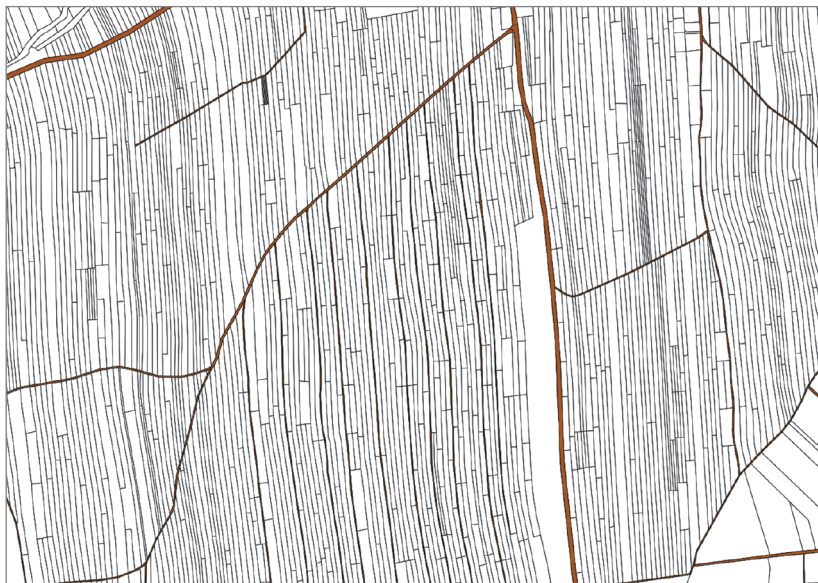
The analyses in Table 4 show that the average elongation index in the municipality is 3.66. The most favourable index is found in the Trawniki precinct (4.49), while the least favourable index is found in the Biskupice precinct (2.58). The average value of this index is also the highest in the Trawniki precinct (4.63) and the lowest in the Ewopole precinct (1.92). By analysing the percentage of parcels with the lowest elongation values (> 1.00), it can be seen that the highest number of such parcels belongs to the Ewopole precinct (54%). The smallest percentage in this category is in the Trawniki precinct (2%). The highest number of parcels with the most favourable elongation factor is found in the Trawniki precinct (45%). The spatial picture of the elongation of parcels is presented on a fragment of Biskupice village – Figure 5.

¹ A simplified formula for the geometry of registered parcels proposed by the experts at realexperts.co.uk was adopted for the study.

Table 4. Factors characterising the geometry of parcels, for the precincts of the municipality of Trawniki

Precinct	Average index value	% of number of parcels below the index 1.00	% of number of parcels within index values 1.01 to 2.00	% of number of parcels within index values 2.01 to 3.00	% of number of parcels within index values 3.01 to 4.00	% of number of parcels within index values 4.01 to 5.00	% of number of parcels above the index value 5.01	Synthetic parcel elongation index for the precinct
Bonów Kolonia	3.59	10%	25%	15%	12%	9%	30%	3.61
Biskupice	2.91	16%	26%	21%	12%	6%	17%	2.58
Dorohucza	3.12	15%	21%	20%	14%	10%	21%	3.68
Ewopole	1.92	54%	10%	10%	7%	7%	12%	4.04
Oleśniki	3.13	16%	23%	18%	13%	10%	21%	3.74
Pelczyn	3.61	5%	20%	22%	15%	11%	27%	3.87
Struża	3.27	15%	18%	18%	14%	12%	22%	3.15
Struża Kolonia	3.54	10%	22%	18%	12%	10%	28%	3.67
Stostrzytów	2.5	28%	26%	15%	10%	8%	14%	3.18
Trawniki	4.63	2%	10%	13%	16%	15%	45%	4.49
Trawniki Kolonia	4.23	5%	15%	14%	16%	12%	38%	4.27

Source: Authors' own study based on EGiB data



Source: Authors' own study based on EGiB data

Fig. 5. Fragment of a map showing the problem of elongation of parcels in the Biskupice precinct

2.5. Analysis of the road network without direct access to a public road

As the study indicates (Table 5), 3317 registered parcels do not have direct access to a public road with a total area of 663.84 ha. This is 16% of the total number of parcels in the municipality and 8% of the total area of the municipality. The highest percentage of parcels without access to a road is located in the Struża precinct (39% of all parcels), while the lowest is in the Pęczyn precinct (1% of all parcels). Analysing the problem in terms of area, the Struża precinct has the highest proportion of parcels without road access (42% of the precinct area), while the Pęczyn precinct has the lowest (> 1% of the precinct area). The spatial picture of parcels without access to a public road is illustrated in Figure 6.

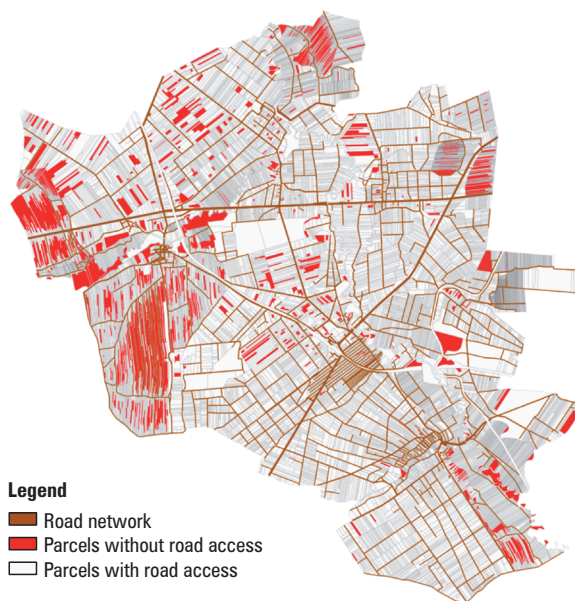
Table 5. Surface area and percentage share of the number of parcels without access to a road in individual districts of Trawniki municipality

Precinct name	Area	Total number of parcels	Number of parcels without road access	% number of parcels without road access	Area of parcels without road access	% of the area of parcels without road access
Bonów Kolonia	227.8377	264	62	23%	38.605089	17%
Biskupice	889.5992	2 726	852	31%	216.010482	24%
Dorohucza	1304.0197	2 883	555	19%	59.98088	5%

Table 5. cont.

Precinct name	Area	Total number of parcels	Number of parcels without road access	% number of parcels without road access	Area of parcels without road access	% of the area of parcels without road access
Ewopole	377.9673	901	19	2%	5.978628	2%
Oleśniki	1808.1794	4 858	275	6%	60.571324	3%
Pelczyn	360.4487	748	11	1%	1.068854	0%
Struża	214.1376	1 500	585	39%	90.537023	42%
Struża Kolonia	615.6097	932	136	15%	67.299667	11%
Siostrzytów	894.6714	2 895	566	20%	56.431198	6%
Trawniki	755.3655	1 888	167	9%	27.947766	4%
Trawniki Kolonia	744.369	1 004	89	9%	39.416148	5%
Total	8192.2052	20 599	3317	16%	663.847059	8%

Source: Authors' own study based on EGiB data



Source: Own elaboration based on EGiB data

Fig. 6. Spatial picture of registered parcels without access to a public road

3. Discussion and conclusion

The study of the spatial structure of the municipality of Trawniki shows that there are numerous flaws in the land structure of this municipality, which hinder the development of agriculture and increase its costs. This spatial situation was mainly influenced by land divisions that have been dispersed over centuries within or outside the village due to inheritance issues, creating a chequered pattern of land. The study presents the results of a multifaceted analysis concerning the spatial structure of rural areas in the villages of the Trawniki municipality, in order to determine the degree of defectiveness of the spatial structure. The analysis of the tenure structure in the municipality of Trawniki showed that land owned by natural persons is predominant. The total area in this category is 7087.87 ha, which is 84.23% of the total area of the municipality. The results of the research on land use structure demonstrated that arable land predominates in the study area (58.75%), while the calculated productivity index showed high suitability of land for agricultural production. Its highest values are achieved: for arable land in Struża Kolonia (81.83%), and for grassland in Struża (56.90%). The research has indicated that the land fragmentation in the Trawniki municipality is high. The largest proportion of parcels is in the two smallest of the assumed area ranges. In the study area, the parcels have unfavourable geometry due to being excessively elongated and narrow. This is evidenced by the elongation index of the parcels calculated during the analyses. The analysis of the road network revealed a high percentage of the number of parcels without direct road access in various villages of the municipality. The highest percentage, amounting to 39% of the number of parcels, is found in Struża, while the lowest – in Pełczyn (less than 1.5%). The research has shown that the spatial and functional structure of all the villages in the studied municipality requires improvement, so a detailed study is advisable to prioritise land consolidation and exchange works, as it would significantly improve the spatial structure of the studied municipality.

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