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LAND CONSOLIDATION URGENCY RANKING FOR THE VILLAGES OF THE BRZYSKA COMMUNE

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Abstract
The present spatial arrangement of rural areas in southeastern Poland stems from socio-economic conditions that originated, for instance, at the time of annexations and Socialist rule. Adverse phenomena in the structure of rural areas, such as fragmentation of land, inhibit the development of farmsteads and lead to ineffective use of the agricultural area, increased financial expenditure and limited options for using the latest technological developments. The land consolidation procedure provides a comprehensive solution to the problem. The procedure, inscribed in the sustainable development of rural areas, aims at optimising the spatial parameters of farmsteads, creating a functional network of roads and reclaiming land, and constructing land improvement structures. Due to limited financial and human resources, consolidation projects cover relatively small areas that are disproportionate to considerable needs. Therefore, determining land consolidation urgency is essential in the context of delimiting priority areas. This paper presents a ranking for the urgency of land consolidation in the villages of the Brzyska commune, in the district of Jasło, Sub-Carpathian voivodeship. The villages were analysed in detail for the presence of 15 features directly affecting the spatial structure quality of the study area. The calculated values were standardised, and afterwards, using zero unitarisation, priorities were set for the analysed villages in terms of their requirement for land consolidation.
Key words: land consolidation, land exchange, spatial structure of land, agriculture, land fragmentation

Introduction

The spatial arrangement of villages is a result of centuries-long human intervention. To make their living, people changed natural landscapes adapting them to their own needs but did not consider the adverse effects their activities could have. The structure of rural areas was altered, to a decisive extent, by human settlement, which divided the area according to specific principles. This division resulted in the emergence of various forms of land use. The economic development of the rural community resulted in continuing transformations of the structure of land taking place at a rate dictated by the stages of development and the economic conditions (Noga, 2001).

The world literature mentions historical socio-economic conditions as the major adverse factor affecting the structure of rural areas, and hence the agricultural activity environment. The negative phenomena include land fragmentation noted down in countries such as Albania, Bangladesh, Bulgaria, China, Czech Republic, Estonia, Ethiopia, Ghana, Hungary, India, Israel, Jordan, Lithuania, Nepal, Peru, Poland, Romania, Slovakia, Syria, Taiwan, Turkey, Ukraine USA and Vietnam (van Dijk, 2003; Demetriou, 2014). Muchová and Raškovič describe historical reasons for excessive land fragmentation in Slovakia, including land property inheritance rules and real property regulations distinguishing between buildings and land (Muchová and Raškovič, 2020). Using the example of Lithuania, Pašakarnis and Maliene highlighted excessive land fragmentation in post-Socialist countries, associated with unregulated privatisation of land (Pašakarnis and Maliene, 2010). Researchers investigating the reality in Ukraine (Martyn et al., 2022) and presenting the results of the analysis carried out in Albania (Deininger et al., 2012) share this view. Jürgenson raises this issue at a deeper level, using the example of Estonia where a need exists for creating proper legal regulations to allow solving the problem of land fragmentation and take the latest technical developments into account (Jürgenson, 2016). Wang et al. see multiple divisions of land, characteristic of conventional agriculture, as the main reason for land fragmentation in China (Wang et al., 2021). Despite the variety of reasons, researchers generally agree on the disadvantages of the internal land fragmentation, defined by van Dijk as a “fragmentation within a farm” (van Dijk, 2003. Thus, the experts emphasise the necessity to undertake corrective actions.

The correct configuration of land is one of the factors allowing profitable agricultural production (Hiironen and Riekkinen, 2016). The following factors play a vital role in the farmstead's spatial structure: number, surface area, shape and elongation of plots as well as their access to a road and adequate location of the farmer's dwelling. As regards production profitability, the number of plots should not be more than six per farm (Noga, 2001). Another factor determining the farm's productivity is the surface area of plots. Plot width, length and shape also affect the farmstead's spatial functionality

and profitability. Literature specifies the desired plot width as 20-40 m. However, the optimum plot width should also take into account land use type, soil type, slope angle and the working width of agricultural machinery. In contrast, in calculating the correct plot length for the farmstead, its surface area, use, soil type and fieldwork mechanisation level should be considered. The expected plot length ranges from 250 to 600 m. Labour productivity increases in proportion to plot length from 210 to 400 m. Plot elongation, expressed as its width to length, affects working time (necessity to reverse) and contributes to crop losses at the plot's border. Studies demonstrated that the optimum plot elongation should be 1:5 (Noga, 2001). Another element shaping the development of agriculture is the previously mentioned access of plots to roads and the condition of existing roads. As the plot fragmentation proceeded, the direct network of roads did not develop. Therefore, most plots lack a direct connection to the farmstead (Noga, 1977). Numerous informal access easements appeared at that time. The problem intensified with the development of technology, preventing the passage of modern agricultural machinery. In the Subcarpathian voivodeship, in southeastern Poland, agricultural land features notably high fragmentation and small plot surface (Wójcik-Leń et al., 2022). The present network of roads offering direct access to agricultural fields is not adapted to access by modern agricultural equipment. These factors constitute a critical barrier to the development of agriculture (Radziszewska, Jaroszewicz, 2012).

The land consolidation process is a comprehensive solution to defects inac the agricultural area (Stręk and Noga, 2019). Since land consolidation projects are expensive, they should be preceded by a thorough land configuration analysis (Leń 2018, Janus and Taszakowski, 2018, Marinković et al., 2022). In the context of delimiting potential areas for consolidation, it is also essential to identify agricultural wasteland (Wójcik-Leń, 2022).

The land consolidation process is commonly used in transforming the spatial structure of rural areas i.a. in Poland and the other countries of the European Union. The Act of 26 March 1982 on the Consolidation and Exchange of Land defines land consolidation as a rural management procedure aiming at the transformation of the spatial arrangement of rural land to create more favourable management conditions by improving the territorial structure of farms, ensuring reasonable configuration of the land, and aligning the limits of real properties with the system of water irrigation structures, roads and terrain (Ustawa, 1982). By contrast, the Polish Rural Development Programme (PROW) for the years 2014-2020, conducted in Poland, describes land consolidation as works during which new plots are formed in a configuration different from that of original plots to reduce the number of small, scattered plots constituting a single farm and to increase their average size (PROW 2014–2020).

A land consolidation procedure is initiated at the request of the majority of plot owners in the projected area or owners of more than half of the surface area of such land in total. It is generally financed by the state budget but also from earmarked funds, the budgets of local administrative units and owners of the consolidated land. This procedure makes it possible to design a new arrangement of farms and enhances the configuration of land by reducing the number of plots, increasing plot surface area, decreasing the distance between the plots and the farmer's dwelling and adjusting their irregular shape. It also improves the agricultural network of roads offering access to plots. In turn, at the post-consolidation management stage, the width, surface condition and density of roads improve, which shortens access to fields.

Land consolidation is the more effective, the worse is the spatial arrangement of the concerned area. Woch found that for the consolidation of land with an average plot surface area of 0.35 ha and, on average, 6.5 plots per farmstead, the plot surface area increased by eight per cent and the number of plots decreased by half. For worse land configurations, the surface area increased up to 200%. Consolidating plots having a better configuration (> 0.80ha) the surface area increased by 50%, and the number of plots decreased by 40% at the maximum. Surveys showed that consolidating poorly configured land, being predominant in southeastern Poland, increased the income derived by its owners on average by 20-30%. A return on land consolidation costs is expected within 4 years, and the post-consolidation management costs - are within 20 years (Woch, 2007). Benefits related to land consolidation are reflected in the present-day surveys on the economic aspects of land consolidation. Janus and Markuszewska analysed the persistence of changes introduced by the land consolidation procedure. They investigated the site where a land consolidation project was completed 40 years earlier. Having analysed the agrarian structure of the land, they found traces of land consolidation effects such as size and the number of plots per farmstead and road access of the plots (Janus and Markuszewska, 2019). Hiironen and Riekkinen evaluated land consolidation in terms of its impact on agriculture, profitability, improvement of the ownership structure and costs of agricultural activity. To this end, they examined 12 land consolidation sites in Finland and found that land consolidation was an effective tool

to improve the ownership structure and decreased production costs by 15% (Hiironen and Riekkinen, 2016).
The aim of the report is to determine a hierarchy of the land consolidation urgency for the villages of Brzyska commune, located in southeastern Poland. The research is based on 15 criteria, selected in accordance to the expert knowledge and the practise of the land cocsolidation works realisation in Poland, in a range of the studial analyses of the rural areas spatial structures (Janus and Taszakowski, 2014) The detailed analysis concerned the elements of the spatial and demogrephic structure, determining the potential needs foe the land consolidation works. Within the research procedure, conducted with the authors' calculating methods, an assessment of the land consolidation urgency for each village has been elaborated. The result of the analysis carried out is the land consolidation urgency ranking for the studied villages.

Methodology of research and materials
The priority of this paper is to analyse and evaluate the spatial structure of rural land in the Brzyska commune, based on the structure of ownership, land use, land fragmentation and road access of plots. All seven precincts in the commune were analysed in detail. Figure 1 shows the location of the Brzyska commune in Poland, Subcarpathian voivodeship and the district of Jasło.

Figure 1. Location of the Brzyska commune on the map of Poland, Subcarpathian voivodeship and the district of Jasło. Source: own elaboration.

The findings provided grounds for describing the specific features of the current spatial structure and preparing suggestions for optimisation methods. We developed a land consolidation urgency ranking, taking the impact of land configuration on the development of agriculture into account.
Adverse land configuration in rural areas is an obstacle to profitable agricultural production. Therefore, the agricultural production areas should be transformed as soon as possible by consolidating land. However, the consolidation of large areas is impossible due to economic, technical and social reasons. Thus, it is necessary to prepare land consolidation needs and urgency ranking. To compare different villages scattered over the area, a relevant evaluation methodology needs to be designed, followed by the ranking in pursuance of the purpose adopted in this paper. The variables adopted in the multiple-criteria assessment should be converted and made uniform. The converted variables are deprived of labels and their values fall within similar ranges. This type of transformation is called the standardising method. The standardised values of diagnostic features are aggregated, which produces a synthetic feature characterising each village depending on the adopted objective (Figure 2.) (Leń, Mika, 2016).

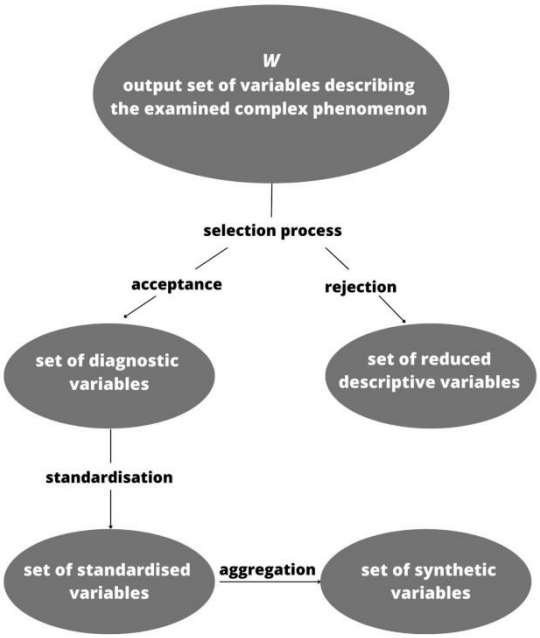

Figure 2. Development of a synthetic variable. Source: [Leń, Mika, 2016]

The synthetic values provide the basis for a ranking to order the villages from the worst to the best synthetic value. Such a list was prepared based on the spatial structure of the land, using zero unitarisation to set the priority in the land consolidation ranking for the precincts of the Brzyska commune. Fifteen diagnostic features, describing each precinct, were adopted (Table 1) for the identification of the areas for land consolidation in the Brzyska commune. The criteria of the analysis were selected with reference to the studial analyses methodology, applied in the land consolidation project assumptions, elaborated at an initial stage of the land consolidation proceeding in Poland (Janus and Taszakowski 2014). The variables were classified as stimulants and destimulants of land consolidation urgency.

Table 1.

Features adopted as stimulants and destimulants Source: own elaboration.

Selected features	Mean	Median	Min	Max	Coefficient of variation (V)
Stimulants					
Total area of the village	641.0	365.6	200.7	1887.1	97.0
Total number of plots	1344.0	1033.0	404.0	3040.0	71.1
Average plot area per village	0.4	0.5	0.3	0.6	29.1
Number of inhabitants	948.1	618.0	356.0	2296.0	76.7
Number of residents per 1sq km	177.5	165.3	86.4	293.4	38.8
% of arable land	53.7	49.9	46.4	70.6	17.3
% of pastures	10.7	10.1	6.8	13.4	22.3
% of land owned by private farmers	72.4	72.6	64.6	82.4	8.0
Number of private sector plots	1108.3	693.0	339.0	2652.0	79.3
% of the number of plots without access to roads	38.9	39.1	30.0	51.2	20.5
% of the surface area of plots without access to roads	39.9	39.7	24.0	46.7	19.6
Destimulants					
% of forests	17.9	21.5	0.0	33.5	73.9
Fragmentation ratio (Leń, Noga, 2010)	3.4	3.4	3.0	4.0	10.2
% of land owned by the State Treasury	12.9	11.9	1.6	27.9	79.6
Average plot area in the private sector	0.4	0.4	0.3	0.6	26.3

The ranking of villages was prepared using the Zero Unitarisation Method (ZUM), which allows for standardizing diagnostic variables by testing the range of the characteristic (Leń, Mika, 2016). There are three groups of diagnostic variables describing the study object (Leń, Mika, 2016):
1) stimulants (the larger-the-better characteristics) – variables that, with increased values, improve the evaluation of a characteristic of the analysed object; then, standardised variables are calculated according to the formula:

$$Z = \frac{(x - x_{\min})}{(x_{\max} - x_{\min})} \quad (1)$$

2) destimulants (the smaller-the-better characteristics) – variables that, with increased values, deteriorate the evaluation of a characteristic of the analysed object; then, standardised variables are calculated according to the formula:

$$Z = \frac{(x_{\max} - x)}{(x_{\max} - x_{\min})} \quad (2)$$

3) neutral variables – variables assuming the highest rank (the optimum) only for a certain value or range of values; the further from the optimum, the lower rank of the phenomenon. Then, standardised variables are calculated as below:

$$Z = \frac{(x - x_{\min})}{(x_{opt} - x_{\min})}, \text{ for } x < x_{\text{opt}}, \tag{3}$$

$$Z = \frac{(x - x_{\max})}{(x_{opt} - x_{\max})}, \text{ for } x > x_{\text{opt}}, \tag{4}$$

where:
Z – standardised variable,
x – non-standardised variable,
$x_{\max}$ – maximum value of the variable in the specific set,
$x_{\min}$ – minimum value of the variable in the specific set,
x_{opt} – the optimum value of the variable in the specific set.

Standardisation of diagnostic features is a preliminary stage leading to an overall multiple criteria assessment of each object taken into consideration. Their overall assessment can be achieved through aggregation. To obtain a synthetic measure the mean values are calculated for sets describing the respective characteristics (Leń, Mika, 2016) according to the following formula:

$$z_i = \frac{1}{p}\sum_{j=1}^{p} x_{ij} \quad (5)\ (i = 1,\ldots,m)$$

Standardised measures fall within the range <0;1>. The results can be interpreted as the average optimum value of each object. Thus, the higher the synthetic measure, the higher the object's position in the ranking being created (Leń, Mika, 2016).

Discussions and results

According to studies presented in Table 2, land consolidation should be carried out in Kłodawa in the first place (synthetic ratio: 0.58). This village features a defective spatial structure. The farms are excessively fragmented (so-called internal fragmentation) (van Dijk, 2003), and plots smaller than 0.30 ha account for 65.1% of all the plots. This is due to the presence of a considerable number of plots without access to roads, accounting for 46.0% of all the plots (327 plots have no road access). In this precinct, a high position in the ranking and potentially satisfactory effects of land consolidation are additionally determined by the high percentage of agricultural land (93.77% of the village area) and the absence of afforested areas. The situation is similar in the precinct of Błażkowa, which ranks second (synthetic ratio: 0.56). All land consolidation works in the Brzyska commune should follow the order shown in Table 2 and Figure 3. These procedures would contribute to improving the configuration of the agricultural production space, being a key condition of agricultural development.

Table 2. Land consolidation urgency ranking of villages Source: own elaboration

Ranking position	Value of synthetic measure	Name of precinct
1	0.58	Kłodawa
2	0.56	Błażkowa
3	0.51	Wróblowa
4	0.51	Brzyska
5	0.46	Ujazd
6	0.27	Dąbrówka
7	0.26	Lipnica Dolna

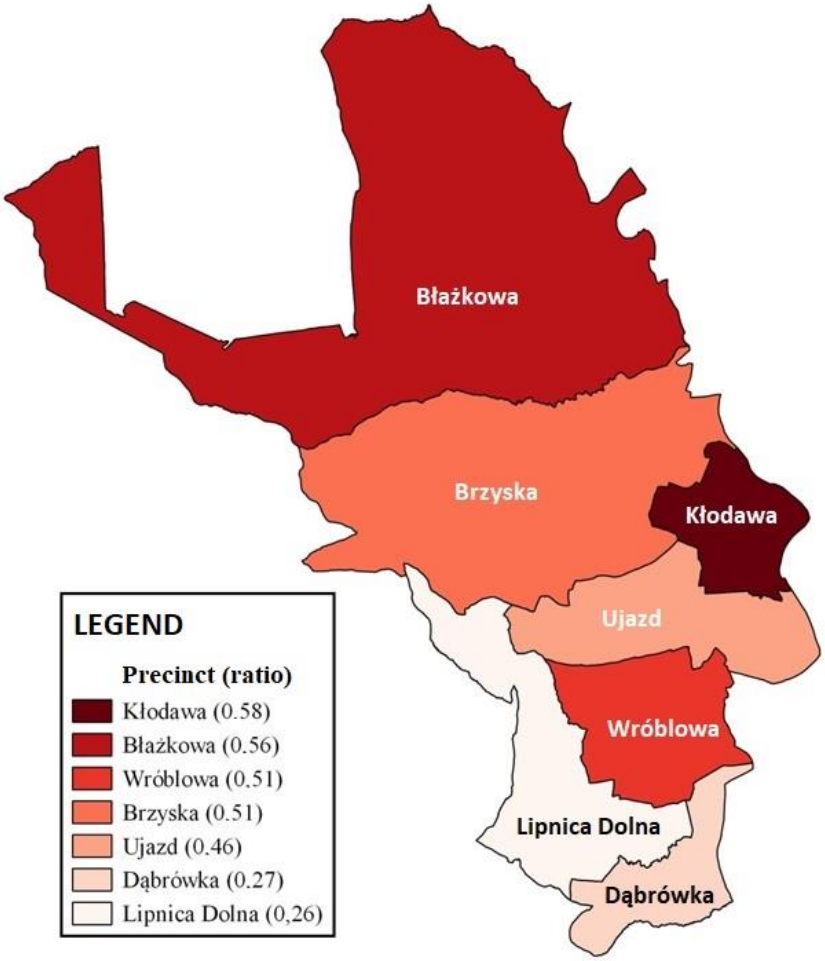

Figure 3. Land consolidation urgency map in the Brzyska commune. Source: Own elaboration

Conclusions and proposals

The analyses demonstrate that the Brzyska commune has a poor spatial structure. The fragmentation of land implies that the average surface area for the commune in the private sector is 0.44 ha. It differs significantly from the corresponding mean value in Poland and the European Union. This phenomenon also adversely affects the development of agriculture, decreasing its economic efficiency. It should be highlighted that plots smaller than 0.10 ha are not eligible for the programme of direct payments from the European Union (Ustawa, 2023) and plots smaller than 0.30 ha cannot be divided (Ustawa, 1997).

Another factor compromising the quality of the spatial structure of the examined area is that the plots have no access to roads. The analysis showed that about 40% of plots have no direct access road. This directly increases the cost of agricultural production due to the cost of transport. Furthermore, an insufficient road network prevents access to modern agricultural equipment, restricting the development of machinery parks. Agricultural activity in such spatial conditions generates extra costs, which compromises its profitability. This phenomenon should be deemed particularly harmful because the agricultural activity is the primary source of livelihood for 48.6% of the commune inhabitants. A farmer running activity in this area will find it difficult to compete with farmers from the member states of the European Union.

Therefore, land consolidation is the right direction to pursue. Commitment to taking action is desirable both from local government authorities and from real property owners who often oppose such operations. The land consolidation process will optimise spatial parameters such as number, surface area and shape of plots, number of plots without road access, and plot width, and reduce the number of plots making a farmstead. This operation also leads to an adjustment of the road network, which reduces the time to reach the fields. All these actions contribute to increasing the profitability of agricultural production. It is worth noting that apart from improved agricultural conditions, land consolidation has

additional consequences: socio-economic (improved living and working conditions), environmental and landscape (amelioration, reclamation), organisational and legal (abolishment of land easements, joint property and common land). Consolidated lands become more attractive to tourists and offer better conditions for the development of non-agricultural businesses. It is impossible to carry out an operation transforming a defective structure across the whole area at the same time, at least due to financial reasons. Thus, such works must be carried out as a priority in villages with the most urgent needs.

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