

IDENTIFICATION OF AREAS WITH UNFAVORABLE AGRICULTURE DEVELOPMENT CONDITIONS IN TERMS OF SHAPE AND SIZE OF PARCELS WITH EXAMPLE OF SOUTHERN POLAND

Jaroslaw Janus, Agnieszka Glowacka, Piotr Bozek

University of Agriculture in Krakow, Poland

j.janus@ur.krakow.pl, a.glowacka@ur.krakow.pl, p.bozek@ur.krakow.pl

Abstract. Modern agriculture development possibilities are highly dependent on many factors, including those which are related to the parameters of land spatial structure (including parcels fragmentation and parameters related to their shape). In particular, unfavorable shape of parcels in combination with their small sizes is the most common reason for non-profitability of agricultural production. It is one of the major causes of land abandonment. South Poland is the area of high diversification in terms of the landform, soil quality and spatial structure parameters. It is one of the regions in Europe where the phenomenon of land fragmentation is the most common, significantly affecting the disappearance of its agricultural function. The data which allow a comprehensive study of the differentiation in parcel parameters (which affect the cultivation costs) are included in cadastral datasets, generally stored in CAD files or GIS databases. Appropriate data analysis allows identifying areas with particularly unfavorable conditions for agricultural production. The article presents the results of the analysis carried out in chosen parts of southern Poland (the province of Malopolska). The analysis is aimed to calculate selected indices, related to the shape and size of land plots correlated with the farm income opportunities. The study included over 1800 villages from the region and more than 4 million parcels, for which geometric data were obtained and analyzed. The results can be used at many stages of the planning process at the local and regional level considering the limitations of agricultural development caused by spatial parameters of the parcels in the area.

Keywords: land fragmentation, land consolidation, rural areas.

Introduction

The development of modern agriculture depends on many environmental, social and economic factors. To a large extent, it also relates to factors influencing the profitability of agriculture production, which result from changes in both the situation on the world trade market and economic policies [1]. Because of increasing globalization of the world economics, the impact of local and regional policies is diminishing. Its influence is however still at a considerable level.

Some of the factors essentially affecting the ability to maintain profitable agricultural production are environmentally determined [2], but it becomes more usual to include also the factors of ideological and ethical nature [3]. Environmental factors include the climate and hydrological conditions, relief, and soil quality. Anthropological factors consist of elements such as the quality and density of transportation network [4] and parameters for agricultural land fragmentation [5; 6].

The costs paid by a farm, which are associated with unfavorable land parameters, can be divided into two groups: concerning the parameters of individual parcels and concerning the location of all parcels relative to the farm centre [7].

The costs associated with the cultivation of individual farmlands, which through simplification can be regarded as the owner's record parcels, are primarily affected by constituents such as the shape and size [7; 8]. In some cases the actual cultivation area does not match entirely the (cadastral) plot's boundary. It also includes official co-ownership, but the scale of these discrepancies within the whole farm is small.

Spatial diversification of the plots' parameters in Europe is vast [9], which is also characteristic for individual countries and even regions. In Poland, the average area of a single plot ranges from 2.54 ha (northeast Poland) to 0.36 ha (south Poland) [10], what also correlates with various types of the plots' layout. Figure 1 shows in the same scale spatial diversification of average-sized parcels in Poland with three types of layout.

The diversification of the parameter determining the number of plots in a farm behaves similarly. Here, the value for individual provinces varies from 5 to 10, yet in some communes in southern and eastern Poland the values can exceed 20. The data indicate noticeable differences in the farming activity by the subjects operating within identical provisions of the law and economic conditions, which determine the prices of products. Among other factors, excessive costs associated with spatial

parameters of farms lead to a gradual abandonment of farming activities in the areas where the phenomenon is the most common. Another result of such situation is that many of those areas are permanently set aside [11] and, often uncontrollably, undergo the process of afforestation.

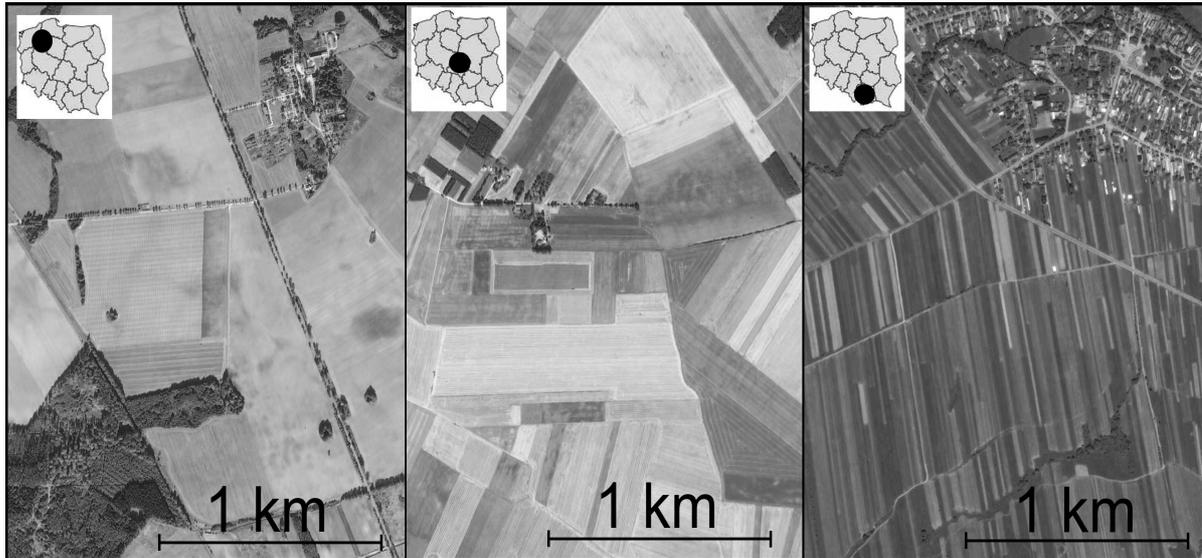


Fig. 1. Diversification of average-sized plots in Poland

Study area

A good example of these processes is the area of southern Poland – the province of Malopolska, which is the most diversified in terms of spatial parameters region of Poland [12; 13]. It was selected as a representation of the proposed methodology for determining the areas with the highest costs of farming generated by the size and shape of plots.



Fig. 2. Location of Malopolska Province in Europe and in Poland

Materials and methods

Known indices that incorporate the shape and size of a single plot include elements such as their perimeter and area [7]. Consequently, they show the quantity that does not possess information on economic effects. What is more, when the synthetic index is formulated, it cannot later be used for economical evaluation since the known relationships of costs that occur while farming use basic characteristics of plots, such as their length, width and area, i.e. the parameters of which the values must be known. Therefore, an index has been suggested which includes the abovementioned factors and allows to determine spatial diversification of the farm economical costs increased by fragmentation.

The research uses cadastral databases that contain the Malopolska region, which is administratively divided into 22 districts and 182 communes. The communes are divided into almost 2000 surveying sections (most often identified as villages). The villages where the agricultural role dominates were the subject of the research.

The data used in the analysis were in the SWDE format text files, which for most time in Poland was a mandatory format for cadastral data (although additionally backed by the GML format) [14]. The files possess information on the geometry of the cadastral objects (plots in this case) and their attributes, for example, the form of use and data on the owners. The processed datasets contained information on 4.1 million plots located in 1850 surveying sections of agricultural function (which by simplification can be regarded as individual villages). Urban areas were excluded from the research.

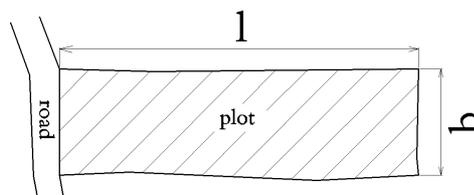


Fig. 3. Model plot and parameters that influence farming costs

Examining a single, model plot of a farm (Fig. 3) it is possible to determine the following ways of calculating the costs of its cultivation, with the plot's size and shape taken into consideration [15]:

$$K_r^{orne} = z_{lo} * l + z_{bo} * b + \frac{j_{po} * l}{4} \text{ for farmlands,}$$

$$K_r^{zielone} = z_{lz} * l + z_{bz} * b + \frac{j_{pz} * l}{2} \text{ for plots that constitute grasslands,}$$

where z_{lo}, z_{lz} – parameters describing the costs related to the length of a plot (boundary losses);
 z_{bo}, z_{bz} – parameters describing the costs related to the width of a plot (returns, boundary losses, costs related to the return zone);
 j_{po}, j_{pz} – parameters related to passes through the farmland (final passes, additional transportation).

The values of the abovementioned coefficients were determined basing on the studies from the previous century conducted, among others, in Switzerland [16]. The values were used to create tables regarding the dominant direction of agricultural production and the level of mechanization. It is possible to consider the diversification of the costs affected by the agricultural use of a given plot in two ways. The first one requires the use of data on land use stored in cadastral databases (the method used in the discussed studies). The second one uses data on the actual land use that is represented by satellite images or processed LIDAR data. The values of the coefficients are expressed by the grain unit (GU), a unit defined as the energy and protein equivalent of 1 dt of cereals, used in statistical and economic studies. The grain unit allows comparing the productivity of different farms (including the production disadvantages caused by various factors) regardless of the region, country and time. It is finally possible to compare the prices and their temporal fluctuations. In the study, the following values of the coefficients have been used for the plots where the arable function dominated:

$$z_{lo} = 0.49 \text{ (GU} \cdot \text{hm}^{-1} \cdot \text{ha}^{-1}), z_{bo} = 4.19 \text{ (GU} \cdot \text{hm}^{-1} \cdot \text{ha}^{-1}), j_{po} = 0.60 \text{ (GU} \cdot \text{hm}^{-1} \cdot \text{ha}^{-1})$$

and the following for the plots in which grassland is the dominant form of their use:

$$z_{lz} = 0.26 \text{ (GU} \cdot \text{hm}^{-1} \cdot \text{ha}^{-1}), z_{bz} = 2.58 \text{ (GU} \cdot \text{hm}^{-1} \cdot \text{ha}^{-1}), j_{pz} = 0.54 \text{ (GU} \cdot \text{hm}^{-1} \cdot \text{ha}^{-1})$$

For every plot there have been determined the following geometric characteristics: area, relative longitudinal extension, length, and width. This was followed by determining the remaining plots characteristics, which are crucial for the calculation process: dominant form of use and appurtenance to a group of farms based on the cadastral data. The analysis included only the plots which can be included in agricultural production because of their use.

Finally, for every village there has been an index calculated, which showed the level of the farming costs expressed in grain units:

$$W = \frac{\sum_{i=1}^n (K_r * a_i)}{\sum_{i=1}^n a_i},$$

where n – number of plots in the analysis (agriculture use),

K_r – coefficient of the plot's costs, calculated adequately to the knowledge of the plot's use and equations 1 or 2,

a_i – plot's area.

Results and discussion

Spatial diversification of the values of the proposed fragmentation index in Malopolska is shown in Fig. 4. The values of the index spread between 1.9 and 12.1. The distribution of the values and basic statistics are presented in Fig. 5. The index is noticeably diversified in one region which has a direct impact on the profitability of farms by lowering the profit from 1 ha of land. The distribution of the values is close to normal and the major group of villages has the average profit coefficient between 3 and 5 GU·ha⁻¹. The villages represented by the highest values are located in the southwest of the region, where the soils are of low quality and the relief is complex (mountainous areas). Further agricultural role of these areas will probably decrease.

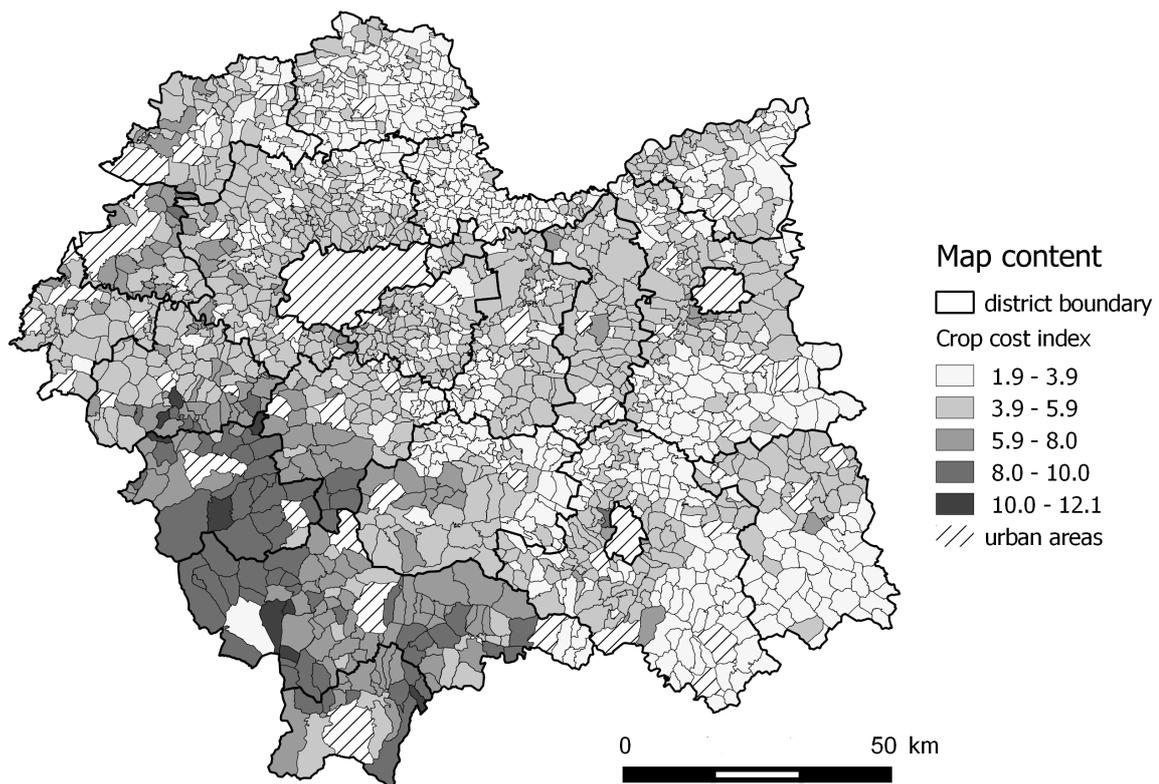


Fig. 4. Spatial diversification of index values that result from farming costs in Malopolska

The results of the calculated index must be reconsidered whenever it is associated with different factors affecting the functioning of a farm. Its diversification, however, suggests that it is important to differentiate the policies that support agriculture without excluding the regional level.

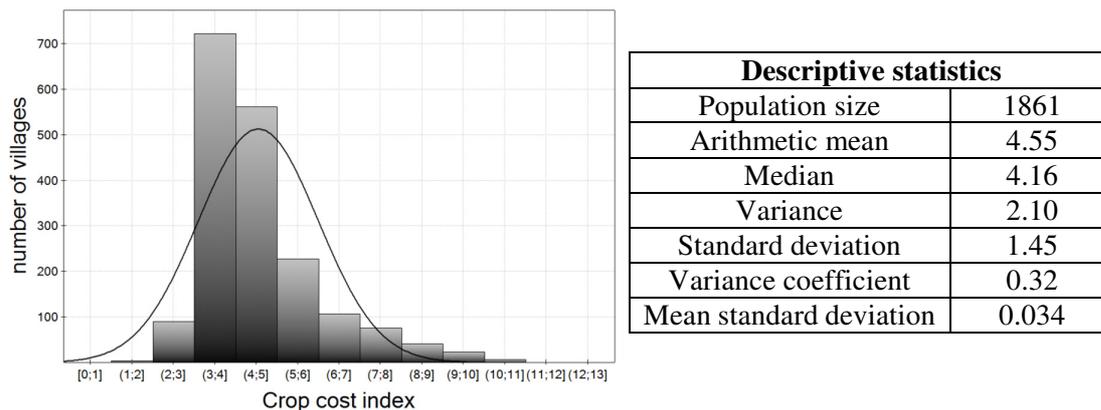


Fig. 5. Basic statistics characterizing diversification of farming costs that depend on size and shape of plots in Malopolska

Conclusions

The obtained values indicate that the use of an index including the plots' spatial characteristics that influence the economical cost of farming is effective. It contains more information than indices which consider only the differences in the plots' areas. Agriculture is the main function of the plots located in villages; therefore, the indices should be designed, from the usefulness point of view, for their main recipient. The knowledge of spatial distribution of the costs generated by farm holding within a region or the whole country allows improving the agricultural policies, what can especially lead to equalization of the chances for similar income of farms which often function in different conditions but compete on the same market. Adequate policies in this matter are crucial for stopping uncontrolled land abandonment and should be a constituent of villages' sustainable development.

Calculating the values of the proposed index in a synthetic form allows comparing the conditions in which agriculture functions (from the point of view of the costs generated by the parameters of land fragmentation). It is possible for all regions in distant places and different countries, because the units used in the index make its values universal.

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