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Changes in the Spatial Structure of Agricultural Land and Their Influence On the Results of Agricultural Production

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Abstract. The results of the research included in the study concern the analysis of the spatial structure of agricultural land, belonging to non-resident owners for the object in the south-western Poland. The basic surface element adopted for the research was the continuous part of the registry parcel, covered by a one form of use. The specialized computer programs were used for the research and made it possible to obtain and process the necessary information contained in the land and building registry documentation maintained in a digital system. The adopted technology has allowed obtaining dozens of spatial configuration features of the surveyed parcels, which in the next stage were the subject to detailed research. The analysis covered eight basic features of the parcels layout, the first four of which determine the spatial parameters of the parcel, two further features concern the estimated cultivation costs dependent on its layout and the last two describe the location of the parcel in the village and in the farm. The obtained result gave the basis for finding positive and negative sides of the examined fragments in the existing land system, pointing to the disadvantages and limitations, resulting from changes made over the years.

1. Introduction

Socio-economic changes in agricultural areas are closely related to the function of a particular area and the organization of the production process carried out in its scope. The presented research results of many authors indicate a significant relationship between the spatial configuration of the farm land and its profitability [1, 2, 3, 4, 5]. From these researches, it appears that the land belonging to the farm should be optimally shaped and located as close as possible to the economic centre. This solution improves the organization of the entire agricultural production process, and first and foremost, it reduces the expenditures on transport that have a significant impact on the income.

Estimation of the size of economic changes, resulting from the modification of the shape of the parcel or the cultivated field, requires measurable recognition of geometric indices and the knowledge of the influence of individual elements of a farm's layout on the results of agricultural production [2]. Existing restrictions resulting from unfavourable location or the configuration of parcels, they reduce the production capacity of land, reducing the efficiency of the production process. It is therefore important to take such actions, which will enable the correction of existing defects in rural land systems and increase in the efficiency of the cultivation process.

2. The purpose, scope and method of the elaboration

The article is a continuation of the research, related to the assessment of the layout of farm land parcels in the area of the southern Poland. The aim of the article is to analyze and estimate the spatial configuration and distribution of non-resident owners land in the chosen village in the context of the reconstruction of its land system. The village of Koźlice located in the Lower Silesia Voivodship was the object of research. In the process of evaluation of the non-resident owners' farms land the specialized computer software was used, enabling determination of the spatial and technical parameters necessary for the assessment of the analyzed parcels and farms: „MK", „SWORG", „STATISTICA". The basic surface elements adopted for the research were the continuous parts of the registry parcels, covered by a one form of use (arable land) – conventionally defined in the study as a "parcel". The study of their shape involved the evaluation of their layout, by comparing individual features of the parcels layout with the values considered to be correct or optimal and analysis of the distribution of the parcels in the village, involving the examination of their location in relation to the adopted settlements and the centre of the village. The complete assessment of the configuration of the parcels was made using a synthetic measure of their configuration in the form of so-called cultivation costs, depending on the configuration and distribution of parcels [6]. The research covered all parcels existing in the village, being part of non-resident owners' farms.

3. Basic spatial and technical parameters of parcels

On the basis of the data contained in table 1, it can be initially statedwhat are some of the average parameters of the spatial configuration of the studied parcels. The obtained mean values of these features indicate that the examined sample is mostly shaped correctly, in addition to the indexes of cultivation costs, which have a significant increase in terms of access. Slightly different, more detailed information can be read from the developed number distributions, which clearly reflect the existing production conditions and indicate that the correct configuration of the analyzed parcels stated at the beginning of the analysis is slightly different. Figure 1 presents a graph of the distribution of parcels in relation to their area.

Table 1. Basic descriptive statistics of selected features of the spatial configuration of non-resident owners' parcels.

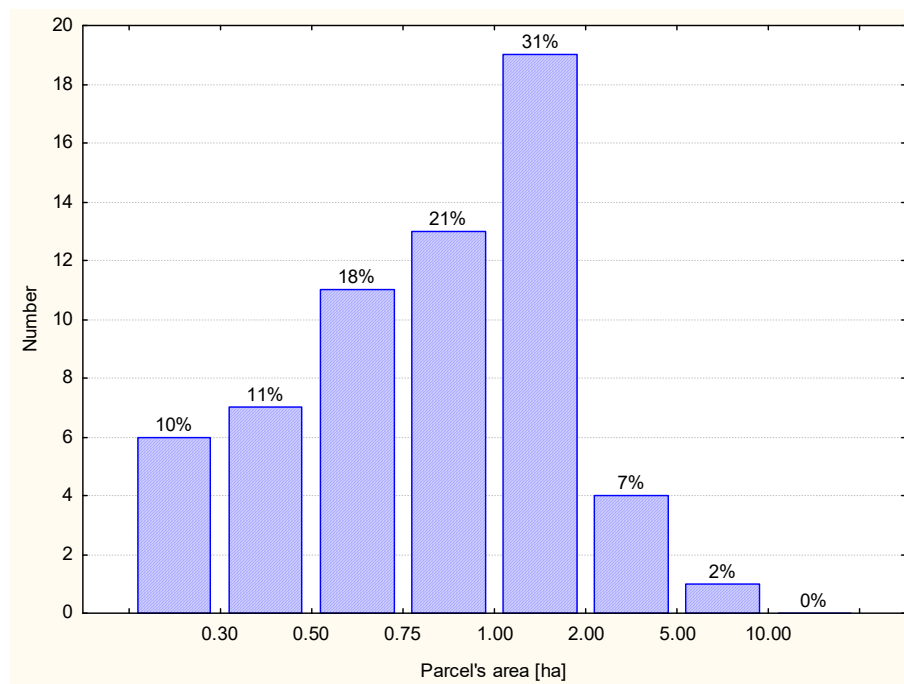| The name of the variable	The type of statistics			
	Average	Median	Minimum	Maximum
Area of the parcel [ha]	1,09	0,85	0,26	7,43
Length of the parcel [hm]	2,04	2,10	0,31	4,40
Width of the parcel [hm]	0,70	0,42	0,13	7,10
Extension of the plot	6,20	4,80	0,04	22,40
Layout costs without the access to the parcel [cereal units per hectare]	4,12	3,36	1,63	21,05
Layout costs with the access to the parcel [cereal units per hectare]	10,75	10,74	1,63	29,30
The distance of the nearest corner of the parcel from the particular settlement [hm]	11,80	8,72	1,75	31,64
The distance of the parcel from the center of the village [hm]	15,38	11,44	0,90	33,35

Figure 1. Distribution of the number of the parcels depending on their area.

According to [2, 3] the minimum area allowing the use of mechanical cultivation in field works should not be less than 1 hectare. In the analyzed graph, parcels with such a surface constitute only 40% of the surveyed population. The obtained results show that despite the high average area (1.09 ha) among the surveyed sample there are many parcels with the area that differs significantly from the optimal one. The majority of the surveyed population (60% of parcels) has too small areas below 1 ha. About 21% fall in the two smallest intervals up to 50 ares and nearly 40% have an area of 50 to 100 ares. Too small areas of parcels created during ground divisions, made over generations, cannot guarantee adequate income from agricultural production in these times. Inadequate area and the shape of a parcel under cultivation cause additional expenses, which reduce the obtained income. As it can be seen on the discussed example, it is worth to carefully examine the distribution of the features of particular elements of the spatial structure, because the general interpretation of the average values of the examined parameters may contribute to the misinterpretation of the existing production conditions and cause that the object requiring reconstruction will be omitted in the qualification process. Cultivation length is another parameter of the spatial configuration of parcels subjected to analysis. The average value of this parameter obtained in the calculation process in accordance with table 1 is equal 2.04 m. This parameter falls within the wide range from approximately 30 to 440 m. As results from the research, the optimal length of the parcel, which is covered by a mechanical cultivation process, should not be less than 100 m. Below this range, large costs associated with cultivation are generated, which reduce the income from production [7]. It follows from the distribution of numbers in relation to the areas of parcels presented in figure 2, that there are 24% of parcels which do not meet the optimum length criterion. In the first intervals of length up to 50 m there are very few of them - only 2%. In the next two intervals, as their length increases, parcels numbers reach 7 and 15% respectively. In the smallest optimal interval, the number of parcels is at the level of 16%. In other length intervals, there is the greater number of parcels with lengths from 200 to 300 m (about 40%) and from 300 to 400 m (16%). The remaining constitute about 7%. The result of the analysis of the length of the parcels confirms in this case compliance with the average value of this parameter. However, the length of the parcel alone does not affect the production efficiency as much as the area

and the next parameter, which is the cultivation width of the parcel. As can be seen from table 1, the average cultivation width of the considered parcels is relatively large and equals 70 m.
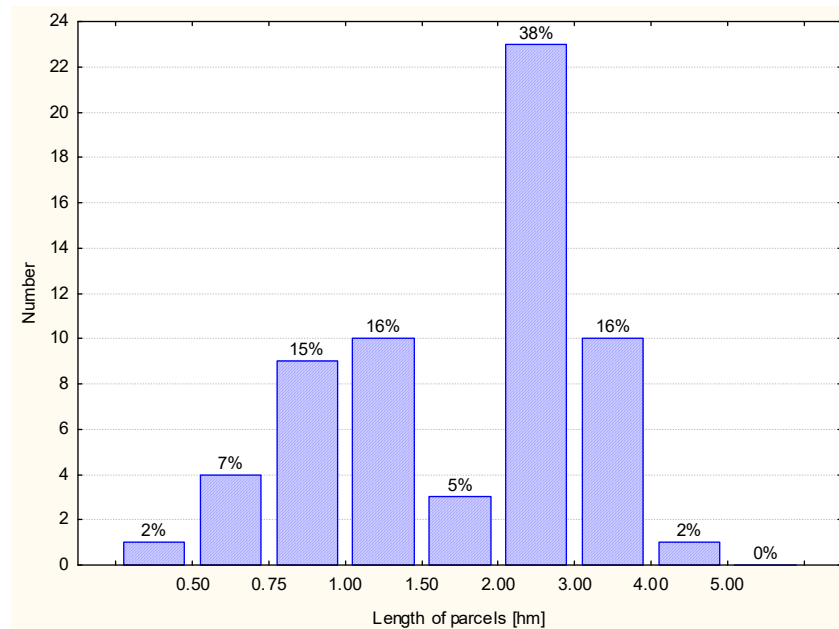

Figure 2. Distribution of the number of the parcels depending on their lengths.

According to [2], parcels with such widths can be covered by a mechanical cultivation process without generating additional cultivation costs. The minimum width of parcels considered appropriate in this case should not be less than 30 m. This means that the average value of the width parameter in the examined area is twice as large as the mentioned interval. Nevertheless, the occurrence of parcels with inadequate widths cannot be ruled out. Another distribution of parcels number in relation to their width (figure 3) accurately represents the entire examined population at particular widths ranges. The information contained in it shows that about 30% of parcels have unsuitable widths below 30 m. It is similar to the previously analyzed area and length parameters. The result indicates the adaptation of the land system to the horse-drawn agricultural tools used in the past, for which the optimal values of the tested parameters were lower. Analysing the distribution mentioned above it can be seen, that there are not many more parcels, only about 31% which fits in the smallest interval of the correct width. The remaining 59% of parcels have the widths appropriate for mechanical cultivation. The distribution of this population is characterized by a gradual decline in numbers, corresponding to the increase in the width of the parcels, except the last interval containing parcels with the widths greater than 200 m. The last discussed parameter will be the elongation of parcels. It has been estimated on the basis of the parcel area and its cultivation width. According to the obtained results, the elongations of parcels in the studied village fall into intervals from 1: 2 to 1:20 and more (figure 4). Extensions greater than 1:20, according to the regulations in force in Poland, are unacceptable [8]. Proper elongation of parcels is not a constant feature. According to [9], it depends on the area of the parcel. In practice, the elongation should be related to this feature, because it depends on the right proportions of length and width. With the exception of the first interval, which includes the most of parcels (about 31%) with elongations up to 1: 2, in almost every subsequent interval, the percentage of parcels is at the level from 8 to 18%, with the exceptions of intervals from 1:6 to 1:8 and beyond 1:20, where the percentage is 5% and 2% respectively. Considering the possibilities of implementing modern systems and solutions in the agricultural sector, the result of the research, including the four analyzed parameters, indicates the defectiveness of the examined spatial structure and points to the need of necessary changes.
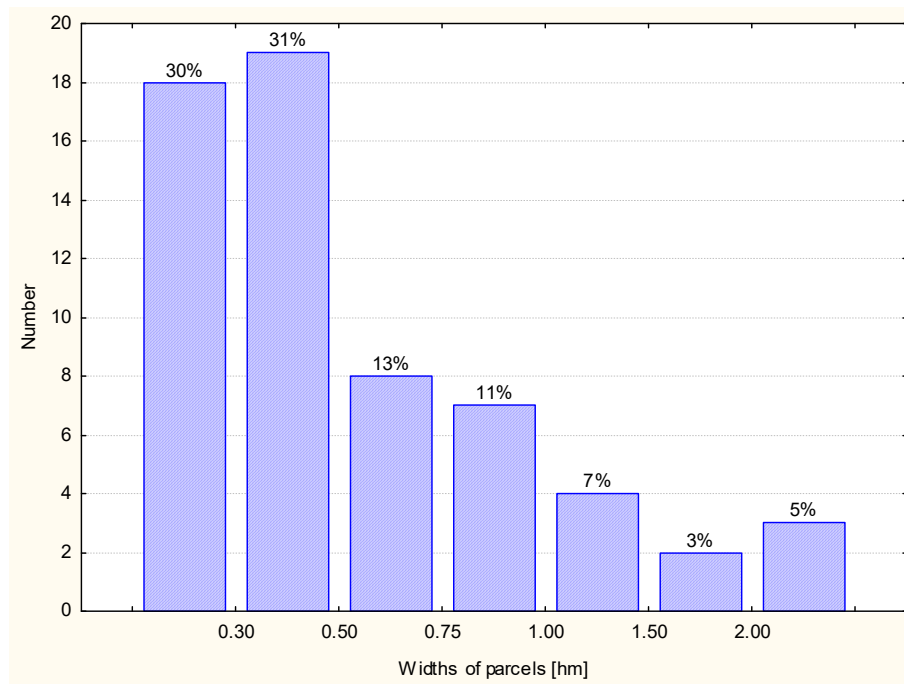
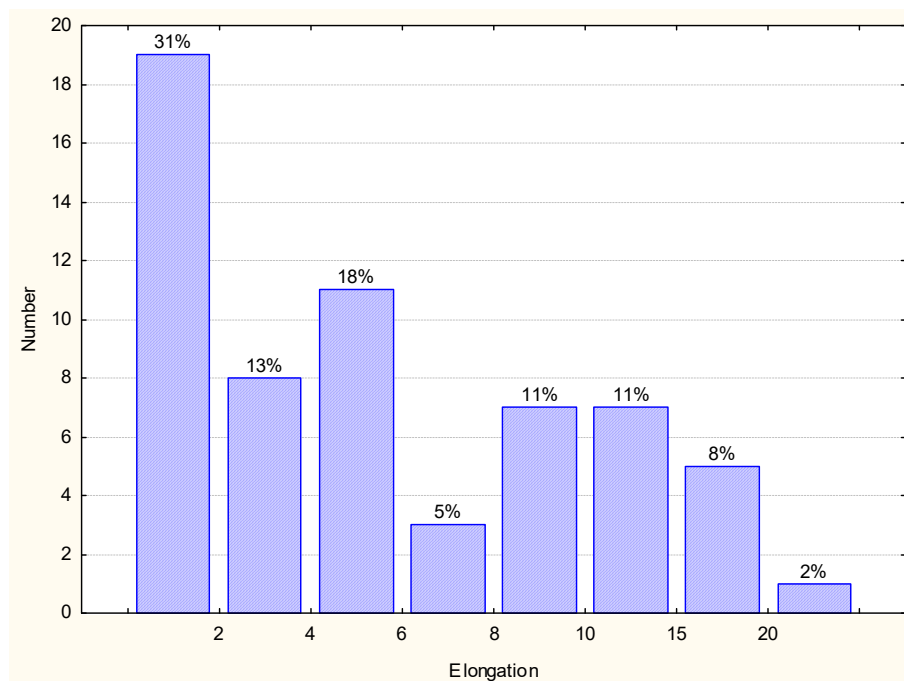**Figure 3.** Distribution of the number of the parcels depending on their widths.

Figure 4. Distribution of the number of the parcels depending on their elongation.

4. Location of parcels in the village

Assessment of the location of parcels within particular farms, settlements of which are outside the area of the studied village, was carried out basing on the distance of the nearest corner of the parcel to the agreed places of entry from the village, in which settlements of these farms are located. To analyze the location of parcels in the village, the distance between the village centre and the nearest corner of the parcel was used. The studied village is characterized by compact development in the central part,

which in the case of the ground system reconstruction may limit the possibilities of reduction of the distance from the settlements to the planned land parcels. It appears from the studies of [10] that the optimal distance of land from the settlement should not exceed 500 m. According to [11], this value should not exceed 1500 m. Basing on the location of buildings in the village and on the layout of the road network, the average distance of land from the accepted settlements was estimated. According to table 1, this value is 1180 m and is 358 m lower than the actual distance of land from the centre of the village. This fact confirms the presumed location of the non-resident owners' parcels in the places closest to the actual settlements. Such localization system of the parcels of non-resident owners may cause problems in the context of the acceptance of newly-separated surface shares. In the case of undertaking of land consolidation works, correct location of these parcels in the opinion of the (non-residential) owners can counteract the inclusion of this land into the consolidation proceedings and thus cause creation of new design invariants, limiting the possibility of building a new, more profitable land system. Considering this aspect, it would be more advantageous to conduct a consolidation process involving several neighbouring precincts, which would enable the separation of all land for individual farms in the localities, where their settlements are located. From the presented in figure 5 distribution of the number of parcels in relation to their distance from the adopted settlements and from the centre of the village follows, that along with the distance of the parcels from the village centre to 1000 m, there is an increase in the number of parcels both in relation to adopted settlements and to the village centre.
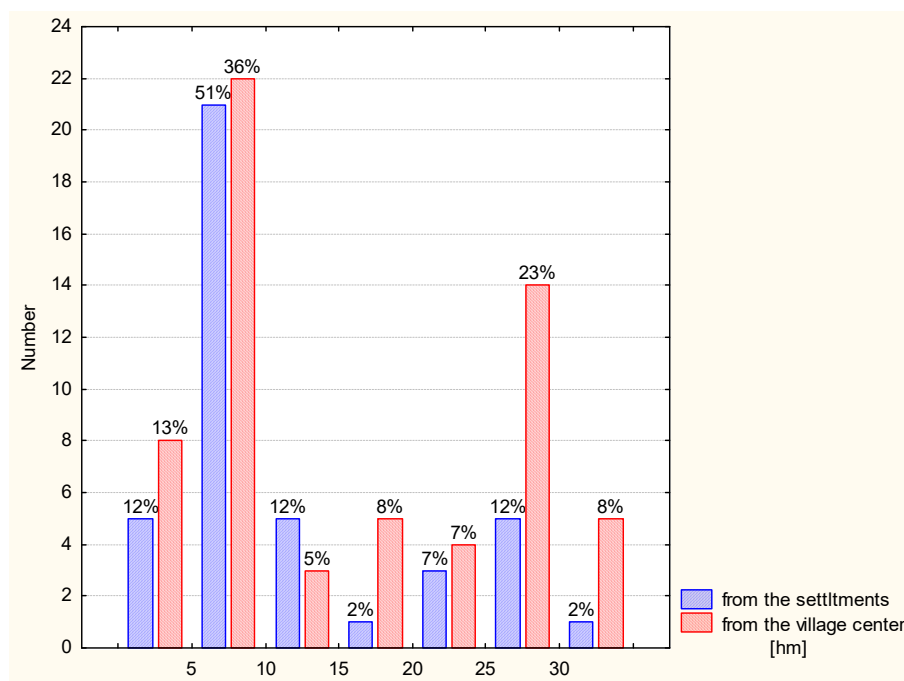

Figure 5. Distribution of the number of arable parcels depending on their location in relation to the settlements and to the centre of the village.

However, attention should be paid to the percentage of parcels in the second interval. In the distance from 500 to 1000 m and from 1000 to 1500 m in relation to accepted habitats, there are 15% and 7% more plots than those located in the centre of the village. Such result confirms the correct distribution of the examined lands near the determined places of entry. This is the natural result of the real estate trading, during which when making a decision about the acquisition of arable land, the closest location to the production centre is taken into account. Further intervals of parcels' distances are characterized by a reverse situation to that discussed previously. The smaller number of parcels in

the ranges from 1500 to more than 3000 m confirm the distribution of non-resident parcels in relation to the accepted places of entry and their small number, showing their sporadic occurrence in the central part of the object.

5. Cultivation costs dependent on the spatial configuration of parcels

The analysis of the values of basic parameters of the spatial configuration such as area, length, width or elongation, enables creation of a general picture of the land condition of the examined object. Separate analysis of these parameters, as was already stated on the example of elongation, can provide in practice information, which to some extent may be subject to interpretation irregularities. In this type of research, it seems more beneficial to use one synthetic measure of spatial configuration of land, taking into account all the mentioned parameters, including the location of parcels. For this reason, examination of the assessment of the shape of individual parcels were enriched with the analysis of the so-called cultivation costs depending on the parcel layout. The aforementioned index was estimated for each of the examined parcels assuming full mechanization of the field works using medium power tractors and the yields of cereals on the level 5 t/ha. According to [9] the size of this index for parcels with optimal area and correct shape should not exceed 4 cereal units /1ha. Determining its size for each parcel it can be stated, to what extent the analyzed population has correct or inappropriate configuration. For checking the correctness of the location of the tested surface elements, the cost ratio was estimated in two variants: without taking into account the distance from accepted settlements and with taking it into account. The obtained results were presentedon one distribution of numbers to facilitate the interpretation of the analyzed population (figure 6).
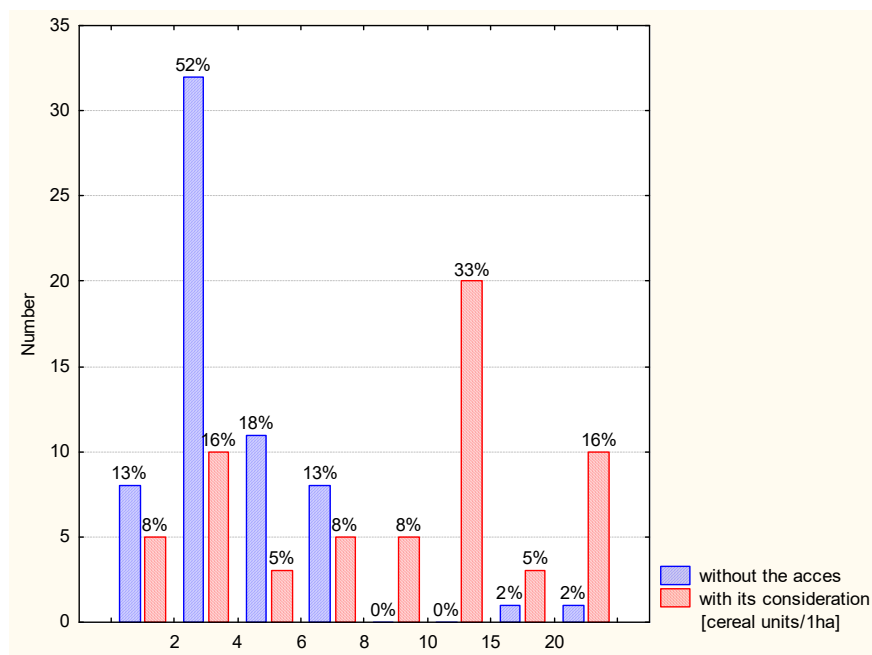

Figure 6. Distribution of the number of arable parcels depending on their cultivation costs.

In the examined village, the average value of land layout costs without access is at the limit of optimal value (table 1). Taking into account the distribution of parcels with regard to accepted places of entry, it should be noted that the level of the average value more than twice exceeds the acceptable limit and is equal over 10 cereal units /1ha. This value indicates that the location of the land of the non-resident owners, despite of the mostly proper concentration around established theoretical settlements, goes well beyond the acceptable range. This is also confirmed by the median value of this

parameter, which shows almost the same level. Analyzing the results contained in the distribution of parcels number in relation to their costs, including access and without this factor, It should be stated that the configuration of parcels itself in the studied village is mostly correct. About 65% of parcels are within the optimal range of cultivation costs depending on the spatial configuration of the parcel. About 18% slightly exceeds their acceptable level. Only 18% of parcels can be considered as defective. From the point of view of the assessment of the configuration of the parcels in the village it can be said that the situation is not bad. Keeping in mind, however, that an excessive increase in the distance of parcels from the settlement can significantly contribute to the increase in additional transport expenditures, the chart presents the second variant of the costs with access to the examined parcels. Comparing the distributions of both variants, some large discrepancies can be noticed. The observed significant change in the value of this parameter, unfortunately, indicates that only 24% of the parcels, not 65%, as it was the case previously, can be considered as properly configured. In subsequent intervals there are large numbers of parcels, the costs of which indicate a low level of agricultural production efficiency. If, in this case, the additional distance between the designated place of entry and the actual settlement of the farm would be taken into account, the index of cultivation costs could again rise significantly.

6. Conclusions

Research carried out in the field of evaluation of the configuration and distribution of parcels belonging to external non-resident owners in the village of Koźlice provided the basis for pointing out defects in the ground system, which developed over many generations. The results obtained indicate the deficiency of this system and the inability to effectively manage this area. This is confirmed by the detailed characteristic of the basic parameters of the spatial configuration of the parcels, as well as the analysis of their location relatively to production centres. The examined example well illustrates the impact of the location of parcels on the level of incurred cultivation costs depending on the spatial configuration of the parcel. The comparison of the results of this index in two variants on the one hand gives the basis for stating that the configuration of the plots of the non-resident owners itself in the studied area in about 65% can be assessed positively. On the other hand, if transport costs are taken into account, it drastically decreases and allows to state that only about 25% of the studied population can be assessed positively. The obtained values of indices of cultivation costs show a real picture of the lack of possibility of effective development of these plots and they lead to undertaking of reconstruction of the studied ground system. However, considering the correct configuration of approximately 65% of the surveyed population in the first variant (without taking into account the access) it can be considered if it would be more beneficial to replace the costly process of rebuilding this area with the exchange of land, which would significantly improve the production conditions both of the local farms, as well as of those which settlements are located in neighbouring precincts.

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