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ASSESSMENT OF THE EFFECTIVENESS OF LAND CONSOLIDATION WORKS, AS ILLUSTRATED WITH THE CASE OF BIELCZA VILLAGE

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Summary

Land consolidation is a process consisting in the designation of new cadastral plots with a different shape compared to the original ones, in order to reduce the number of small and scattered plots of land that make up a farm, and to increase the average size of homesteads. Within the scope of a land consolidation project, works related to post-consolidation land development are also carried out, which mainly include the creation of a functional network of access roads to agricultural and forest land, and the implementation of tasks, which impact the regulation of hydrographic conditions within the area covered by the consolidation, and which affect land reclamation.

Having understood the opportunities as well as threats related to the construction of the highway, the Self-government of the Małopolska region (Małopolskie Voivodship) initiated activities related to the implementation of the first infrastructural consolidations in Poland in relation to the proposed highway-adjoining areas. On September 21, 2005, an agreement was signed with the General Directorate for National Roads and Highways in Warsaw [Generalna Dyrekcja Dróg Krajowych i Autostrad w Warszawie], pertaining to cooperation regarding the consolidation of land related to the Kraków-Tarnów section of the A4 highway, currently under construction.

Infrastructural consolidation, otherwise known as highway-related land consolidation, is a procedure that consists in ordering the space adjacent to the highway construction area, as well as to another investment project in linear form. The purpose of the present article is to investigate the effectiveness of land consolidation works in connection with the construction of the highway, as illustrated with the example of a part of the village of Bielcza, in Borzęcin municipality, Brest district.

Keywords

village • land consolidation • A4 highway

1. Introduction

Land consolidation is one of the processes which is shaping agricultural space, the aim of which is to reduce the number of cadastral plots, while increasing their average area within one homestead [Long 2014]. It is an important tool in the process of agricultural

space renewal around the world [Huang et al. 2011]. It facilitates increasing the efficiency of agricultural production by reducing cultivation costs related to the cost and time of commuting to the fields [Lemmen et al. n.d.]. Furthermore, land consolidation is perceived as a comprehensive tool that allows the achievement of the agricultural economy objectives, while at the same time having a positive impact on the environment [Zang et al. 2021].

After the land consolidation process has been completed, the newly designated cadastral plots have a different shape, different area, and often also a different location compared to the original ones. Changing the parameters of the cadastral plots is aimed at optimizing the spatial parameters of farms in order to increase the efficiency of agricultural activity [Taszakowski and Doroż 2020].

Throughout the world, expectations for land consolidation work have evolved over the years [Jiang et al. 2022]. Land consolidation projects have ceased to be merely the means of shaping agricultural space; instead, they have become a comprehensive tool that is designed to carry out tasks in the socio-economic and environmental zone, while significantly affecting many areas of everyday life as well [Rao 2020]. Land consolidation works in Poland are carried out in accordance with applicable regulations, but also must comply with the guidelines of the European Parliament and the European Commission [Callesen et al. 2022]. In addition to improving the spatial parameters of agricultural land, land consolidation projects also address the task of post-reclamation land development, which is related to the creation of a functional network of access roads to agricultural and forest land. In addition, post-consolidation works regulate hydrographic conditions and facilitate land improvement in the area covered by the consolidation project [Taszakowski et al. 2017].

Land consolidation works are classified as complex, time-consuming and costly works, but their effects are visible in many areas of socio-economic life [Inceyol and Cay 2022]. Due to the high costs of consolidation works, they should be implemented in areas where it is possible to achieve the best results. These effects should be assessed by factors significantly improving the conditions for conducting agricultural activity [Janus et al. 2016]. Such conditions include the spatial structure related to the number and average size of cadastral plots. Reducing the average number of cadastral plots in the area covered by the land consolidation project and increasing their average size is the first factor that significantly influences the conditions for conducting agricultural activity [Zhou et al. 2019]. The improvement of the conditions for agricultural activity should be assessed not only in the context of changing the total number of cadastral plots in the area covered by the land consolidation project, but also in terms of improving the conditions for homesteads with the least advantageous spatial situation [Len 2018]. The improvement of the situation for farms with the worst spatial conditions translates directly into the land consolidation results for the entire area. Access to a public road facilitates transportation of both farming equipment and crops [Harasimowicz et al. 2017]. This makes it possible to reduce the time of transport, which in turn reduces costs for farmers [Bahar and Kirmikil 2021]. Increasing the efficiency of agricultural activity requires the use of modern agricultural equipment. If there are

plots of highly elongated proportions within the area of land consolidation project, the use of such equipment is difficult or may even be impossible. There are several methods for determining the elongation of cadastral plots [Demetriou et al. 2013]. These methods allow us both to identify areas with unfavourable conditions, and to assess whether the consolidation process has brought the expected results in terms of improving those conditions. The determination of the above indicators is the basis for the identification of areas in which land consolidation works should be carried out, and it facilitates the assessment of their effects [Wojcik-Len et al. 2018].

Only the application of modern IT tools in conjunction with the content of substantive knowledge allows for the correct implementation of land consolidation works, but also for a reliable assessment of their outcomes. There are several research methods that enable the assessment of spatial conditions [Basista and Balawejder 2020]. GIS tools are used in the majority of cases. The inclusion of spatial data and GIS tools in the analysis makes it possible to assess the current conditions both in the area covered by the land consolidation project, and in the areas where the implementation has already been completed. The use of GIS tools applied successively in different time periods allows for the determination of changes taking place in any area [Janus et al. 2022, 2021]. GIS tools are represented by both commercial and open source tools. Both of them make it possible to conduct analyses, which serve as a valuable source of information in the process of consolidating agricultural land.

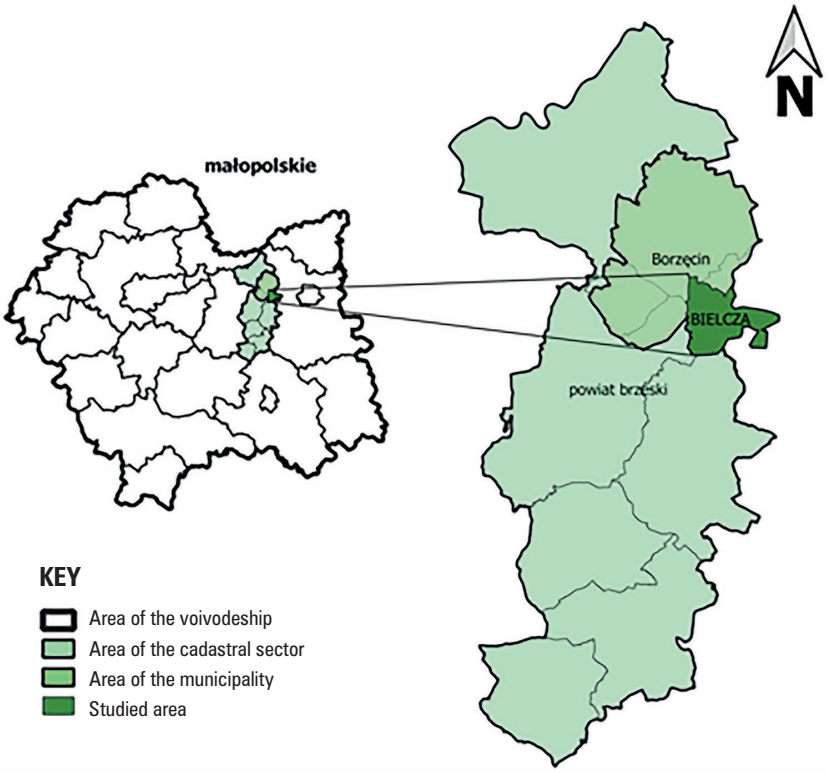
2. Study area

The study area covered the land record designation (cadastral sector) of Bielcza, located in the Borzęcin municipality, in the district of Brzeg, within the Małopolska region (Małopolskie Voivodship). The location of the stydied area is shown in Figure 1.

Bielcza is located in the south-eastern part of the Borzęcin municipality, adjacent to the following cadastral sectors: Biadoliny Szlacheckie, Wokowice, Łęki, Borzęcin, Waryś, Wierzchosławice, Biadoliny Radłowskie, and Łętowice. An important aspect is the presence of the Uszwica river, flowing through the western part of the village. The total area of Bielcza is nearly 1700 hectares, while the practical section is based on a part of the village, which was specified in the decision to initiate the land consolidation procedure.

3. Materials and methods

The article presents a methodology that allows for effective evaluation of land consolidation works for any given area. The work contains four analyses that facilitate an unequivocal assessment of the effectiveness of the consolidation process. These analyses combine vector data, represented by land and building records data, with GIS tools. The research also applied an orthophotomap in order to verify the obtained results. The solutions here presented make it possible to determine the situation in accordance with the condition before and after the land consolidation procedure, as well as to assess



Source: Authors' own study

Fig. 1. Location of the studied area

whether the overall situation in the consolidated area has improved as a result. The methodology was presented using the case of the Bielcza cadastral sector, but it can be applied to any given area. Each of the analyses was performed using the open source QGIS software application. The said application allows its user to work with the most important formats of cadastral data, containing both visual and descriptive information. In Poland, the applicable format for cadastral data is *.gml. It stores both vector information about the boundaries of cadastral plots and information about the owners of the plot, or about its belonging to a specific cadastral group.

The first analysis concerned the number of cadastral plots and their sizes, and it entailed comparing, on the basis of visual and descriptive data, the number of plots before and after consolidation, and their areas. The analytical process used the boundaries of cadastral plots covered by the consolidation project, as well as their area sizes. This latter data was obtained from the change log that was imported in the text file format and linked to the visual data. The attribute obtained from the combination of two data sources has been visualized in the QGIS software application.

The second analysis concerned the number of cadastral plots included within specific farms. It was carried out on the basis of 3 previously selected farms, charac-

terized by the largest number of plots of land that they comprised. It was based on the visualization of the distribution of cadastral plots belonging to individual homesteads against the background of the Bielcza cadastral sector. For this purpose, three different colours were used to depict cadastral plots of particular farms. The comparison of the condition before and after the consolidation procedure made it possible to evaluate the changes that took place for selected homesteads as a result of the land consolidation project.

The third analysis was related to the access of the studied cadastral plots to public roads. In order to perform that analysis, a spatial analysis was carried out, which used cadastral plots and information about those plots, which function as access roads. The spatial query was to indicate plots that have no connection with public roads. Then, an analysis of the improvement of parameters and functionality of the road network was performed. The width of the roads was measured on the orthophotomap in order to compare the status before and after the land consolidation procedure.

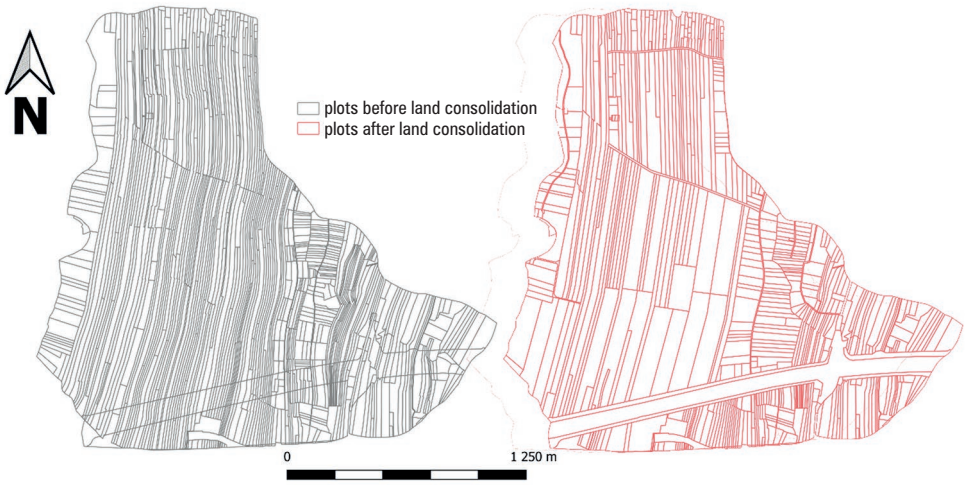
The last analysis performed was related to the elongation of the cadastral plots. The present work uses the method proposed by Bożek [2019]. It is based on the determination of parameters related to the length and width of the plot for a regular quadrangle containing all vertices of the plot vector. In order to obtain this parameter in the QGIS software application, the minimum bounding geometry function was applied, as well as the software functionalities allowing to combine the obtained parameters with the actual plots, and to calculate the ratio of the width to the length of the cadastral plot.

4. Results

4.1. Analysis of the number of plots and their sizes

Having compared the number of cadastral plots before and after consolidation, we found that it was reduced from 926 to 621. The number of plots decreased by 33% compared to the original quantity. The reduction in the number of cadastral plots is shown in Figure 2.

The set representing the sizes of cadastral plots has been divided into six ranges: below 0.1 ha; 0.1 – 0.2 ha; 0.2 – 0.5 ha; 0.5 – 1.0 ha; 1.0 – 2.0 ha; and above 2.0 ha. The largest change occurred in the range of area below 0.1 ha, where the number of cadastral plots decreased from 282, which accounted for 30.4% of the total number of plots, to 149, which accounted for 24.0% of the total number of plots. The number of plots in the first 5 ranges decreased by: 133, 100, 32, 44, and 15, respectively. The last range is an exception, where the number of cadastral plots did not decrease, but quite the reverse: it increased from 16 plots, representing 1.7% of the total number of plots to 35, representing 5.7% share in the total number of cadastral plots. The size of the area decreased from 329.1281 ha to 328.7776 ha, and this difference resulted from the establishment of the cadastral external border of the land consolidation area.



Source: Authors' own study

Fig. 2. Analysis of the reduction in the number of cadastral plots (left – before, and right – after the land consolidation procedure)

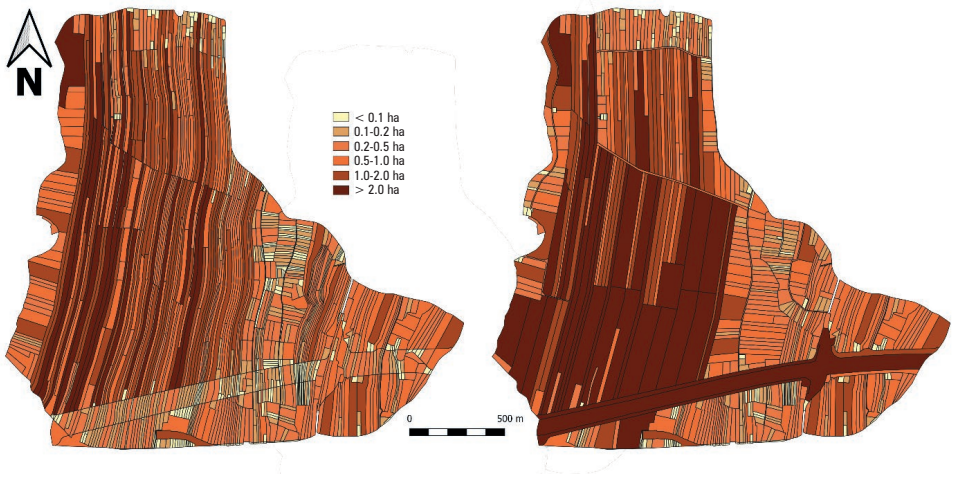


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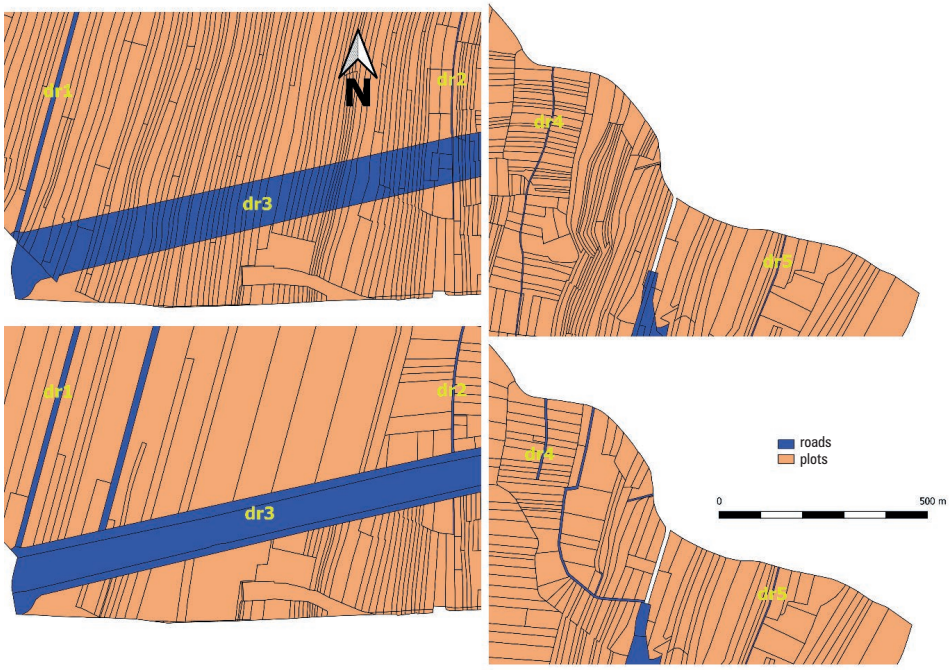
Fig. 3. Analysis of the fragmentation of cadastral plots (left – before, and right – after the land consolidation procedure)

4.2. Analysis of the cadastral plots' access to public roads and their quality

The analysis of the access of cadastral plots to public roads led to the conclusion that the number of cadastral plots with access to public roads increased from 554 (59.8% of all plots before land consolidation procedure) to 581 (93.6% of all plots after consolida-

Source: Authors' own study

Fig. 4. Analysis of public road access before and after the land consolidation procedure



Source: Authors' own study

Fig. 5. Analysis of the improved parameters of road network (top – before, and bottom – after the land consolidation procedure)

tion). Regarding cadastral plots with no access to public roads, their number decreased from 194 (21.0% of all plots before consolidation) to 14 (2.2% of all plots after land consolidation procedure). Cadastral plots constituting roads also decreased from 178 (19.2% of all plots before consolidation) to 26 (4.2% of all plots after land consolidation procedure). With the use of GIS tools, roads (blue), plots with access to roads (white), and plots with no access to roads (red) were visualized. The difference is noticeable due to the fact that after the consolidation the number of red plots is negligible, which is related to the reduction in the number of plots without access to public roads.

The second part of the analysis consisted in presenting, on the basis of five selected roads, the method for improving the parameters and functionality of the road network in the Bielcza area (Fig. 5). Each road was widened as a result of land consolidation. The greatest widening occurred in the case of the road marked 'dr1', because in this case the widening was by as much as 2.70 m. Other changes are presented in Table 1.

Table 1. Road widening

No.	Working designation of the road	Road width before land consolidation [approx. m]	Road width after land consolidation [approx. m]
1	dr1	10.50	13.20
2	dr2	2.80	5.00
3	dr3 (A4 highway)	110.50	110.50
4	dr4	3.20	4.90
5	dr5	2.90	3.00

Source: Authors' own study

4.3. Analysis of the number of cadastral plots within particular homesteads

The next analysis presents the results of the land consolidation procedure for the three largest farms (homesteads). In each farm, the number of plots has significantly decreased. The biggest difference can be noticed in the case of homestead No. 1, where the number of plots was reduced from 86 to 46. The second largest difference was recorded for homestead No. 3, where the number of plots was reduced from 16 to 4. The smallest difference was noted in homestead No. 2, where the number of plots decreased from 19 to 11.

A study was also carried out referring to the average plot area of the homestead, which increased in each of the studied cases, however, the biggest difference was noted for homestead No. 3, where the change was 1.2188 ha with an increase factor of 2.80.

In Figure 6, three colours have been used to indicate the assignment of plots to individual homesteads, whereas other farms that were not taken into account in the present study are marked in white.

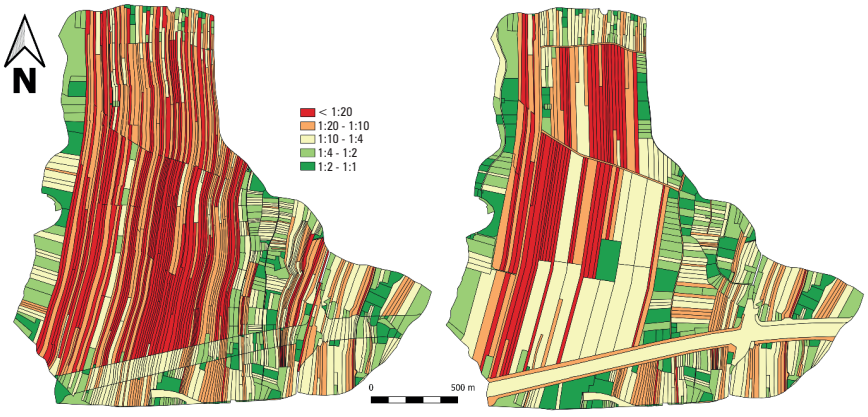
Source: Authors' own study

Fig. 6. Analysis of the number of cadastral plots within particular homesteads (left – before, and right – after the land consolidation procedure)

4.4. Analysis of the elongation of cadastral plots

The analysis of the elongation of the cadastral plots was carried out on the basis of five ranges of the plot elongation ratio: below 1:20; 1:20–1:10; 1:10–1:4; 1:4–1:2; and 1:2–1:1. The biggest change in the number of cadastral plots occurs in the range 1:10–1:4, where the number of plots has dropped from 322 (34.8%) to 200 (32.2%). The number of plots in the first four ranges decreased by 73, 96, 122, and 17, respectively. An exception is the last range, in which the number of cadastral plots increased from 88 (9.5%) to 91 (14.7%).

In Figure 7, the most elongated plots are marked in red, while the most favourably shaped ones are marked in green.



Source: Authors' own study

Fig. 7. Analysis of the elongation of cadastral plots (left – before, and right – after the land consolidation procedure)

5. Conclusions

As a result of the land consolidation procedure, there was a reduction in the number of cadastral plots, which resulted in an improvement in the area structure. The fragmentation of plots has decreased as a result of consolidation works. The average size of the land plots in homesteads was also increased. As a result of land consolidation procedure, the number of plots without access to public roads has decreased, which is a very beneficial outcome for owners who can use their fields more efficiently as a result. Another advantage of land consolidation is the minimization of costs related to access to some arable fields. As a result of land consolidation procedures, roads were widened, regulated, surveyed and designated with their own subdivisions. This allowed for their rational use and improvement of farming and forestry management in the studied area. In the case of the A4 highway, the cadastral plots that had been created as a result of previous divisions and regulations have now been consolidated. In connection with the consolidation of land, irregularities in the location of plots and the land checkerboard were eliminated. Also, the number of plots was reduced and their course was adjusted to design invariants, such as: roads, ditches, and construction areas. As a result of land consolidation project, cadastral plots were designed so as to be suitable for mechanical cultivation and, at the same time, to create better conditions for farming and forestry.

GIS tools allow for the assessment of areas covered by land consolidation procedures. By the application of GIS tools, it is possible to conduct a proper assessment, both in the areas where the consolidation is on-going, and in those where it has been completed. Such assessment can be conducted for any area. The proposed analyses are universal, and they can become an important element of the evaluation of the outcome of consolidation works.

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