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INCREASE IN THE MARKET VALUE OF LAND AS AN EFFECT OF LAND CONSOLIDATION PROJECTS

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ABSTRACT

Aim: The economic effect of an increase in the market value of land is a factor usually neglected in the assessment of land consolidation projects. However, it should be expected after procedures aimed at reorganizing the spatial structure of land plots. To fill the research gap in this area, a study was carried out to identify potential changes in land values as a result of completed land consolidation projects. **Methods:** Data from nine land consolidation projects carried out in Poland between 2007 and 2013 was used in addition to the results of an artificial neural network model developed within the framework of statistical analyses of agricultural real estate markets for municipalities where land consolidation projects were carried out. **Results:** Taking into account the increase in the market value of land as a result of consolidation, the balance of costs and benefits of planned or implemented projects significantly improved. The increase ranged from 1.2% to as much as 28.4%. **Conclusions:** The effect of increased land values would be a serious argument in assessing the profitability of implementing land consolidation projects. The increase in land value as an economic and social effect of land consolidation increases the probability of revitalizing local property markets and contributes to the wealth and creditworthiness of landowners. Exposing this effect can increase public interest and support for the implementation of consolidation projects, which is a very important step on the way to village renewal and activation.

Keywords: land consolidation, market value of land, statistical methods, land valuation, neural networks

JEL codes: Q15, R32, C45

INTRODUCTION

Among the factors taken into consideration when evaluating consolidation projects, the economic effect of the increase in the market value of land tends to be overlooked. Although the aspects of production values – which are determined by the surface area, shape and quality of agricultural land [Leń 2018, Colombo and Perujo-Villanueva 2019, Nguyen and Warr 2020] – are usually addressed, these characteristics do not exhaust the list of important determinants of the market value of agricultural land [Marks-Bielska 2013]. There is no practice of analyzing the agricultural land market prices in the consolidated areas. No one poses the question of how these prices will increase upon the improvement of the layout of the village in question, although this is to be expected. Market value change seems vital, especially from the perspective of landowners [Wojewodzic

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et al. 2021]. This effect can be considered potential since it will only be monetized when transactions are made or farmers apply for mortgages or contribute land as assets to a company. Therefore, the awareness that the market value of possessed land will increase can already serve as an important incentive for increased social acceptance of land consolidation projects [Lisec et al. 2014], especially since agricultural land is an essential element of estate for most farmers [Krupowicz et al. 2020]. An increase in the market value of land leads to an increased amount of a potential sales transaction or a potential loan, with the land serving as mortgage collateral. The improvement of agricultural suitability and an increase in potential market value itself may prevent farmers from abandoning land cultivation. Where the value of land is high, it is more reasonable to cultivate – even sporadically – or lease it. A revival of the real estate market and its main functions can also be expected – above all, the correction of space [Kucharska-Stasiak 2000].

The existing research also indicates that one of the positive long-term effects of consolidation project implementation is a noticeably lower percentage of areas permanently set aside and abandoned [Janus and Markuszewska 2019, Janus and Bozek 2018] (i.e., areas where market value is depreciated). Reduction of land fragmentation and improvement of access to fields, which is connected with the process of land consolidation, constitutes a significant benefit to landowners [Muchová and Jusková 2017, Lisec et al. 2014]. Indeed, convenient access to property is regarded as one of its most important features on the local market [Schilbach 2001, Wojewodzic et al. 2021, Dacko et al. 2021]. This refers to both agricultural plots and those intended for construction purposes in the future. It is worth remembering that changes in the layout of farms [Leń and Król 2016], a new network of roads [Krupowicz et al. 2017], and an increase in property value are factors that increase the interest in agricultural land among potential buyers from outside the area.

The impact of land consolidation implementation on the value of agricultural land is a complex issue. This is because the implementation of consolidation projects involves a change in the aspect that is key to land value, namely the location and geometric features of the plots of individual owners [Lazić et al. 2020, Uyan et al. 2020]. Due to the use of land-value maps in the process of executing consolidation projects and the principle of equivalence before and after consolidation [Muchová et al. 2018], which is commonly applied in such projects, it appears that the value of land should remain unchanged [Tezcan et al. 2020]. However, value maps used in consolidation projects usually show the agricultural suitability of land in a given region of the village being consolidated, not the market value of the individual plots or whole properties. According to the assumptions of consolidation projects, plots' average surface area, their distance from farm buildings, and shape and access to roads are the parameters that should improve by implementing a land consolidation project [Krupowicz et al. 2017, Ertunç 2020]. Other things that often get improved (depending on the scope of the investments) are water conditions and the quality of accessways [Kirmikil and Arici 2013]. In many cases, the plots' spatial parameters qualify them for construction purposes, provided that their location meets the local conditions of spatial planning [Salata et al. 2015]. Consolidation also improves the land's farming conditions as a result of such activities as the elimination of escarpments, shrub removal, or other rehabilitation measures [Pijanowski et al. 2021]. Consequently, there are many actual and potential benefits of consolidation projects, which, when taken into consideration, may significantly improve economic assessments of the efficiency of such endeavors. In addition to the above, there is another generally overlooked effect. This is the aspect the authors addressed by analyzing local agricultural land markets and using data from nine consolidation projects carried out in Poland between 2007 and 2013. The research was conducted in 2019 as part of implementing the KSOW project 'Economic Efficiency of Land Consolidation in Poland'.

DETERMINANTS OF THE VALUE OF AGRICULTURAL LAND

A key element in considering the value of land is its location. The origins of the economic theory of location and the rent of land theory are associated with the work of classical economists, who based their work

[2] Directive 2009/28/EC of the European Parliament and of the Council has been substantially amended several times. From the need for further amendments, the directive had to be recast for the sake of clarity

on the observation of activities in agriculture and farm operations. Smith's thesis that doing business in different locations entails different costs and yields different results was developed by Ricardo, Thünen, and Weber, laying the foundations for land rent theories [Wojewodzic 2017]. Agricultural production space, through its quality and location, significantly affects the economic results obtained. Therefore, compared to other characteristics, the location of agricultural land is of primary importance to market participants – especially with respect to neighbor trade. Śnieg [2003] noted that location is one of the most critical factors impacting the market value of any property, including agricultural ones. One may even state that the location of an agricultural plot determines its other characteristics (i.e., neighborhood, surface area, and access. As pointed out by Woch et al. [2011], in Polish conditions, driving over one kilometer to a plot smaller than 1 ha is not economically viable. Croplands that are too small hinder the intensification of production and, thus, limit the possibility of generating the differential rent due to the quality and location of the land [Wojewodzic 2017].

Agricultural properties, in addition to attributes that are common to properties in general (i.e., location or surface area [Tomić et al. 2021, Demetriou 2016]) also have attributes that are specific to them because they create conditions for agricultural production. Consequently, the professional Polish standards of asset valuers recommend that the following characteristics are taken into consideration when describing and evaluating the state of undeveloped agricultural properties not intended for construction and not having the potential for land-use change:

- location, position, and neighborhood;
- value in use (soil valuation) and land diversity;
- surface area, shape of the property, and topography;
- accessibility as well as availability of structures and equipment used for agricultural production;
- obstacles to cultivation (e.g., flintiness, infrastructure network, etc.);
- agricultural condition.

As research by Śnieg [2003] demonstrates, the layout of a farm's fields in the aspect of its shape is an important factor impacting the value of agricultural properties. An agricultural plot may take the form of various geometric figures [Akkaya Aslan 2021]. It may have an elongated or compact shape, regular or irregular. These shapes may be more or less advantageous from the perspective of agricultural activity, which is not unimportant to market participants. Other important factors determining the value of agricultural land include, according to Śnieg, surface area, land quality and its accessibility, the neighborhood of the agricultural plot and its distance from a built-up area, as well as the factor of time.

According to Woś [1996], agricultural land is worth what the buyer offering the highest price is willing to pay for it. Acting rationally, they will condition the price on expected benefits, which are determined by the property's market features (attributes).

Bud-Gusain [2005] noted that the degree of usability of both a single plot and a larger complex of plots is determined (in spatial and economic terms) by the layout, surface area and structure of agricultural land, soil valuation, and share of the different soil valuation classes in the agricultural land, as well as water conditions and climate for farming [Ertunç et al. 2021]. Schilbach [2001] points to such features as location, shape and size of an agricultural plot, quality of land, distance from the center, accessibility, and agricultural condition. Marks-Bielska and Lizińska [2015] noted in their research that in Polish conditions, location (relative to rural buildings), soil quality, and surface area have the most considerable impact on the prices of agricultural properties. However, the market prices of land showed that market participants also took into consideration the area's forest cover in addition to the occurrence of adverse farming conditions. Kempa [2010] also highlighted the importance of the surface area of agricultural plots but with respect to using them for non-agricultural purposes, as well as the price-impacting roles of soil quality and distance from a densely built-up area.

What emerges from the above-cited studies dedicated to the issues of agricultural land value in Polish conditions is a set of recurrent factors and attributes that should be obligatorily considered in analyzing and modelling local markets [Dacko et al. 2021]. Over a short period of time, these elements remain practically unchanged for all the plots in a given village, although they certainly undergo slow, evolutionary changes. However, consolidation changes the situation radically. It results in the creation of new plots with more advantageous variants of market features [Wojewodzic et al. 2021]. This change cannot occur without impacting the value of agricultural land in the village where a consolidation project is carried out.

In the case of land consolidation, awareness of the potential increase in the market value of agricultural land can be an important argument for the local community to proceed with consolidation.

Estimating a potential change in land value due to consolidation project implementation seems to be a valuable complement to the existing studies on the effectiveness of the execution of land consolidation projects [Kirmikil and Arici 2013]. To fill the research gap in terms of covering all the actual and potential effects of consolidation project implementation, a study was designed and conducted, which involved a group of nine consolidation projects carried out in Poland from 2007-2013. A comprehensive examination of the factors impacting the value of agricultural properties within the municipalities covered by the consolidation projects, along with an analysis of the changes in the plots' features as a result of a consolidation project, allowed the authors to determine potential changes in land value as a result of consolidation project implementation.

STUDY AREA, DATA SOURCE, AND METHODS

The evaluation of the impact of consolidation projects on land value changes was preceded by the acquisition and processing of data on nine consolidation projects located in six Polish voivodeships:

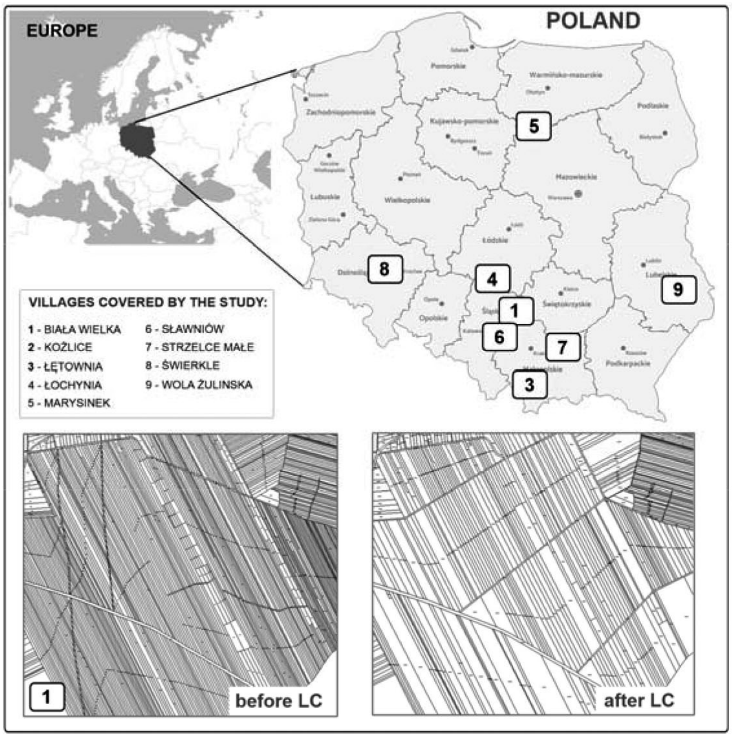

Fig. 1. Location of the areas under consolidation covered by the study with an example of changes resulting from a land consolidation project

Source: own study.

Lesser Poland, Lublin, Silesian, Lower Silesian, Masovian, and Opole (Fig. 1). Also, data on the market trade in agricultural properties in the municipalities where the consolidation projects where implemented was used. The data came from all the precincts in the municipality where the consolidation project was implemented.

Based on data obtained from official registers of property prices and values (maintained in Poland at the level of *powiat*, i.e., the second-level unit of an administrative division of Poland), a database was created containing the prices of unbuilt agricultural plots sold on the market in 2018–2019 (292 transactions in total). Each transaction was described using parameters that, in light of the literature review, were regarded as potentially significant in modelling the values of agricultural plots. The information included market price, surface area and structure of the agricultural areas, transaction date, location (voivodeship, tax district, municipality, village, plot number), and geometry (length, width, and perimeter) of the plots. Moreover, each plot was assessed in terms of shape, precise location, neighborhood, access to a public road, obstacles to usage, level of agricultural condition, and distance from the nearest built-up area. In summary, all relevant market characteristics of undeveloped agricultural land were taken into account, including three key characteristics that change due to the land consolidation project (plot area, plot elongation, and road access).

Statistical analysis of the market was adopted to determine changes in agricultural land value. It was carried out using neural networks. The reason for selecting this tool was the fact that on the real estate markets, the relationships between the analyzed features are usually non-linear and non-monotonic. In such situations, neural networks work well [Lanillos et al. 2020]. The criterion taken into account when choosing a neural network model was the principle simplicity of modelling [Szaleniec 2008]: if several different models explain a given phenomenon to a similar extent, the model that is conceptually simpler should be chosen. As McCluskey [1996] noted, a more complex network analyzes more input variables but also requires more observations. Therefore, the simplest possible network architecture was searched for, with a moderate number of neurons in the input and hidden layers (Fig. 2).

The aim of the study also necessitated taking into account the market features that change significantly

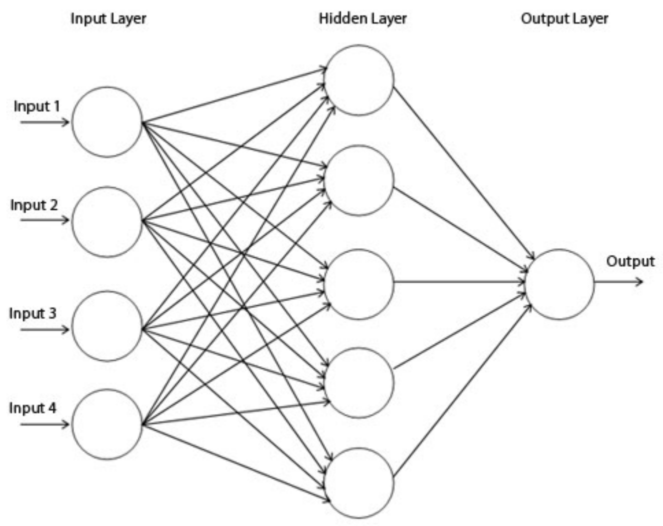

Fig. 2. Neural network illustrative structure
Source: own study.

Table 1. The list of predictors used for an artificial neural network model

Item	Name	Predictor values or variants
1	Tax district	1, 2, 3, 4 – pursuant to the Act of 15 November 1984 on agricultural tax and the Regulation of the Minister of Finance of 10 December 2001 on assigning municipalities and cities to one of four tax districts
2	Location (general)	Average level of unit prices (PLN/m2) for municipalities from which the data on transactions involving agricultural plots were obtained: Szczurowa (2.4), Jordanów (4.2), Lelów (2.3), Mykanów (1.6), Łopiennik Górny (2.3), Mściwojów (4.8), Pilica (2.8), Praszka (2.4), Gaworzyce (3.2), Dobrzeń Wielki (3.6), Opole (2.9), Strzegowo (2.7)
3	Location (detailed)	1 – peripheral (away from settlement development clusters) 2 – indirect (bordering settlement development clusters) 3 – built-up zone (location within settlement development clusters)
4	Quality of land (soil)	Variants of calculated soil valuation index Wb (quotient of the surface area calculated for agricultural tax and the physical surface area): 1 – poor (Wb to 0.8) 2 – average (Wb above 0.8 to 1.2) 3 – good (Wb above 1.2 to 1.6) 4 – very good (Wb above 1.6)
5	Share of arable land	Values from the range of 0.00 to 1.00, calculated as the quotient of the surface area of arable land and the total area of a parcel of land
6	Observed limitations in use	1 – large (simultaneous occurrence of at least two aspects such as: flintiness, wetness, noticeable soil variability, bushes and coppices, wasteland, proximity of forests, sharp angles of plot boundaries) 2 – moderate (one of the above) 3 – lacking
7	Neighborhood	0 – not directly bordering a built-up area 1 – directly bordering a built-up area
8	Plot area	up to 0.5 ha (very small plots) from 0.5 ha to 1 ha (small) from 1 ha to 2 ha (middle-sized) from 2 ha to 3 ha (large) above 3 ha (very large)
9	Plot elongation	Values in a range from 1.0 to 114.6, calculated as a quotient of a parcel's sides (longer/shorter)
10	Road access	0 – no access to a road 1 – access to a road

Source: own study.

as a result of the implementation of a land consolidation project and, in accordance with the theoretical premises and initial data analysis, have the largest impact on the value of agricultural land (Table 1).

The model was developed using the Statistica 13 package with a Data Mining module. The size and structure of a neural network is always determined by the complexity of the phenomenon under study, particularly the number of explanatory variables considered [McCluskey 1996, Szaleniec 2008]. For the purpose of building the network, the data is divided into three subsets [Migut 2019]. In this case, the division was as follows:

- training set – 70%;
- test set – 15%;
- validation set – 15%.

Of the several dozen networks tested in parallel within 200 epochs, the best results were achieved by multilayer perceptron (MLP). As indicated by Szaleniec [2008] and Tadeusiewicz and Szaleniec [2015], this neural network model is currently very popular. The multilayer perceptron had one hidden layer numbering 11 neurons. For hidden neurons, a hyperbolic tangent (tgh_x) was selected for the activation function:

$$tgh_x = \frac{\sinh_x}{\cosh_x} = \frac{e^x - e^{-x}}{e^x + e^{-x}} \qquad (1)$$

where:

x – neuron's total excitation signal

e – Euler's number

For the output neuron, the activation linear function (*y*) was selected:

$$y = ax + b \qquad (2)$$

where:

x – neuron's total excitation signal

a – slope

b – intercept

These settings are recommended for multilayer perceptron resolving regression problems using the sum of squares (SoS) as an error function:

$$E_{SoS} = \Sigma_{i=1}^{n}(Y_i - t_i)^2 \qquad (3)$$

where:

Y_i – predicted values

ti – actual values

n – number of observation

RESULTS

To ensure the necessary minimum of predictors (equivalent to the number of neurons in the input layer), an analysis of network sensitivity (N_s) was conducted. This neural network functionality shows which input data are most relevant. The sensitivity analysis indicates an error increase due to the elimination of individual predictors from the neural network model [Tadeusiewicz and Szaleniec 2015]. Sensitivity analysis indicates the role of a given predictor in the model. In light of sensitivity analysis, particularly relevant were access to a road (N_s= 6.70) and location factors – general location (N_s = 2.57), specific location (N_s = 2.52), and tax district (N_s = 2.18). Relatively important factors were soil quality (N_s = 2.07), obstacles to usage (N_s = 2.05), and a parcel's vicinity (N_s = 2.03). A less important role was played by surface area (N_s = 1.34), the share of arable land (N_s = 1.20), and plot elongation (N_s = 1.05).

Regarding the accuracy of the model, it was found that the correlation levels between the actual and predicted values were as follows: 0.89 – for the training set, 0.82 – for the test set, and 0.80 – for the validation set. These results were acceptable because, according to theory, the results for the validation set should not be significantly different from the test set [Szaleniec 2008, Migut 2019].

Once the model was developed, changes in selected features of plots before and after consolidation were examined for nine consolidation projects (Table 2).

Table 2. Changes in selected features of plots in the analyzed group of land consolidation projects

Village name	average area of the plot (ha)		average elongation of the plot		number of plots without access	
	before consolidation	after consolidation	before consolidation	after consolidation	before consolidation	after consolidation
Biała Wielka	0.32	0.54	31	24	102	17
Koźlice	0.71	1.03	6	5	2	0
Łętownia	0.12	0.23	5	4	1400	169
Łochynia	0.44	0.99	12	10	51	3
Marysinek	0.87	1.88	7	6	16	0
Sławniów	0.35	0.62	7	9	226	14
Strzelce Małe	0.41	0.66	12	8	178	16
Świerkle	0.93	2.95	12	7	41	1
Wola Żulińska	0.37	0.75	16	15	100	3

Source: own study.

Table 3. Changes in land value as a result of land consolidation project implementation

Village name	Eligible costs of the consolidation project and post-consolidation management	Market value of the land (2019)		Change in the market value of the land	
		before consolidation	after consolidation		
	mln PLN*	[PLN/ha]*	[PLN/ha]*	[%]	mln PLN*
Biała Wielka	10.495	19461	20499	5.3	0.989
Koźlice	2.883	34764	36087	3.8	0.704
Łętownia	5.545	29459	37820	28.4	6.307
Łochynia	1.792	21929	23877	8.9	0.651
Marysinek	1.603	24736	25628	3.6	0.362
Sławniów	4.282	24419	24717	1.2	0.203
Strzelce Małe	3.418	19195	21575	12.4	1.312
Świerkle	0.774	32074	35415	10.4	0.796
Wola Żulińska	3.125	19693	20971	6.5	0.601

* In nominal prices.

Source: own study.

The villages varied significantly regarding the average surface area and elongation of a plot before and after consolidation (Table 4). Also, the percentage of plots without access to a public road varied markedly. Especially high fragmentation of plots was recorded in the village of Łętownia. The average surface area of plots in this village increased twice as a result of land consolidation, but it was still insufficient from the perspective of modern requirements of farming (0.23 ha). The villages of Marysinek and Świerkle compared favorably in terms of post-consolidation plot size. The surface areas of the plots in these villages were already large before the implementation of consolidation projects and, as a result of consolidation, their size increased even further. In Marysinek, the surface area of plots grew to 1.88 ha. Meanwhile, in Świerkle, the average size of a plot after consolidation was almost 3 ha.

The worst average plot elongation (31:1) before consolidation was recorded in the village of Biała Wielka. After consolidation, the elongation was reduced by 21%, but it still remained the largest compared to the other villages. Plot elongation was most reduced in the villages Świerkle (by 39%) and Strzelce Małe (by 35%). It is worth noting that in the village of Sławniów, this parameter (with a moderate value of 7:1) increased by 19% after consolidation. A relatively smaller elongation was recorded in the villages Łętownia (5:1) and Koźlice (6:1). Nonetheless, consolidation projects improved this parameter – by 28% in Łętownia and by 17% in Koźlice.

Plots without access were most numerous in the village of Łętownia (1,400 cases). As a result of consolidation, their number fell to 169. It is worth repeating that the issue of access was very important in the valuation of agricultural land in the ANN model. A significant reduction in the cases of a lack of road access was achieved in the following villages: Sławniów, Strzelce Małe, Biała Wielka, and Wola Żulińska (Table 2). Projected changes in value were made for each of the nine areas separately (Table 3). There was no statistically significant effect-of-time trend on changes in market prices of agricultural land during the period studied. The value of 1ha of land before and after consolidation was presented for each village.

Changes in land value was most noticeable in the village of Łętownia, where the increase was 28.4% – which, in the case of this consolidation project, corresponded to a total amount of PLN 6.3 million. A large increase in value (12.4%) was also recorded in the village of Strzelce Małe. It was estimated at PLN 1.3 million. A relatively smaller effect was recorded in the villages Sławniów (1.2%) and Marysinek (3.6%), where the value of land increased by PLN 203,000 and PLN 362,000, respectively.

Creating an increase in land value is not fundamentally the aim of land consolidation projects; it is an aspect that is usually overlooked. However, changes in land market value in light of the ANN model with respect to eligible costs of land consolidation projects indicate that public funds can also be spent more efficiently in this context. The investment in the villages Łętownia and Świerkle showed a very good ratio of investment to effect, which was almost 1:1.

CONCLUSIONS

The elaborated model indicated that the impact of a land consolidation project on land value, though it varies, proved to be significant and should not to be overlooked in the process of evaluating the effects of such activities. The average extent of land value changes at the level of the entire villages analyzed was large and indicated the reasonableness of analyzing each completed consolidation project on an individual basis. Agricultural real estate prices were determined in a neural networks model by many different predictors. Some of them were improved by land consolidation. Such changes, according to the model results, have contributed to an increase in land value.

Based on the studies, it can be stated that land value change was largely determined by the extent of changes in the analyzed features of parcels of land, such as their size, shape, and access to a road. An important aspect was also the varying extent to which the analyzed features impacted land value in different municipalities.

Changes in land value as a result of consolidation projects can be treated as one of the effects included in a direct economic analysis of the costs and benefits of consolidation project implementation. They can also be viewed in social terms as a long-term factor impacting the development directions of a given locality and landowners' decisions about land uses or sales.

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WZROST WARTOŚCI RYNKOWEJ ZIEMI JAKO EFEKT REALIZACJI PROJEKTÓW SCALENIOWYCH

STRESZCZENIE

Cel: Ekonomiczny efekt w postaci wzrostu wartości rynkowej gruntów rolnych jest czynnikiem zwykle pomijanym w ocenie projektów scaleniowych, choć należałoby się go spodziewać jako następstwa zabiegów porządkujących strukturę przestrzenną działek. Dążąc do wypełnienia luki w badaniach naukowych podejmowanych w tym zakresie, autorzy artykułu zrealizowali projekt, którego celem była identyfikacja i określenie w wymiarze kwotowym oraz procentowym potencjalnych zmian wartości gruntów w wyniku wykonanych projektów scalenia gruntów. **Metody:** W opracowaniu wykorzystano dane z 9 projektów scalenia gruntów zrealizowanych w Polsce w okresie od 2007 do 2013 roku oraz wyniki modelu sztucznej sieci neuronowej opracowanego w ramach analiz statystycznych rynków nieruchomości rolnych dla gmin, w których przeprowadzono projekty scalenia gruntów. **Wyniki:** Z przeprowadzonych badań wynikało, że w efekcie scalenia dochodzi do wyraźnego wzrostu wartości rynkowej gruntów rolnych, a uwzględnienie tego faktu znacząco poprawiłoby bilans kosztów i korzyści realizowanych projektów scaleniowych. Wzrost ten zawierał się w przedziale od 1,2% do nawet 28,4%. **Wnioski:** Efekt wzrostu wartości gruntów rolnych byłby poważnym argumentem w procesie oceny opłacalności realizacji projektów scaleniowych. Wzrost wartości ziemi jako ekonomiczny i społeczny efekt scaleń gruntów zwiększa prawdopodobieństwo ożywienia lokalnych rynków nieruchomości przyczyniając się do wzrostu zamożności i zdolności kredytowej właścicieli tych gruntów. Zdaniem autorów opracowania, eksponując ten skutek można zwiększyć społeczne zainteresowanie i poparcie dla realizacji projektów scaleniowych, które są bardzo ważnym krokiem na drodze do odnowy i aktywizacji wsi.

Słowa kluczowe: scalanie gruntów, wartość rynkowa gruntów, metody statystyczne, wycena gruntów, sieci neuronowe