

# **Analysis of the Determinants of Land Property Prices in Rural Areas in Poland**

**Monika MALETA, Beata CALKA and Elzbieta BIELECKA, Poland**

**Keywords:** Cadastre, Land Management, Property Taxes, Valuation

## **SUMMARY**

Transaction prices of land property are influenced by a number of factors that also affect the attractiveness of the market area. Land property prices determinants can be studied because of the impact they have on modelling transaction prices and terms of their correlation. The study attempts to analyze some characteristics influencing agriculture land property prices, and then taking into account the relationships delineation areas where land property prices are similar. The elaboration is a theoretical and empirical. The considerations were carried out in the context of changes in transaction prices under the influence of spatial differentiation factors such as morphometric parameters of a parcel (e.g. parcel area, shape), land use, quality of soils, location and a natural conditions. Both statistical and spatial analyses were made. The article provides a contribution to an area-wide quantitative statistical description and classification of determinants of agriculture land prices. Research is based on data from the Lands and Buildings Register in Poland, which constitutes a part of cadastral system.

# **Analysis of the Determinants of Land Property Prices in Rural Areas in Poland**

**Monika MALETA, Beata CALKA and Elzbieta BIELECKA, Poland**

## **1. INTRODUCTION**

The list of factors affecting the price of property transaction is very long and depends on the type of the analysed property (Burinskiene et al. 2011; Demetriou et al. 2013; Akkaya Aslan et al. 2007; Harris et al. 2013; Brankovic 2013; Kirmikil, Arici 2013; Pšunder, Tominc 2013; Hallin, Liska, 2007). Real estate prices are determined by factors: physical, economic, legal and social. General recommendations for the selection of market characteristics is given in Standard III.7, according to which the features are, in particular: locational characteristics, physical and functional affecting the value of the property. The price of built up parcels is determined by the technical infrastructure, location, plot size, distance from the centre, etc. The factors determining the price of undeveloped land property will be location, purpose established in land development plan or actual usage, condition of the technical infrastructure and soil class. The impact of each factor depends on the local market and their interrelated nature. Transaction prices of land property depend on the spatial variability of selected characteristics. Some of the factors are correlated and their impact on prices is negligible. Determining the number of price-setting characteristics can be guided by the "criterion of seven" (Tomaszewski 1975) which says that the number of characteristics should not exceed a few and it is necessary to reduce price-determining factors. This article is an attempt to determine the effect of selected features on the price of land with particular attention to: the plot size, shape, form of ownership of land (ownership or perpetual lease), land use and the type of owner (the person or legal entity). The study used statistical methods which allow to determine the relationship between the analysed features and the transaction price. Based on the selected and the most important characteristics of price-setting similar land properties were grouped using the k-means cluster procedure.

## **2. FACTORS AFFECTING THE LAND PROPERTIES PRICES**

The price of the land properties can be affected by many different factors. These characteristics can be divided into quantitative and qualitative factors (Gawron 2012). The method of quantitative analysis of the impact factors is relatively simple, slightly more difficult is to take into account the impact of qualitative factors. It seems difficult to identify which characteristics are more important and which less important. One of the key factors determining the prices of plots is their location. Studying the variation in the prices can be noted that predominantly their value depends on their spatial geographical position. A purpose of a specific plot consequent on the arrangements of local development plans or a study of conditions and directions of spatial development is another factor having an influence on the level of land prices. The analysis of the impact of these price-setting features will not be considered by the authors. The paper focuses mainly on the less popular characteristics that occur in the real estate market and in a specific way affect transaction prices.

---

Analysis of the Determinants of Land Property Prices in Rural Areas in Poland (7785)  
Monika Maleta and Beata Calka (Poland)

One such feature is the shape of the plot. This feature determines whether a property can be used to implement the planned investment. The shape of the plot is an important factor of the property price and should be built on a statistical similarity to a rectangle, only then the classification of the suitability of the property for the realization of the objectives set is possible. In fact, land properties take various forms. Currently available parameters that describe the geometry of the plot are: the surface area and its perimeter. To assess the shape of the plot (Podciborski, Kill 2011) mention three states of shapes: regular, fairly regular and irregular. Currently, in the legislation and the scientific literature does not work a parameter, due to which you can clearly determine the shape of the plot as favourable or unfavourable. Most commonly evaluation of the shape is made in an approximate and subjective way. The shape of the plot can also be described by specifying the minimum width of the plot or lengthening on the basis of which it is assessed as favourable or unfavourable. This assessment is then dependent only on one parameter. The attractiveness of the parcels and the ability to use them for specific purposes also affects the area of the property. The area of land property is one of the basic features included in the estimation of land. The influence of the surface area of the plot on the unit price of land was determined, i.a in the works (Zrobek, Belej 2000) and (Prystupa 2001). The dependence of the unit price of land property on the size of the area by Bitner (2010) seems to be obvious: for larger areas we should pay less and more for smaller per unit.

Land use is another important feature of price-setting. Structure of use is the change of land use or distribution of certain functions in a given area. The use of land is varied within different types of communities (rural - borough). In rural areas predominates the structure of agricultural land use and their use within the administrative boundaries of the city is the process of internal reorganization of replacing agricultural land by the more intensive forms of use. Analysis of land use structure consists of extracting the areas with the same mode of use (agricultural land, forest and urbanized, etc.) and determining the impact they have on the price. Another feature is the type of acquired rights to the property. In case of analysis to ownership of real estate, you can extract the land which was given on lease, permanent management, management, administration and which are only the subject of the ownership or co-ownership. Analysis of the structure of ownership and land use forms provides a range of information about the changes taking place in the spatial formation of the price.

### **3. CASE STUDY**

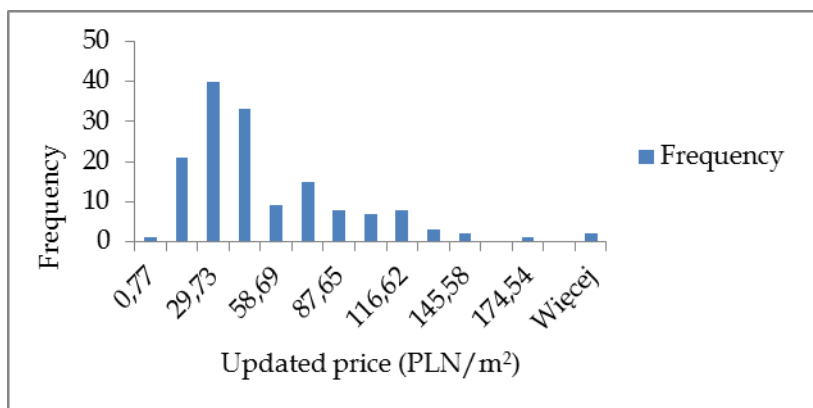
#### **3.1 Area, data and methods**

Subject of the analysis was the local real estate market of undeveloped and built up land properties covering the city of Stoczek Lukowski. A detailed description of the study area is presented in the work Maleta (2013). The conducted study was based on the information contained in the register of prices and real estate values. The registration data for the city of Stoczek Lukowski were obtained from the District Centre of Geodetic and Cartographic Documentation in Luków. The input data base consisting of 255 transactions was subjected to verification of their suitability for the analysis of price of land due to the impact of such characteristics as land area, shape, manner use of property, type of ownership and ownership form. Finally, to the full analysis adopted a set of 150 prices of undeveloped land properties

and 64 prices of built up, forming a database of representative land. It can be concluded that although these attempts do not include all lands that were traded on the local real estate market during the period, but they are representative. The examined real estate transactions include land transactions in the period of ten years, from September 2002 to May 2012. Land properties were describing by the characteristics: parcel identification number, transaction price, date of transaction, the general location, area of the property (ha), a form of ownership, the type of owner, type of land use, quality class. The research problem, was to determine the influence of selected characteristics on land properties prices. The research started with the appointment of trend of changes in plots unit prices. On the grounds of analysis of the local market and the research it can be concluded that in the city of Stoczek Lukowski occurred trend changes in transaction prices. The trend indication of price changes was calculated by linear regression. The calculation of the work are shown in Maleta (2013). On the basis of the determined indicator examined land properties prices brought to an update on the day of the last transaction in the database, that is - in May 2012. This eliminates dependency of property prices over time. Studying the impact of individual factors on the price-setting transaction prices were conducted separately for built up and undeveloped land properties. Calculations were based on publicly available spreadsheet program of Microsoft Excel and Statistica 10.

### 3.2 Property market of undeveloped land properties

Real estate prices of undeveloped land properties were clearly differentiated and varied per  $1\text{m}^2$  from  $0.05\text{ PLN/m}^2$  to  $177.76\text{ PLN/m}^2$ . Distribution of updated transaction prices in  $\text{PLN/m}^2$  in the municipal area of Stoczek Lukowski, concerning undeveloped land properties in the analysed period are presented in the histogram (Figure 1).



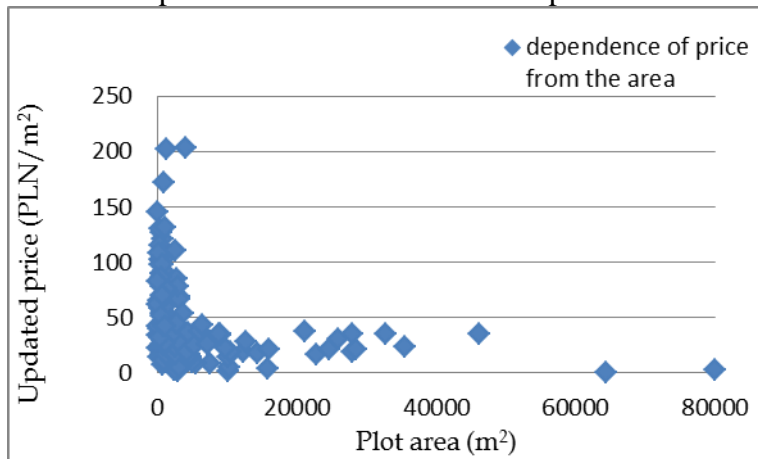
**Fig. 1.** Land properties transaction prices of undeveloped land properties in 2002-2012.  
*Source:* own elaboration.

The prices after the update take values between  $0.77\text{ PLN/m}^2$  and  $203.50\text{ PLN/m}^2$  at an average price at  $47.58\text{ PLN/m}^2$ . In order to determine the change in transaction prices under the influence of the spatial differentiation of parcels analysed the structure of the geodesic surface plots in the studied period. The study showed that the average size of undeveloped parcel was  $5253.33\text{ m}^2$  with a minimum area of  $4\text{ m}^2$  and a maximum area of  $79929\text{ m}^2$ . Stoczek Lukowski is dominated by the plots about area to  $3000\text{ m}^2$  (70% of all transactions

---

Analysis of the Determinants of Land Property Prices in Rural Areas in Poland (7785)  
Monika Maleta and Beata Calka (Poland)

relating to undeveloped land properties ). By analysis showed the decreasing number of plots in relation to the growing surface. The graph below shows the relationship between the price of undeveloped land and its surface in the period of 2002-2012 (Figure 2).



**Fig. 2.** The relationship between the surface of the plot and the transaction price of undeveloped land properties. *Source:* own elaboration.

Then analysed the structure of land use, which consisted of extracting the plots with the same type of use and identifying the impact they have on property prices. The largest number of transactions involved building grounds (79 transactions), another group are land parcels (66 transactions) and the last land "other" (5 transactions), which includes communication areas, wastelands, different areas and forestlands. Studies were also performed to determine the relationship between the unit price of the plot and quality parameters. The form of ownership of land and the type of owner were analysed as well as the influence of the type of acquired rights to the land, such as ownership or lease and the impact of the buyer in natural person or legal in the transaction prices of land plots. The subject of analysis was also the relation linking the area of the plot with its circuit based on morphometric analysis, which consists in determining the aspect ratio of the plots and examining the relationships between the factor and the price of land property. The shape index is a measure of figure "contents figure " (Bitner 2011). It can take values in the range from 0 to 1. Analysis of the shape of the plot is based on the determination of the area of the property and its circuit. From these parameters, we obtain the dimensionless characteristic called a parcel shape index. In order to establish the relationship between the shape of a plot and its price, the circuit for all the undeveloped land in the database was set and form factors were calculated as the ratio of the area of a plot to the square of its circuit. In a study to determine the shape index was used circularity index (Kaminska 2000), also known as shape ratio (Klimczak 2002):

$$W_k = 12,566 \times \frac{P}{O^2} \quad (1)$$

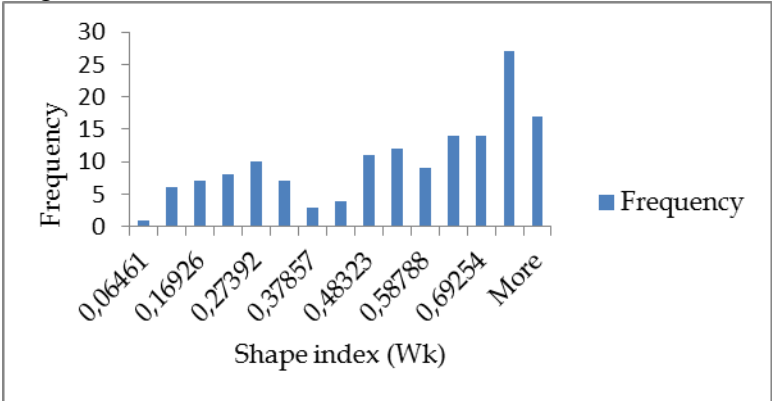
where:

P – area of a plot

O – circuit

This shape index is a scalar quantity, giving a uniform measure by which you can classify the plot. For properties with regular shapes takes values close to 1 and for the irregular and

elongated plots values close to 0. Rating shape of the plot based on this formula shows that the shape is, the better the plot has a larger field at the same circuit and the higher the ratio of the circumference to the field, the shape of the plot is more irregular. The distribution of shape index for undeveloped plots of land in the period is shown in the following histogram (Figure 3).

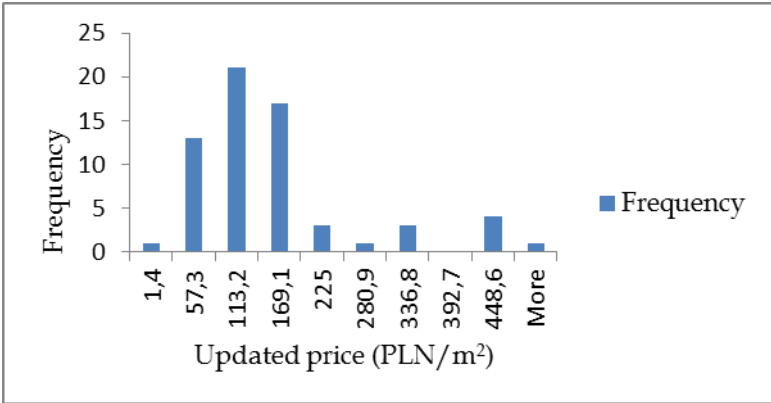


**Fig. 3.** The shape index value of undeveloped land in the period 2002-2012  
*Source:* own elaboration.

The local market was characterized by high values of shape index which proves the existence of plots of regular shapes. In the analysed database of land properties values of shape index were clearly differentiated and ranged from 0.06461 to 0.79719 with a mean value of 0.51670.

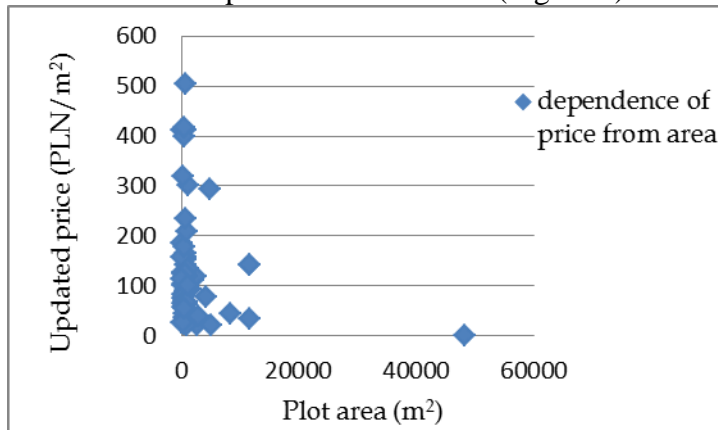
**3.3. The real estate market of built - up area**

Similar considerations as for the real estate market of undeveloped land were also conducted in a group of built - up area. In the analysed database real estate prices for 1 m<sup>2</sup> ranged from 0.41 PLN/m<sup>2</sup> to 469.19 PLN/m<sup>2</sup>. Distribution of unit updated transaction prices in PLN/m<sup>2</sup> concerning the built – up land over the studied period is shown in the following histogram (Figure 4).



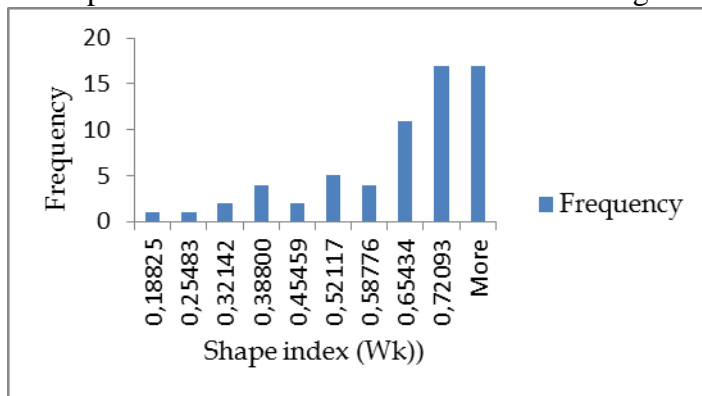
**Fig. 4.** The distribution of updated transaction prices of built - up area during the period considered. *Source:* own elaboration.

The updated prices take values in the range of 1.40 PLN/m<sup>2</sup> - 504.50 PLN/m<sup>2</sup>, while the average price per 1 m<sup>2</sup> was 130.77 PLN/m<sup>2</sup>. The analysis the geodesic surface structure plots showed that the average size of the built - up parcel was 2331.78 m<sup>2</sup> with minimum surface area of 22 m<sup>2</sup> and a maximum 48274 m<sup>2</sup>. The real estate market is dominated as for the undeveloped land, plot of land to 3000 m<sup>2</sup> (87% of all transactions relating to developed land). The graph below shows the relationship between property prices of built - up area on its surface in the period of 2002-2012 (Figure 5).



**Fig. 5.** The relationship between the area of the plot and the updated transaction price of built - up area. *Source:* own elaboration.

The analysis of land use structure showed that among the transactions of purchase and sale of built-up land a dominant are residential buildings (50 transactions), a smaller group are built - up agricultural parcels (13 transactions) and the last group of land figure "other figure " (1 transaction). The form of ownership of land and the type of owner was also analysed. In order to determine the impact of the shape of the plot on its price the form factors were determined for all properties in the database. The distribution of shape index of built - up land in the period 2002-2012 is shown in the following histogram (Figure 6).



**Fig. 6.** The shape index of built - up area in the period of 2002-2012. *Source:* own elaboration.

The real estate market has high values of shape index. There are regular shaped plots which is confirmed by values of shape index that the vast majority exceeded the average value of 0.61675 and ranged from 0.18825 to 0.78751.

## 4. THE RESULTS

### 4.1. Analysis of correlation

In order to determine the impact of the analysed factors on the unit price of built - up and undeveloped land properties dependency correlation between price and selected characteristics was specified. It is assumed that the parameters should be characterized by high spatial variability and low correlating with each other. For this purpose, the correlation coefficients were calculated. They are a measure of the strength of the linear relationship which relate with other variables. The correlation coefficients were determined for all studied characteristics of the configurations: price - feature and feature - feature. The individual parameters show little mutual correlation between themselves. The correlation between the analyzed characteristics of the plot and the price of 1m<sup>2</sup> of undeveloped land and the impact (%) of the parameters of the volatility of transaction prices is shown in the following table 1.

Table 1

List of the coefficients of correlation and impact (%) on the price of undeveloped land

Correlation with price (1m <sup>2</sup> ).	Impact (%)
Plot shape	0.34754 12.8
Plot area (m <sup>2</sup> .)	- 7.69
	0.27734
Land use	0.31761 10.9
Ownership	- 0.01
	0.00780
Type of landowner	- 4.4
	0.20978

Source: own elaboration

Based on the obtained data we can say that the greatest impact on the price of 1m<sup>2</sup> of undeveloped land have, in particular, the physical characteristics of the plot. The decisive role of the highest value of the correlation coefficient plays the shape of the plot, then the usage of real estate, land area and the type of owner. The least important in the study proved to be a form of ownership of land, with insignificantly low correlation coefficient. A sign of the correlation coefficient indicates the direction of the linear dependence. In this case, the dependence of prices on the shape of the plot, and usage tends to increase (positive correlation coefficient), which means that along with the improvement of the shape of the plot and its "tendency to be shapely" grows price per 1m<sup>2</sup> of land. The same situation is with the way of use. The plots designated for development achieve larger transaction prices than property used in a typical agricultural way. The downward tendency show a plot size and the type of owner (negative correlation coefficient) which means that a smaller area of plot obtain in transactions of buying and selling a higher price per 1m<sup>2</sup>. If a landholder was a legal person the plots reached a greater price. Then calculated the correlation coefficients between the price of developed land and selected characteristics. The correlation between the analysed parameters of plot and the price of 1m<sup>2</sup> and the impact of (%) factors to the variability in transaction prices shown in the following table 2.

---

Analysis of the Determinants of Land Property Prices in Rural Areas in Poland (7785)  
Monika Maleta and Beata Calka (Poland)



Table 2

List of the coefficients of correlation and impact (%) on the price of developed land

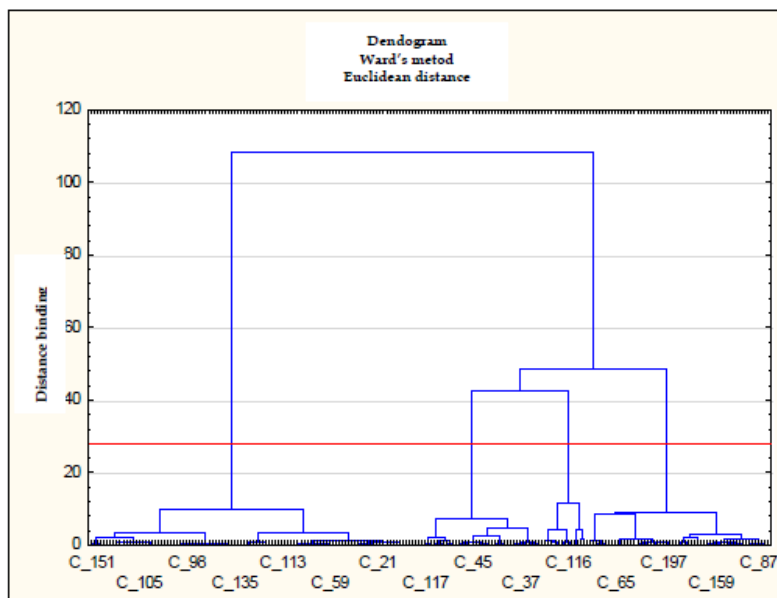
	Correlation with price (1m <sup>2</sup> ).	Impact (%)
Plot shape	0.23160	5.36
Plot area (m <sup>2</sup> )	-0.18542	3.44
Land use	0.09500	0.90
Ownership	-0.20295	4.12
Type of landowner	-0.01364	0.02

Source: own elaboration

On the basis of the study it can be concluded that the greatest impact on the price of 1m<sup>2</sup> of developed land has the shape of plot, then a form of ownership and land area. The least important in the study was the type of ownership and usage of land. In the case of built - up parcels dependency on the shape of plot, and usage tends to increase (positive correlation coefficient). The downward tendency show a ownership form of land, plot area, and the type of owner (the correlation coefficient is negative).

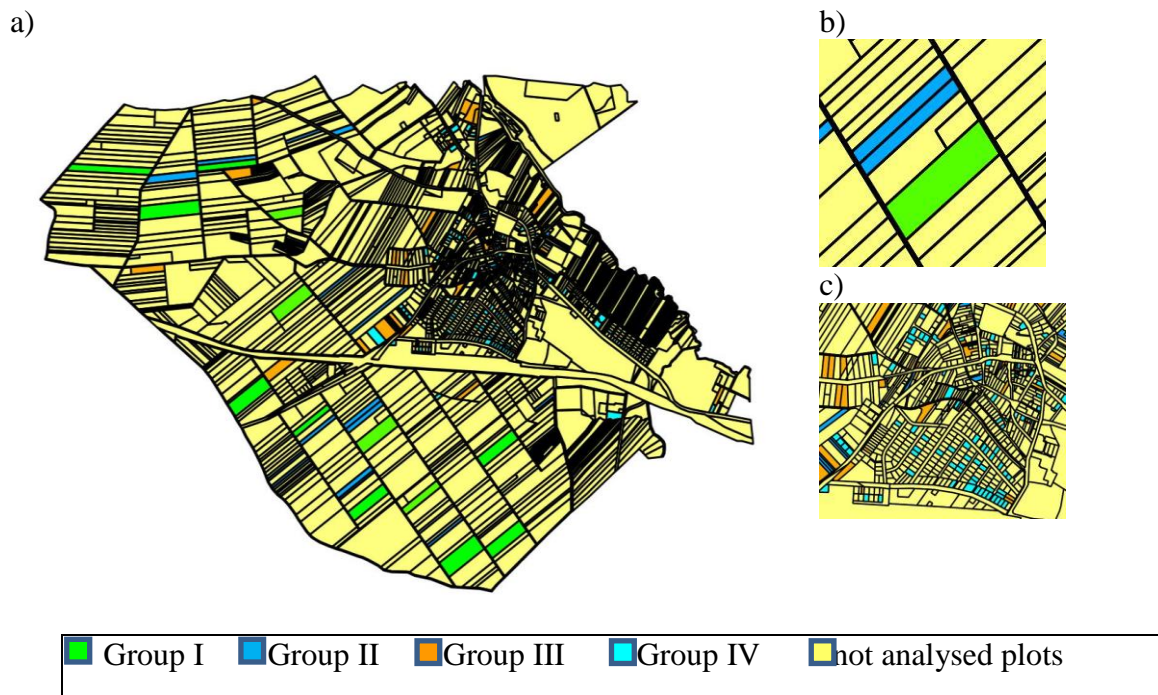
#### 4.2. Cluster analysis

A tested set of built - up and undeveloped land was divided into homogeneous zones. A non-hierarchical k-means cluster procedure was used to group similar land properties. This method initially requires determining the number of clusters (classes, groups) to which the property will be assigned (Suchecky 2010, Calka 2012). The division of property among the various groups was based on quantitative parameters such as shape and plot area. Analysis of the correlation coefficients of these characteristics shows that they are correlated with each other at a low level. The variables were standardized so that they are mutually comparable. Preliminary determination of the number of groups can be based on the results of other analyses, therefore in accordance with Guidici (2003) first conducted hierarchical method, under which determined the optimal number of clusters for which the analysed community is divided. For the preliminary analysis of the data and determining the number of classes used Ward's method, which is characterized by efficiency of remodel an actual data structures and can be used for a small number of objects (less than 300). In this way, a tree diagram was created (Figure 7), based on which you can specify the number of groups.



**Fig. 7.** Dendrogram obtained by the method of Ward  
*Source:* own elaboration with the use of cluster analysis module of STATISTICA

Making cuts in the position marked with the red line was admitted the four focuses to further studies. Then, based on the known number of classes, a method for k-means clustering was used for grouping land properties. Land properties were divided into four groups, classified as the first group of 13 plots, the second 38, the third 55 and the fourth 108. Areas in a group are similar to each other according to a specific similarity measure, and differ from the other classes of objects (Migut 2009). Visualization of the spatial distribution of the property, taking into account belonging to separate groups is presented in the fog. 8. As you can see that plots of group I are shapely, similar to a rectangle and have large surface area, group II are the properties of strongly elongated shape and a smaller area. Group III consist of plots with a more complex shape and definitely smaller area. Group IV are the properties of the smallest area, shaped like a square, centred mainly in the central part of the area of the map, clearly visible in the Figure 8 c.



**Fig. 8.** a) Map of the real estate clustering b) group I and group II c) group III and group IV.  
*Source:* own elaboration with the use of Quantum GIS program.

## 5. SUMMARY

The issue of price differentials in the local real estate market under the influence of the factors forming them was the subject of this study. The research problem, was to determine the influence of selected parameters on the price of land property. The paper examined the relationship between the spatial diversity of area and plot shape, way of use the properties, the form and type of owner's ownership and the price of land property. From the examinations made we can say that the price of land is significantly affected by elements such as the shape of plot, the manner of use and registered area (in relation to the undeveloped property) and the shape of plot, the type of acquired rights to the property and registered area (for developed land). It should be added that the factors selected for study only fragmentary describe the determinants of the prices of plots of land. The analyses do not take into account many other factors that could significantly affect the price of the property. A small number of analysed transactions in the local real estate market typically does not allow to formulate general theses of all developed and undeveloped land properties.

## 6. BIBLIOGRAPHY

AKKAYA ASLAN S.T., GUNDOGDU K.S., ARICI I., 2007. Some metric indices for the assessment of land consolidation projects. *Pakistan Journal of Biological Sciences*, 10: 1390-1397.

BITNER A., 2010. O użyteczności metod statystycznych w wycenie nieruchomości. *Polska Akademia Nauk, Infrastruktura i Ekologia Terenów Wiejskich*, Nr 12/2010. (The usefulness of statistical methods in the valuation of the property. *Polish Academy of Sciences, Infrastructure and Rural Ecology*, No. 12/2010).

BRANKOVIC S., 2013. Real estate mass appraisal in the real estate cadastre and GIS environment. *Geodetski list*, 2, 119–134.

BURINSKIENE M., RUDZKIENE V., VENCKAUSKAITE J., 2011. Models of factors influencing the real estate price. *Environmental engineering The 8th International Conference May 19–20, 2011, Vilnius, Lithuania*.

CALKA B., BIELECKA E., 2014 Taxonomy of real estate properties with the use of k-means method. *International Multidisciplinary Scientific GeoConferences Papers*. Vol. 2, 489-496 pp. Bułgaria. DOI: 10.5593/SGEM2014

DEMETRIOU D., SEE L., STILLWELL J., 2013. A parcel shape index for use in land consolidation planning. *Transactions in GIS*, 17(6):861-882.

GAWRON H., 2012. Wpływ cech fizycznych działek na ceny gruntów budowlanych w aglomeracji miejskiej (na przykładzie aglomeracji poznańskiej). *Olsztyn, Studia i Materiały Towarzystwa Naukowego Nieruchomości – v.20 nr 2*. (The influence of the physical characteristics of plots on building land prices in the urban area (example of Poznań agglomeration). *Olsztyn, Studies and Materials of Real Estate Science Society - V.20 No. 2*).

GUIDICI P., 2003. *Applied data mining – statistical methods for business and industry*. John Wiley & Sons, Inc.

HALLIN M., LISKA R., 2007. Determining the number or factors in the generalized dynamic factors model. *Journal of American Statistical Association*, 97, 167–179.

HARRIS R., DONG G., ZHANG W., 2013. Using contextualized geographically weighted regression to model the spatial heterogeneity of land prices in Beijing, China. *Transactions in GIS*, 2013, 17(6): 901– 919

KAMINSKA G., 2000. Liczbowe charakterystyki struktur przestrzennych. *Geomatyka w badaniach struktur przestrzennych kompleksów leśnych*. Wyd. SGGW, Warszawa: 68-71. (Numerical characteristics of spatial structures. *Geomatics in the study of spatial structures of forests*. Ed. Warsaw Agricultural University, Warsaw: 68-71).

---

Analysis of the Determinants of Land Property Prices in Rural Areas in Poland (7785)  
Monika Maleta and Beata Calka (Poland)

KIRMIKIL M., ARICI I., 2013. The use of landscape metrics to assess parcel conditions pre- and post-land consolidation. *Food, Agriculture and Environment (JFAE)*, Vol. 11, Issue 2, pages 985-989.

KLIMCZAK H., 2002. Modelowanie kartograficzne w badaniach przydatności obszarów pod zalesienie. Wyd. AR, Wrocław. (Cartographic Modeling studies of usefulness of areas for afforestation. Ed. AR, Wrocław).

MALETA M., 2013. Methods for determining the impact of the trend in the valuation of land Property. *Real Estate Management and Valuation*, vol. 21, no. 2, pp. 29-36.

MIGUT G. 2009. Zastosowanie technik analizy skupień i drzew decyzyjnych do segmentacji rynku. StatSoft Polska, Kraków. (Using the techniques of cluster analysis and decision trees to market segmentation. StatSoft Poland, Krakow).

PODCIBORSKI T., KIL J., 2011. Ład przestrzenny obszarów peryferyjnych w aspekcie podziałów nieruchomości niezurbanizowanych. *Barometr Regionalny*, Nr 3 (25). (Spatial order of peripheral areas in terms of non - urbanized real estate division. A regional barometer No. 3 (25)).

PRYSTUPA M., 2001. Wycena nieruchomości przy zastosowaniu podejścia porównawczego. PFSRM, Warszawa. (Property valuation by applying comparison approach. PFVA, Warsaw).

PŠUNDER I., TOMINC P., 2013. Potential usage of generalized real estate market value. *Geodetski vestnik* 57/4.

SUCHECKI B., 2010. Ekonometria przestrzenna. Metody i modele analizy danych przestrzennych. C.H.BECK, Warszawa. (Spatial Econometrics. Methods and models for spatial data analysis. C.H.BECK, Warsaw).

ZROBEK S., BELEJ M., 2000. Podejście porównawcze w szacowaniu nieruchomości. Educaterra, Olsztyn. (The comparative approach in estimation of property. Educaterra, Olsztyn).

## CONTACTS

Phd student Monika Maleta  
mmaleta@wp.pl

Dr Beata Calka  
bcalka@wat.edu.pl

Assoc. Prof. Dr. Elzbieta Bielecka  
ebielecka@wat.edu.pl

Military University of Technology  
them. Jaroslaw Dabrowski  
2 Gen. S. Kaliskiego Str.  
00-908 Warsaw 49

---

Analysis of the Determinants of Land Property Prices in Rural Areas in Poland (7785)  
Monika Maleta and Beata Calka (Poland)

FIG Working Week 2015  
From the Wisdom of the Ages to the Challenges of the Modern World  
Sofia, Bulgaria, 17-21 May 2015