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CHARACTERISTIC OF SELECTED RURAL COMMUNES IN THE OTWOCK DISTRICT IN TERMS OF SPATIAL DISTRIBUTION OF TRANSACTION PRICES OF UNDEVELOPED LAND INTENDED FOR BUILDING DEVELOPMENT

Joanna Jaroszewicz, Tomasz Budzyński
Warsaw University of Technology

Abstract

Real estate turnover is a spatial phenomenon, because the location of properties refers to geographic space. Transaction prices are attribute values which distribution in geographic space can be subject to an analysis. The analysis of spatial autocorrelation of transaction prices of properties permits detection of local outlier transactions, detection of clusters of high and low prices, and the assessment of the statistical significance of such clusters. Transaction prices of undeveloped properties intended for building development obtained in suburban areas, and the location of such properties may suggest the intensity of the occurring processes of functional transformations. Results of statistical analyses of the spatial distribution of unitary transaction prices of such properties may constitute an element of specific characteristic of rural communes located in the vicinity of large cities. The article presents results of the analyses and their interpretation for selected rural communes of the Otwock district. The study was conducted in the scope of research grant entitled: "Spatial analysis of undeveloped land property transactions for the purposes of prediction of unfavourable changes in land use at variance with the idea of sustainable development of suburban areas", implemented in 2015 at the Faculty of Geodesy and Cartography of the Warsaw University of Technology.

Key words: transaction prices, spatial autocorrelation, spatial distribution analyses, changes in the land use function, characteristic of rural communes

INTRODUCTION

The local analysis of spatial autocorrelation of transaction prices of undeveloped land intended for building development permits detection of clusters of high or low prices, and identification of local outlier observations. Transaction prices of undeveloped land intended for building development obtained in suburban areas, and location of such land may suggest the intensity of the occurring processes of functional transformations.

The article presents a hypothesis that a proper performed analysis of the local coefficient of spatial autocorrelation (Anselin statistic), permitting defining the spatial distribution of unitary values of transaction prices, can be an element of the characteristic of the area. The significant clusters of high or low unitary transaction prices permit the designation of characteristic zones (nearby zones, distant zones) in which transaction prices are particularly determined by global factors, e.g. impact of the urban agglomeration. Significant outlier observations permit detection of local centres dominated by the impact of local factors (e.g. local service centres in smaller municipalities). The article also presents the analysis of the effect of the scale of the analyses – represented by the distance defining the radius of so-called neighbourhood – on the obtained characteristic of the area. It is shown based on an example that the accurate selection of the scale is of key importance for obtaining the correct result. The case study was conducted in the area of five neighbouring rural communes of the Otwock district.

SPATIAL DISTRIBUTION OF UNITARY TRANSACTION PRICES

The analysis of spatial correlation has been increasingly frequently applied in research on the spatial distribution of transaction prices of both residential (e.g. Kozioł-Kaczorek, Pietrzykowski 2011, Batóg, Boryś 2014) as well as land properties (Jaroszewicz, Radziszewska 2012). It can constitute an element of the monitoring of the land property market aimed at the rationalisation of spatial planning in a commune (Jaroszewicz, Krupowicz, Sajnóg, 2014).Analysis of spatial correlation is also applied in combination with the regression model of transaction prices, permitting considering the spatial impact of locations (e.g. Basu, Thibodeau 1998, Ismail 2006, Cellmar 2012). It is also used for the analysis of the spatial distribution of indicators determining price-forming parameters of properties, such as the shape and size of a parcel (Maleta, Calka 2015). One of the most frequently applied indicators permitting the determination of spatial correlation is Moran's I indicator. Its value is calculated according to the following formula (Mitchell, 2005):

$$I = \left[n \sum_i \sum_j w_{ij}(x_i - \bar{X})\left(x_j - \bar{X}\right)\right] / \sum_i \sum_j w_{ij} \sum_i (x_i - \bar{X})^2 \qquad (1)$$

where: n – total number of objects; x_i – value of i-th object; x_j – value of j-th object; $\bar{X}$ – mean value; w_{ij} – spatial weight between i-th and j-th object.

Spatial weights adopt a value equal to 0 when the objects are not neighbouring, and value higher than 0 when they are neighbouring. The values of spatial weights are determined in various ways depending on the adopted conceptualisation of the neighbourhood relation. The way of determining the matrix of weights affects the results of analysis (Pietrzykowski 2011). The analysis was based on the assumption that the effect of the value of neighbouring objects is constant. In such a case, spatial weights adopt only two possible values: $w_{ij} = 0$ when the object is not neighbouring, and $w_{ij} = 1$ when the object is neighbouring. The expected value of the indicator amounts to:

$$I_E = -1/(n-1) \tag{2}$$

Testing the statistical significance is based on z-value.

The above formulas show the dependency of the value of the Moran's I indicator on the adopted neighbourhood. This permits the identification of the optimum distance defining neighbourhood returning the spatial autocorrelation indicator with the maximum statistical significance (Zhong-gang L. et al. 2006).

Anselin Local Moran's I statistic (Anselin 1995) permits the identification in geographical space of statistically significant clusters of high values (HH), low values (LL), and local outliers with low values surrounded by high values (LH), and high values surrounded by low values (HL). In the performance of local analysis permitting the identification of clusters, it is important to consider the problem of multiple testing. The higher the number of common neighbours (convergence) the stronger the correlation between tests. The application of the procedure of e.g. FDR (False Discovery Rate) permits considering the problem of multiple testing and spatial correlation allowing for the accurate assessment of the significance of local statistics (Caldas, Singer 2006).

The study involved the procedure of selection of the optimum distance defining neighbourhood for the analysis of spatial correlation based on maximisation of z-value. Analyses of local Moran's I indicator were performed for the determined distances (Anselin statistic). The effect of neighbourhood distances on the obtained results was also described. The analyses were performed both at the level of the entire study area (5 communes) as well as at the level of particular communes. The obtained results permit the development of a specific characteristic of the communes: remaining under the influence of the urban agglomeration, and based on regional centres. The analyses employed tools of software ArcGIS ESRI 10.2.

STUDY AREA

The study was conducted in the Otwock district over an area covering rural communes: Celestynów, Kołbiel, Osieck, Sobienie Jeziory, as well as the rural area of the Karczew commune (Figure 1). They are located in the vicinity of the Warsaw agglomeration, and are strongly correlated with it.

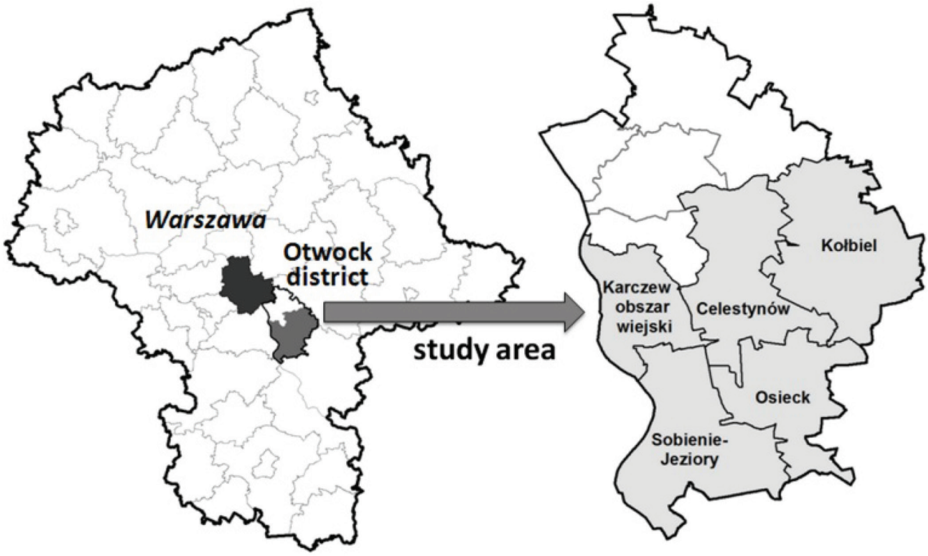

Figure 1. Study area (own elaboration based on PRG data disclosed by CODGiK).

SOURCE DATA

The analysis employed information included in the register of prices and values of properties run for the area of the Otwock district, regarding market transactions concerning undeveloped land properties in the years 2009-2014. The following transactions concerning undeveloped land properties were selected from the register of prices and values of properties:

- Intended for detached house residential development,
- Disclosed as agricultural, which however: a) currently feature building development, b) originated from geodesic division where parcels intended for building development were established, and building development exists in their neighbourhood.

The selection required the identification of each of the transactions in the spatial information system of the Otwock district (www.otwocki.e-mapa.net).

This was followed by an analysis of the shape of the parcel and state of its development (developed, undeveloped, building development located in the vicinity, geodesic divisions) based on the cadastre data, as well as data on buildings and ortophotomap. Based on this, the selection of a given transaction was accepted for further analyses. For the accepted transaction, coordinates x, y in 1992 were recorded for the point located in the middle of the sold property. The information was organised in the data base structure in software ArcGIS ESRI. Transactions considered as non-market transactions (price below 10 PLN/ m^2) were rejected from the preliminarily selected 431 transactions. Eventually, 392 transactions were accepted for further analyses. Their locations are presented in Figure 2. Among 392 transactions, 113 were identified in the Celestynów commune, 80 in the Kołbiel commune, 78 in the rural area of the Karczew commune, 64 in the Osieck commune, and 57 in the Sobienie Jeziory commune. The highest mean unitary prices were obtained in Celestynów.

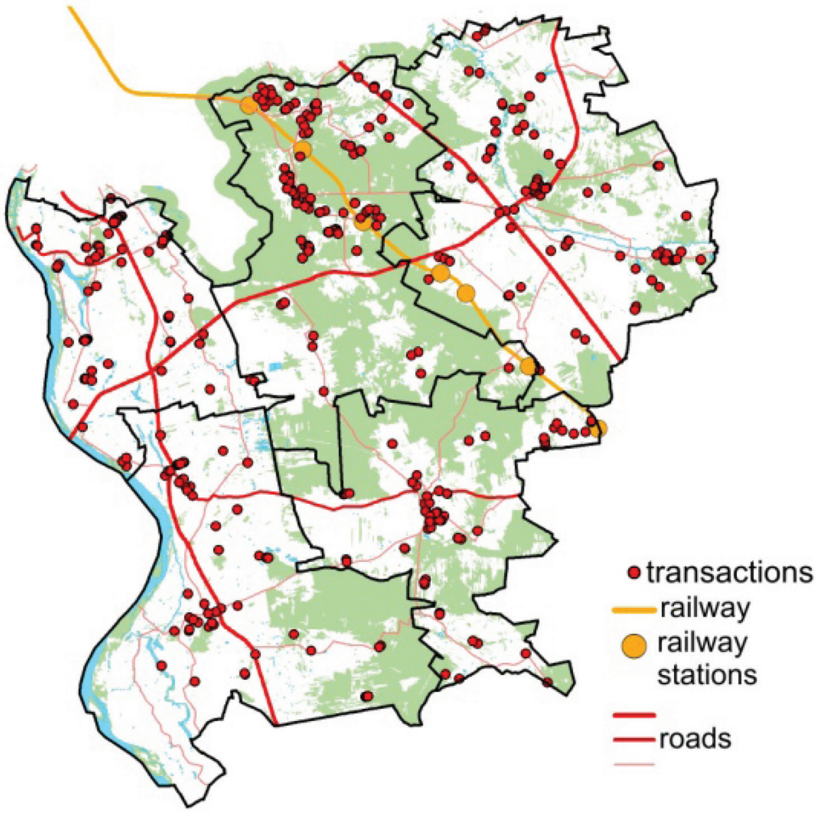

Figure 2. Locations of market transactions concerning undeveloped land intended for building development selected for the analysis (own elaboration).

In particular communes, annual percent changes in prices were determined (Table 1). The determination of the linear trend employed transaction values between the following values: VALUE 1: quartile 1 minus quartile deviation, and VALUE 2: quartile 3 plus quartile deviation.

In the Celestynów commune and in the rural area of the Karczew commune, annual changes in prices show positive values – below 1%. In the remaining communes, the values are negative, and amount to – 2.1% at the annual scale in the case of communes Kołbiel and Sobienie-Jeziory, and – 3.2% for the Osieck commune. No impact of the transaction date on the level of prices of properties was determined based on low and very low values of annual price changes, and statistical non-significance of linear regression indicators *a* at the significance level of 0.1 in each of the five models. Therefore, further analyses assumed the stabilisation of prices of undeveloped properties intended for development other than homestead development in the property markets of the aforementioned communes.

Table 1. Coefficients of regression models – time trends, and the resulting annual percentage changes in transaction prices in particular municipalities (own elaboration)

	a	**b**	**Annual change [%]**
CELESTYNÓW	-0.0386	109.080	-0.4
KARCZEW rural area	0.0333	54.694	0.7
KOŁBIEL	-0.0558	32.170	-2.1
OSIECK	-0.0835	31.680	-3.2
SOBIENIE JEZIORY	-0.0767	43.297	-2.1

ANALYSES CONDUCTED AT THE LEVEL OF THE ENTIRE STUDY AREA

Multiple spatial correlation analyses of the Moran's I coefficient for various distances defining neighbourhood were conducted for the set of all points of location of transactions. The range of distances from d = 400 m to d = 12090 m was adopted with a step Δd = 10 m. The results are presented in a graph (Figure 3) together with marked local extremes of *z*-value. Table 2 comprises results of statistical calculations obtained for the determined distances.

Depending on the adopted scale of the analysis – expressed in distance defining neighbourhood – different results are obtained. The analysis performed for several distances (determined based on local extremes of *z*-value) permits tracing the differences and selecting the accurate scale of the analysis. Table 3 presents the number of transactions which developed significant clusters of high values (HH), clusters of low values (LL), or constituted local outliers: lower than neighbouring transactions (LH) or higher than neighbouring transactions (HL) determined based on the Anselin statistic of local Moran's I coefficient for various distances defining the range of neighbourhood of the analysis. Along with an increase in the scale of the analysis, an increasing number of significant observations is detected. Because FDR adjustment was applied, this does not result from multiple testing of significance, but changes of the scale of the analysis.

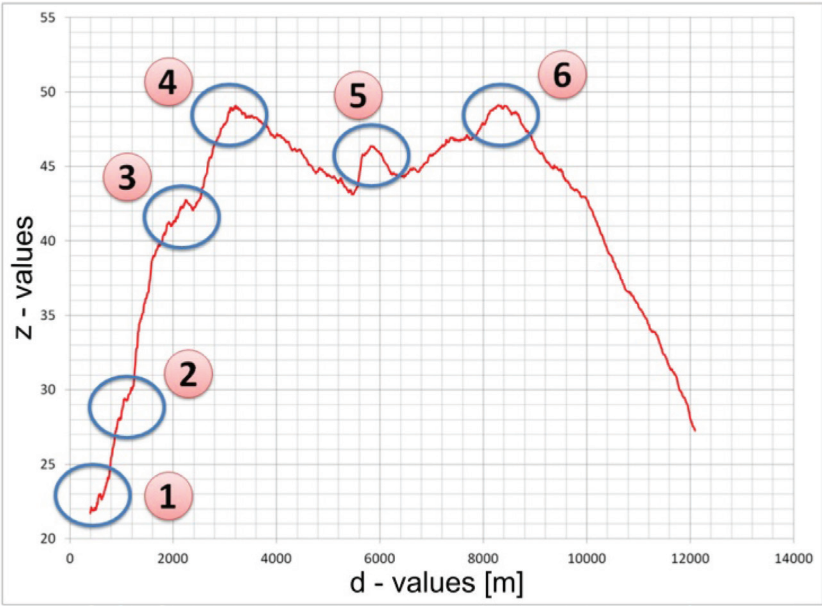

Figure 3. Chart of correlations of *z*-values versus *d*-values adopted for the analysis, defining neighbourhood. Detected local extreme *z*-values are indicated by blue ellipses (own elaboration).

Table 2. Summary of the results of Moran's I statistic for points of local extremes of graph *z*(*d*) (own elaboration)

Nr	d [m]	I Moran's	expected	variance	z-value	p-value
1	590	0.683	-0.0029	0.000888	23.02	0.00000
2	1190	0.635	-0.0026	0.000447	30.15	0.00000
3	2240	0.607	-0.0026	0.000203	42.77	0.00000
4	3210	0.534	-0.0026	0.000119	49.08	0.00000
5	5830	0.366	-0.0026	0.000067	44.91	0.00000
6	8290	0.233	-0.0026	0.000023	49.13	0.00000

Table 3. Number of significant transactions of types HH, LL, LH, and HL, determined based on the Anselin's statistic with neighbourhood adopted for the analysis defined by distances *d* (own elaboration)

d [m]	HH	LH	LL	HL	Figure	d [m]	HH	LH	LL	HL	Figure
590	50	3	-	-	Figure 4.a)	3210	81	14	32	5	Figure 4.d)
1190	63	5	-	-	Figure 4.b)	5830	87	27	96	11	Figure 4.e)
2240	70	7	2	-	Figure 4.c)	8290	95	45	99	9	Figure 4.f)

Figure 4 presents the location of significant observations of developing clusters of high values (marked as type HH – black colour), low values (marked as type LL – blue colour), and outlier observations: low values surrounded by high values (marked as type LH – green colour) and high values surrounded by low values (marked as type HL – orange colour). Moreover, the scale of the analysis was illustrated in reference to the size of the study area by showing the size of neighbourhood with radius d (red circle).

The following conclusions referring to the study area were drawn based on the obtained results:

1. Clusters of high values HH. Along with an increase in distance (increasingly global level of the analysis), the cluster of high prices (HH) becomes more evident. The cluster occurs in the northern part of the study area, neighbouring to urban communes, and located the nearest to Warsaw.

2. Local outlier observations LH. Along with an increase in distance defining neighbourhood, increasingly more transactions are included to local outlier observations of type LH (low values surrounded by high values). For a more local scale of the analysis, outlier observations exclusively constitute parcels sold as agricultural land included in the study. They are surrounded by transactions with high prices developing an HH cluster. Beginning from distance d= 2240 m (Figure 4.c), among observations of type LH, also transactions concerning sale of parcels intended for residential development other than homestead development also begin to appear. For distance d = 5830 m (Figure 4.e) and d = 8290 m (Figure 4.f), an evident circle occurs formed by transactions of type LH around the cluster of high values HH.

3. Local outliers of type HL. They are not detected for the local dimension of the analysis. They are only revealed from distance d = 3210 m (Figure 4.d). Transactions significantly higher than the surrounding transactions occur in centres of villages in which no cluster of high prices was detected. In four out of five cases they are groups around which clusters of high prices were determined in the analysis at the level of single communes (Figure 6). An exception is the easternmost outlier transaction HL in the Kołbiel commune. In this case, observations developing a cluster of low prices were neighbouring.

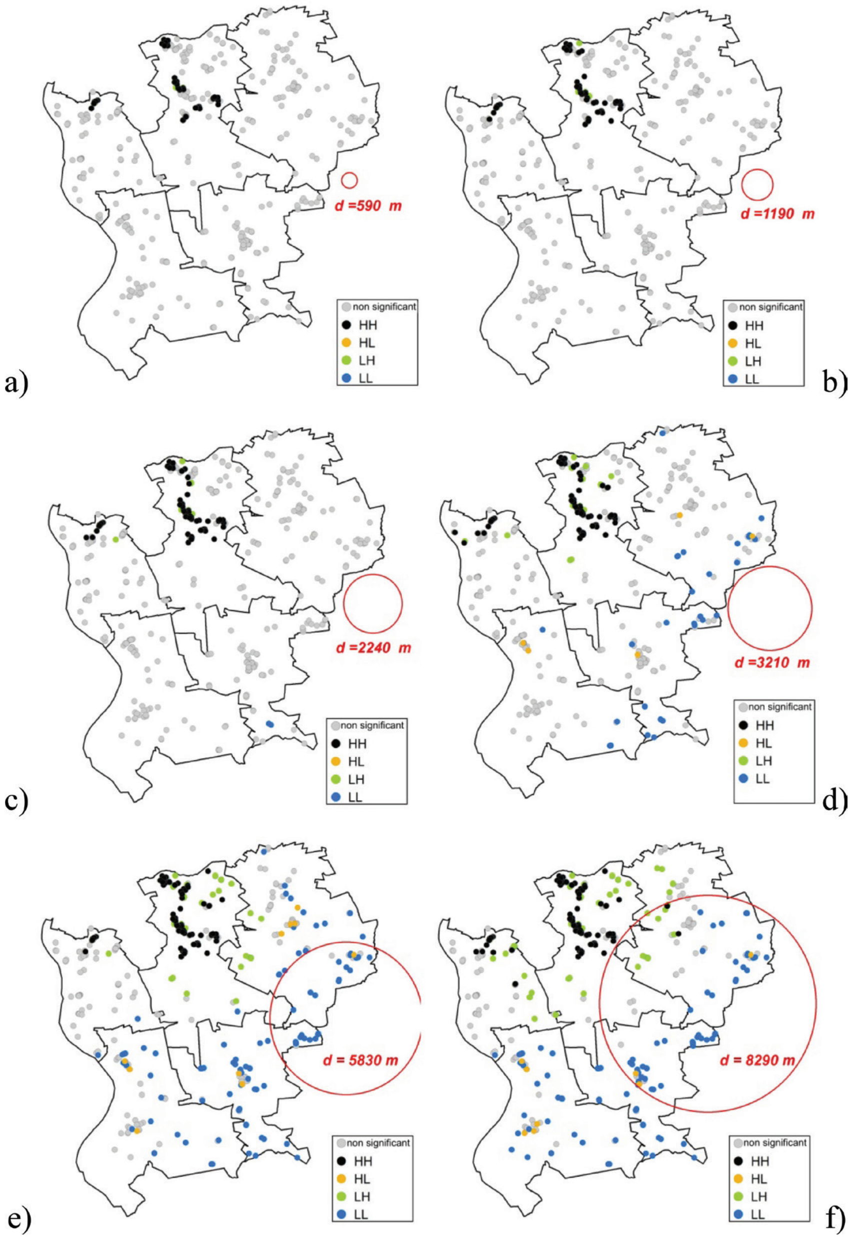

Figure 4. Results of the Anselin Local Moran's I analysis for the adopted distances of neighbourhood, respectively: a) d = 590 m, b) d = 1190 m, c), d = 2240 m, d) d = 3210 m, e) d = 5830 m, and f) d = 8290 m. Red circles show the distance range of neighbourhood in reference to the size of the area of analysis (own elaboration).

4. Observations developing a cluster of low prices LL. They are not detected for the local dimension of the analysis. The first observations constituting a cluster of low prices only appear at a neighbourhood distance of d = 2240 m (Figure 4.c). They are two transactions located at the boundaries of the study area. For distance d = 3210 (Figure 4.d), observations developing a cluster of low prices LL occur in abundance in the south-east of the study area. For a more general level of the analysis, i.e. for d = 5830 m (Figure 4.e) and d = 8290 m (Figure 4.f), numerous observations are disclosed included to clusters of low prices LL arranged in a circle around the cluster of high prices. Statistically non-significant observations occur among them, as well as "grains" of outliers HL of high prices surrounded by low prices.

For the adopted study area and identified transactions, the most accurate scale of analysis is that defined by distance d = 3210 m. It permits the determination of an evident cluster of high and low prices, and identification of locally highest transaction prices in centres of municipalities. It also does not generate an excessive number of identifications of outlier observations of type LH (low prices surrounded by high prices) in the ring around the cluster of high prices. A schematic summary is presented in Figure 5.

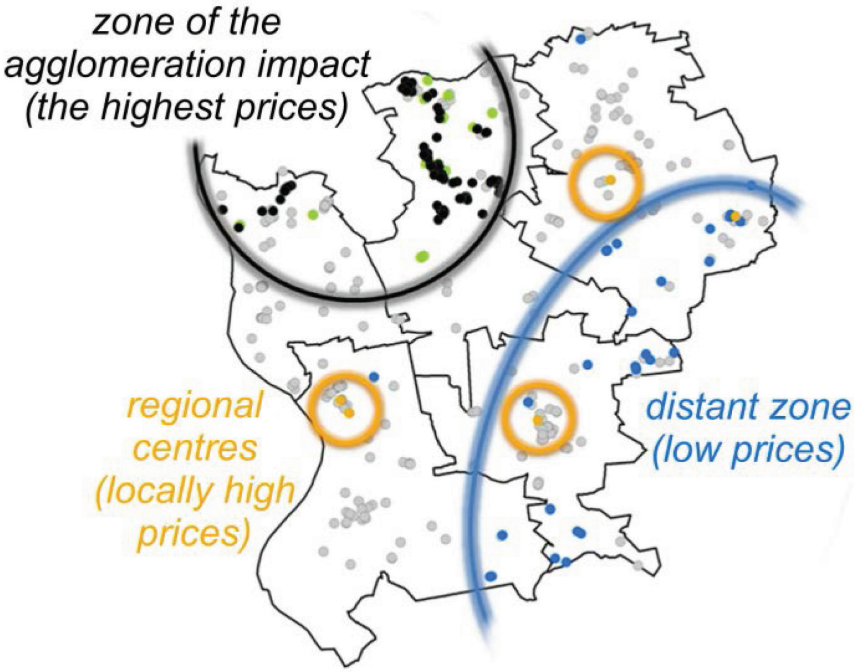

Figure 5. Diagram showing the results of the analysis – zone of the agglomeration impact, distant zone, and regional centres are marked (own elaboration)

ANALYSES PERFORMED AT THE LEVEL OF PARTICULAR COMMUNES

Analogical analyses were performed at the level of particular communes. The results are presented in Figure 6.

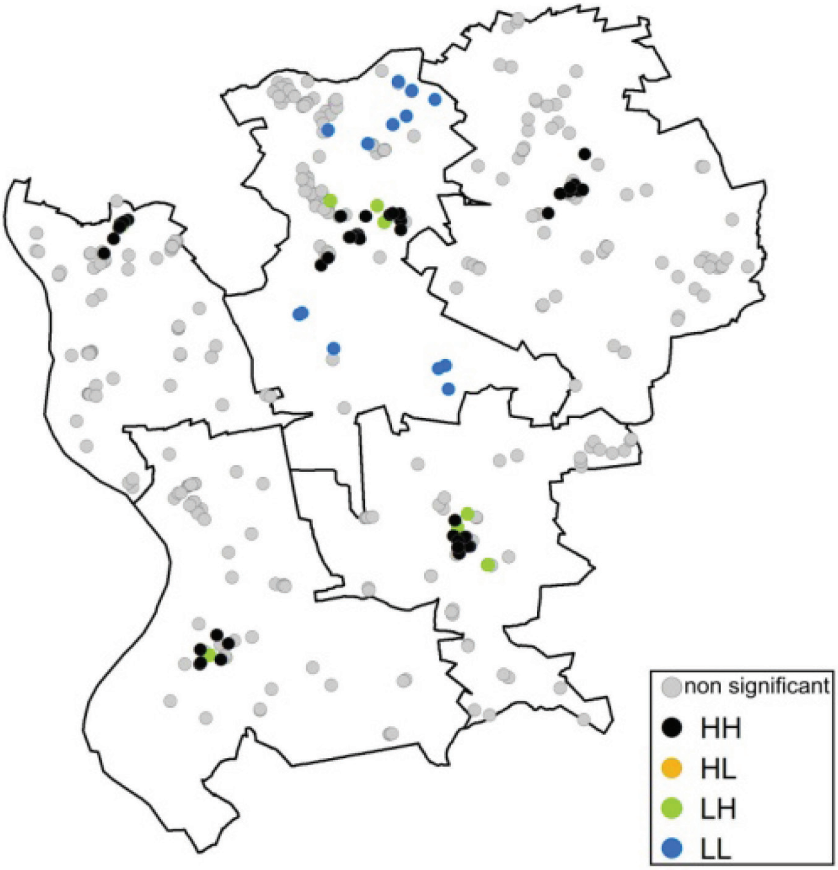

Figure 6. Analyses determined locally for particular communes – shown on a single map (own elaboration)

Clusters of high values in centres of municipalities are visible, overlapping with the location of local outliers of type HL from the analysis performed for the entire area (Figure 5). If the cluster is sufficiently strong, like in the Celestynów commune, also clusters of low values (LL) become visible.

SUMMARY AND CONCLUSIONS

The article presents characteristics of rural communes of the Otwock district directly neighbouring to the capital city of Warsaw in the aspect of spatial distribution of unitary transaction prices of undeveloped land intended for building development.

The analysis covered properties sold in the years 2009-2014, disclosed in the register of prices and values of properties as undeveloped agricultural land intended for detached house development, as well as agricultural land subject to building development or having a potential for building development. After removing transactions considered as non-market transactions from the transaction base, the research covered the sufficiently abundant sample of 392 transactions.

Accurate performance of spatial analyses of the distribution of prices of properties required the prior analysis of price changes. The developed regression models – time trends and calculated price changes for particular communes, permitted adopting the assumption of stabilisation of property prices for each studied market.

The analysis of the spatial distribution of unitary transaction prices of properties employed the analysis of the local Moran's I coefficient (Anselin statistic) with FDR adjustment permitting detection of clusters of high and low transaction prices and outlier observations. The key parameter in this case is the accurately selected scale of the analysis. In the scope of the study, a number of distances were determined defining the size of neighbourhoods, and therefore the scale of the analysis. The analysis performed at an excessively local level does not permit the detection of clusters of high values, and outliers to a satisfactory degree. The analysis performed at an excessively general level result in classification of too many observations surrounding clusters of high prices to outliers of type LH. The accurately selected level of the analysis (distance d of neighbourhood) permits obtaining the characteristic of distribution of unitary transaction prices of undeveloped properties intended for building development in the study area: range of concentration of high prices in the vicinity of the urban agglomeration, distant zone, and regional centres of municipalities. It also permits detecting local outlier prices, i.e. in the case of the conducted analysis, transaction concerning agricultural properties included to the analysis. The parameter of the scale of analysis should therefore be selected with great care.

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Dr. Joanna Jaroszewicz
Katedra Gospodarki Przestrzennej i Nauk o Środowisku Przyrodniczym
Tel. 48 22-234 1569, 48 604 440 646, j.jaroszewicz@gik.pw.edu.pl
Dr Tomasz Budzyński
Zakład Katastru i Gospodarki Nieruchomościami
Politechnika Warszawska, Pl. Politechniki 1, 00-661 Warszawa

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