Methods of Cartographical Presentation of Real Estate Values

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Key words: cartographical presentation, map, real estate value, geostatistics, GIS.

SUMMARY

Despite of elaboration and resolution of appropriate legal acts, there is no political will in Poland to accomplish the mass appraisal, which would allow for determination of at least approximate, but all real estate values. The register of prices and values of real estates is, as yet, the only formally managed data set. Except for limitations in access to its contents, it is maintained fragmentarily and randomly. But in case of necessity to use this data source only, how to make the most of such small piece of information.

In the paper treatment of information on values of real estates as the spatial information was proposed. It refers to objects (parcels, buildings), which possess their own location in geographical space, and their distribution and mutual relationships are one of factors influencing the price. A map is special and simultaneously one of the most effective means of representing information on distribution of objects and phenomena in geographical space. It possesses one special feature distinguishing it from among other means of communication: it directly shows spatial relationships, as simple reflection of reality. Using image of a map one can accomplish (without necessity to involve mathematical apparatus) many mental operations, leading to various conclusions.

The main problem, the author tried to solve, was presentation of information, taking into account human's limited perceptive abilities. Possessing the punctual information concerning locations and values of real estates, he reviewed methods of presentation, beginning from point symbol map, through the extrapolation of this information on the nearest surroundings using Delaunay triangulation and Thiessen polygons, coming up to presentation in the form of continuous surface. Methods of geostatistics in its original understanding were applied here, encompassing mainly kriging – a statistical version of interpolation. Treating value as point height the author also built and presented three-dimensional (3D) models of price distribution, having awareness of greater readability of such image.

Examples presented in the paper confirmed the usefulness of cartographical methods for presentation of real estate values and indicated possibilities of their applications.

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1. INTRODUCTION

Types, specimens and preparation methods of documents necessary for valuation are defined in the Regulation of the Council of Ministers of 29 June 2005 concerning the real estate mass appraisal (Rozporządzenie 2005). A valuation map is the only cartographical document described there. It should be prepared separately for every commune within boundaries of cadastral precincts. It presents valuation zones – areas not divided by other areas, whose boundaries are determined basing on real estate data analyses, within which all parcels have similar characteristics (e.g. location, utility infrastructure) and the same destination in local spatial development plan (residential, industrial).

On a base of cadastral map for every valuation zone its boundaries, identifier, value of one square metre of representative real estates and characteristics of these real estates are published. And this is the end of cartographical methods formal usage in mass appraisal.

But information on values of real estates is an excellent example of spatial information. It refers to objects (parcels, buildings) which have their own location in geographical space, and their distribution and mutual relationships are one of factors influencing their prices (Cichociński, Parzych 2005). Presentation in the form of map (one of the most effective means of expressing information about distribution of objects and phenomena in geographical space) allows showing these spatial relationships directly, as simple reflection of reality. Using map image one can accomplish (without necessity to involve mathematical apparatus) many mental operations, leading to various conclusions.

GIS software brought new possibilities to map making. Unfortunately its application by persons not having required training in this field causes creation of incorrect and sometimes simply ugly looking maps (Baranowski 2006).

A main challenge of the cartography is presenting delivered information with regard of human's limited perceptive abilities. To present values of real estates, from among two methods of cartographical presentation: qualitative and quantitative, the latter can be used. From a list of many quantitative methods, special attention deserve: choropleth map and isopleth map (Ratajski 1989). After certain modifications a symbol map (qualitative in principle) can also be used for presentation of quantitative phenomena. So, there are many possibilities to choose, when one seeks optimal means of expression for the given map. However in every case a map conception should be the result of careful considerations and thorough rehearsals, according to map destination.

Example data presented in this paper – location and prices of one square metre of parcels not built-up – were taken from the register of prices and values of real estates. This register is, as

yet, the only formally managed data set of this kind. Except for limitations in access to its contents, it is maintained fragmentarily and randomly. Despite of elaboration and resolution of appropriate legal acts, there is no political will in Poland to accomplish the mass appraisal, which would allow for determination of at least approximate, but all real estate values. Therefore examples presented below are in some manner limited, which however reflects current possibilities of data acquisition.

2. POINT SYMBOL MAP

Marking locations of objects and phenomena by means of point symbols is the essence of symbol map. In most cases a circle is used (fig. 1), but it can also be a triangle, a square, a diamond, etc.. It is assumed that central point of a symbol matches, regardless of its graphical shape, location of geometrical centre of represented object – in this case parcel. Symbol map assures the close union between geographical reality and its representation on a map, which implies that in the given location there is no other object mentioned in the legend of a map. Application of symbol map to quantitative phenomena presentation consists in varying the size of point symbols, proportionally to the quantities the symbols represent (graduated or proportional symbol map). Another possibility is to use colours changing according to the ordered scale, when the symbol size is fixed (fig. 2).

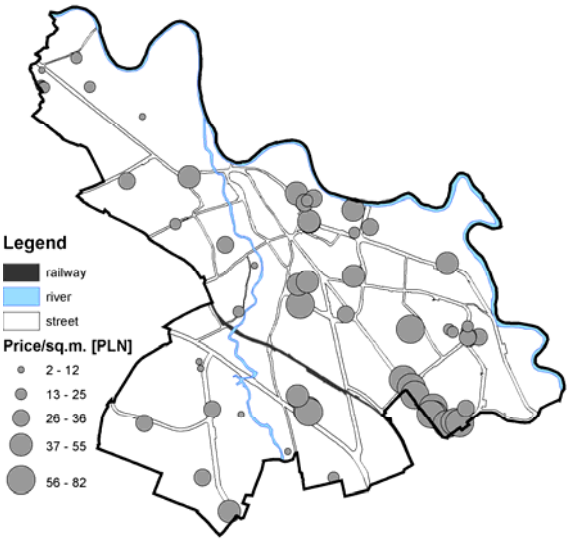

Fig. 1. Graduated (proportional) symbol map.

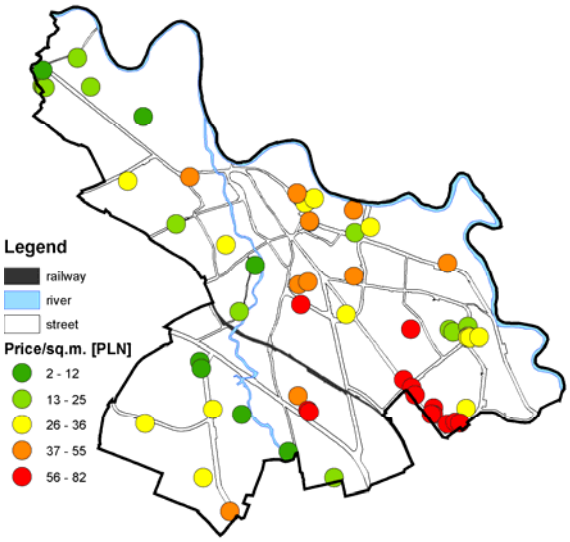

Fig. 2. Symbol map – symbols of variable colours**.**

3. CHOROPLETH MAP

The choropleth map is a method of phenomenon variability presentation, in relation to a network of fields, called reference frame. Phenomena are assigned to these strictly limited fields, having equal or at least approximate size, indirect way, which separates this information from the influence of area size. In case of real estate values presentation it is necessary to make an assumption that these values on certain area are similar. This condition

will be fulfilled in the future by valuation zones delimited during data analyses for the purposes of mass appraisal (The Order 2005).
Presentation of some phenomenon variability by means of choropleth map requires completion of three tasks each time:

– partitioning of the whole mapped area into elementary fields of equal or approximate size,
– acquiring of the full and uniform quantitative information for all fields,
– delimitation of optimal class intervals for this information and finding the suitable colour scale for them.

Only correct accomplishment of these three tasks together leads to proper final effect.

Parcel is a basic field, whereto value is assigned. However, two conditions are not fulfilled in this case: value is directly related to parcel and if values are known for not all the parcels, filling of the space is not complete. Even if the value is specified for every parcel, such small fields create cramped mosaic on the map. On the contrary too large fields may lose essence of variability. Other partitions of the given area into fields can be imposed, for example resulting from possession of statistical information for specified areas, or made especially for the given map. In the first case districts, precincts or quarters of streets form reference frame (fig. 3), in the second one it consists of field systems of size, shape and boundaries chosen according to task for which the information is assembled. Most comfortable appear square fields, because of easy way of setting out (fig. 4). Values assigned to fields are result of averaging of unitary prices of parcels located within the given field.

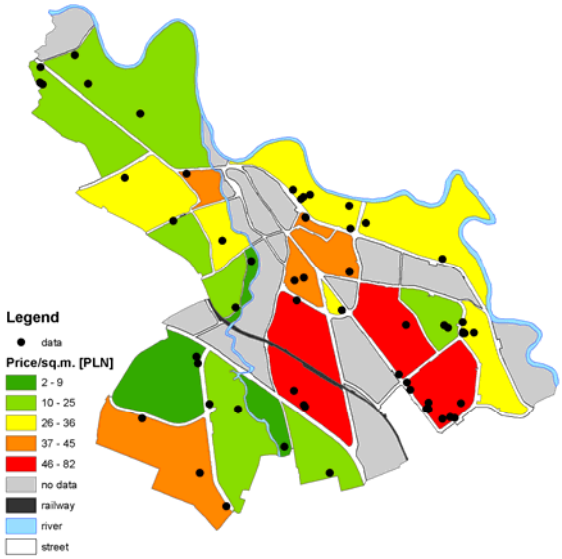

Fig. 3. Choropleth map – fields represented by quarters of streets.

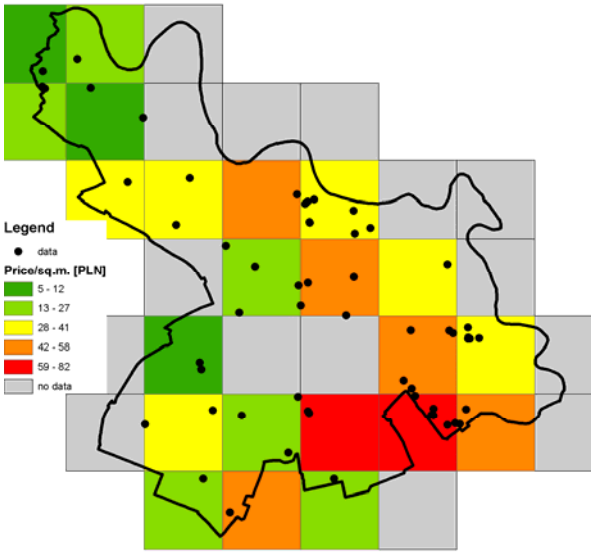

Fig. 4. Choropleth map – square fields.

Voronoi diagram, belonging to geostatistical tools, can be used for determination of fields as well (ESRI 2004). It consists of polygons constructed around points, this way that every position inside the given polygon is closer to its centre point than to any other point (so called

Thiessen polygons). In case of real estates these points are geometrical centres of objects having known prices, for example parcels. For the purpose of Thiessen polygons delimitation, network of triangles based on given points is built in the first step. Delaunay triangulation is used for this purpose in most cases (fig. 5). It is based on the condition that no vertex can occur inside circles circumscribed on formed triangles, which makes for the maximization of their internal angles. Then in the middle of triangle sides perpendiculars are drawn, which form final polygons. After their creation neighbouring points are determined, in other words points which Thiessen polygons have common boundary.

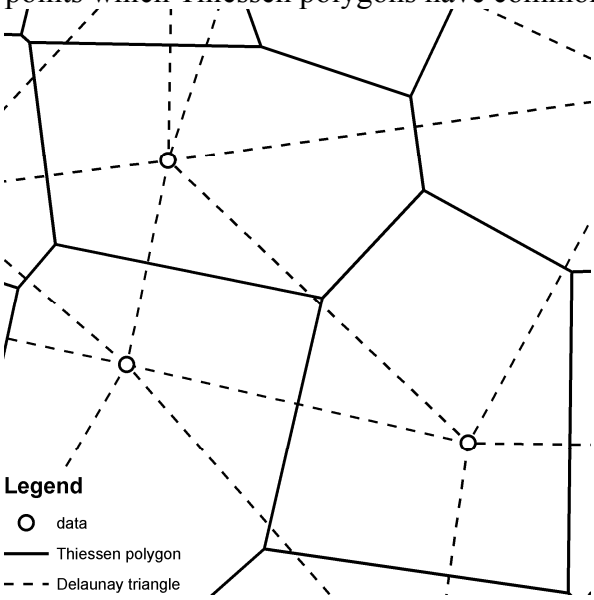

Fig. 5. Schema presenting method of Thiessen polygons creation.

With regard to neighbourhood defined this way, various additional statistical parameters can be calculated. Four of them seem to apply to the analysis of distribution of real estate values:

- mean – the value assigned to a polygon is the mean value that is calculated from the polygon and its neighbours,
- median – the value assigned to a polygon is the median value calculated from the frequency distribution of the polygon and its neighbours,

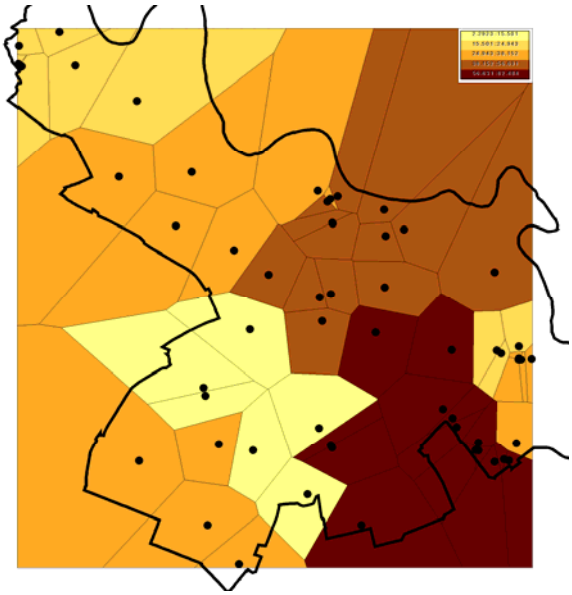

Fig. 6. Voronoi diagram – the mode parameter.

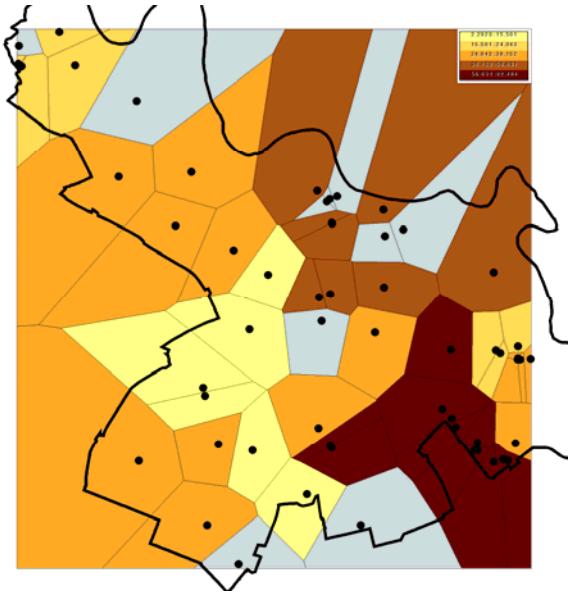

Fig. 7. Voronoi diagram – the cluster parameter.

– mode – all polygons are placed into five class intervals. The value assigned to a polygon is the most frequently occurring class of the polygon and its neighbours (fig. 6),
– cluster – all polygons are placed into five class intervals. If the class interval of a polygon is different from each of its neighbours, the polygon is coloured grey (fig. 7).

Three first parameters cause calculation of mean values and consequently softening accidentally occurring extreme values, while the last one makes possible catching differing values.

Data describing particular fields can be represented on the cartogram in continuous style (by showing every individual value to the degree allowed by accuracy of the drawing) or in presented on above examples discrete way (after precedent division of the whole population into classes presented by following symbols of the legend). In the latter case it is necessary to pay attention to methods of class intervals determination, in other words partitioning of the whole population into groups. Best in view of its own characteristics seems the method of natural breaks – classes are based on natural groupings inherent in the data. Break points are identified by picking the class breaks which best group similar values and maximize the differences between classes. The objects are divided into classes whose boundaries are set where there are relatively big jumps in the data values. Because it does not possesses drawbacks of other classification schemes, forcing placement of class boundaries without value analysis, this method was used for preparation of all maps containing classifications, presented in this paper.

4. ISOPLETH MAP

Assuming smooth variability of values between real estates having known value, the isopleth map can be used for its presentation. This method is based on expressing spatial variability of phenomenon by means of curves (isolines) system, not intersecting each other, having

assigned following increasing or decreasing values, derived from points of equal values, which they connect. The isopleth map, to the greater degree than any other method of cartographical presentation, uses the information obtained from sampling, therefore it often relies on partial information, which has to represent greater population. So it is necessary to determine separately in every case the size of a sample and such distribution of places from which to collect them, so that they sufficiently represent essence and variability of phenomenon on a given area. Unfortunately it is not always possible, especially when the limited collection of real estates having known value is available. If the information hereby collected does not sufficiently represent population, and also when it is non-uniform, then no method of cartographical presentation allows for creation of entirely reliable map.

Image of phenomenon variability, depicted on isopleth map, can be made considerably more readable through filling areas between neighbouring isolines with various symbols. These symbols cannot have the accidental value or the pattern – together they should create the scale of colours.

Collections of points having known value are usually insufficient in regard to their quantity and distribution to calculate isolines and it is necessary to supplement them. A basic and simplest method used for this purpose is linear interpolation. It is used for finding points, which properly connected, form isolines. Its linearity is based on an assumption of proportional changes of value between points taken for the interpolation. To make sure that results are unambiguous it is convenient to divide the whole area into triangles having vertices placed in points representing objects having known value, and then to interpolate along sides of these triangles. The most often Delaunay triangulation is used for this purpose and Triangulated Irregular Network – TIN (one of methods of modelling terrain shape) is the result of this operation. Value preservation of given points and consequently preservation of their quality are its advantages, while as drawback must be mentioned its certain „angularity", especially when built from small quantity of points (fig. 8).

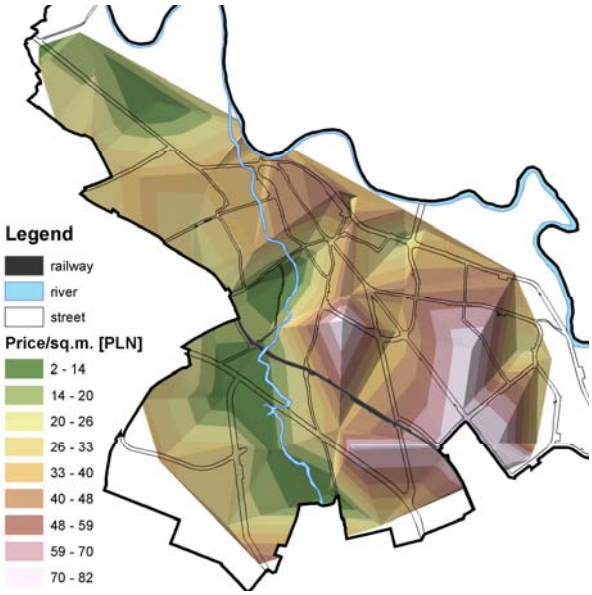

Fig. 8. Isopleth map – linear interpolation on a basis of Triangulated Irregular Network (TIN).

To obtain more smooth image of variability of real estate values one of the two other methods of interpolation can be used: the topographical surface and kriging. First of these methods is specifically designed for the creation of hydrologically correct Digital Elevation Model (DEM). It employs the spline technique. Using knowledge about topographical surfaces, it imposes constraints on the interpolation process that result in a connected drainage structure and correct representation of ridges and streams (ESRI 2004). Example presented in the figure 9 shows the possibility of using this method for a property market as well.

Methods intended usually for presentation of the ground shape, such as the method of topographical surface, preserve values in points of known values, consequently allowing to catch local anomalies, while the kriging method creates surface not so much smooth, but rather averaging possible variations (fig. 10). This is a technique of calculating simple moving average (Namysłowska-Wilczyńska 2006), applied for local estimation, using only data located near the place of estimation. Weights (called kriging coefficients) are assigned to them, changing along with spatial changes of variable being subject to estimation in such way, that root mean square estimation error (called kriging variance) is minimized. This method is used mostly in the mining industry for estimating wealth of deposits and in protection of the environment for calculating the content of pollutants between locations in which samples are collected (Namysłowska-Wilczyńska, PTIP). Dependence of distribution of certain values on their location is an assumption which stands at roots of its usage. The same can be said about values of real estates, which are only partially related to their descriptive characteristics. They also depend on location, which encompasses neighbourhood, shape of terrain, utility infrastructure, accessibility of communication, etc. (Cichociński, Parzych 2006). This is why wider than only presentational usage of this method for the property market can be anticipated. This will be the subject of author's further research.

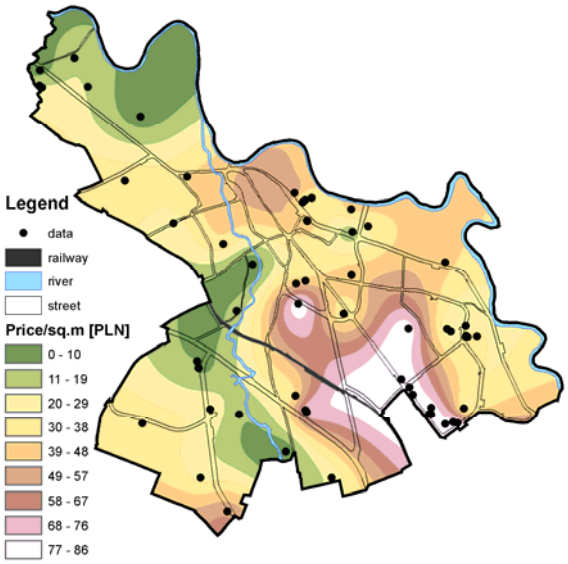

Fig. 9. Isopleth map – interpolation using the method of topographical surface.

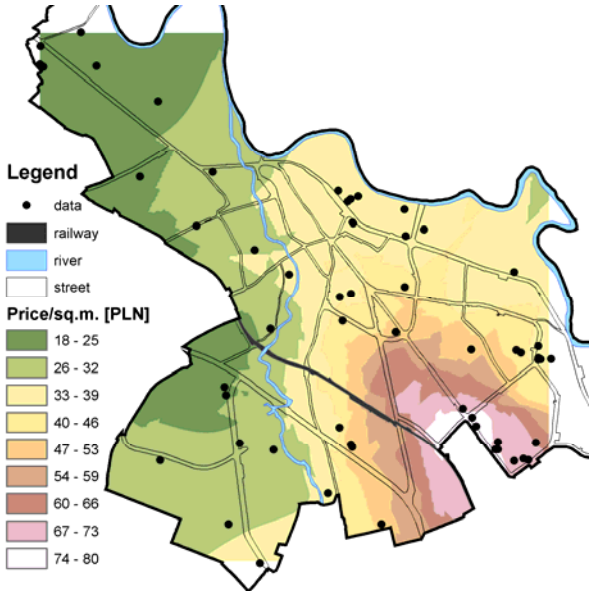

Fig. 10. Isopleth map – interpolation using the kriging method.

5. CONCLUSION

Knowledge of distribution of prices and values of real estates is one of basic factors making possible undertaking correct spatial decisions. Examples presented in this paper showed that many methods of the cartographical presentation exist, which can be used for representing distribution of values of real estates. This is however only starting point for further analyses which can also be supported by cartographical tools. The information on location of other objects and phenomena, such as highway network, buildings or zones of local spatial development plan, presented in form of map, will surely allow for explanation of certain characteristics of real estate values distribution.

It appears however that not all mentioned in the paper methods satisfy the basic criterion of image readability, simultaneously providing exact mapping of objects characteristics. In the first group of symbol maps, the greatest doubt raises about symbols of variable size. To properly present phenomenon variability the range of symbol sizes should be large enough. Consequently, to keep the visibility of smallest symbols, greatest symbols must be pretty large, which of course negatively bears on image readability. This can also incorrectly suggest the greater range of these phenomena. This method however will be indispensable in cases, when the output device has not at its disposal the full scale of colours. A general drawback of symbol map is presentation of point features only, which however becomes an advantage, when exact distribution of values between given points is not known. It assures the precise mapping of the reality, and throws all generalizations on recipient and his experience.

The rest of methods base either on assumption of the extrapolation of known values on certain area and their averaging (choropleth map), or on assumption of smooth variability of phenomenon between locations of known values. However, on the basis of relatively small data set collected in the register of prices and values of real estates it is hard either to confirm

or to reject these assumptions. Further research on this area will probably allow to discover certain general rules of this variability, but proper completion of this task will require additional data, unavailable yet.

REFERENCES

Baranowski M., 2006. Metody geowizualizacji. (Methods of geovisualization). Roczniki Geomatyki 2006, tom IV, zeszyt 2. Polskie Towarzystwo Informacji Przestrzennej, Warszawa.

Cichociński P., Parzych P., 2005. Zastosowanie baz danych Systemów Informacji Geograficznej do wyceny nieruchomości. (Application of Geographic Information System databases for real estate valuation). IV Krajowa Konferencja Naukowa "Infobazy 2005 – Bazy danych dla nauki". Gdańsk, 25-27 września 2005 r.

Cichociński P., Parzych P., 2006. System informacji geograficznej jako niezbędny element powszechnej taksacji nieruchomości. (Geographic Information System as a necessary element of real estate mass appraisal). Geodezja, tom 12, zeszyt 2/1. Uczelniane Wydawnictwa Naukowo-Dydaktyczne AGH, Kraków.

ESRI, 2004. ArcGIS Desktop Help. Environmental Systems Research Institute, Redlands.

Namysłowska-Wilczyńska B., Rusak K., 2005. Zastosowanie geostatystyki I GIS do analizy wpływu czynników naturalnych I antropogenicznych na koncentrację metali ciężkich w glebach rejonu olkuskiego. (Application of geostatistics and GIS to analysis of influence of natural and anthropogenic factors on heavy metals concentration in soils of Olkusz region). Roczniki Geomatyki 2005, tom III, zeszyt 2. Polskie Towarzystwo Informacji Przestrzennej, Warszawa.

Namysłowska-Wilczyńska B., 2006. Geostatystyka. Teoria i zastosowania. (Geostatistics. Theory and applications). Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław.

Ratajski L, 1989. Metodyka kartografii społeczno-gospodarczej. (Methodology of socio-economic cartography). PPWK, Warszawa-Wrocław.

Rozporządzenie Rady Ministrów z 29 czerwca 2005 r. w sprawie powszechnej taksacji nieruchomości. (Regulation of the Council of Ministers of 29 June 2005 concerning the real estate mass appraisal). Dziennik Ustaw 2005, nr 131, poz. 1092.

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