http://dx.doi.org/10.15576/GLL/2023.1.65

GLL

Geomatics, Landmanagement and Landscape No. 1 • 2023, 65–74

NEW TECHNOLOGIES IN REAL ESTATE MARKET ANALYSIS

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Summary

The aim of the study was to present new technologies that are useful for obtaining spatial information on real estate and integrating the data with existing databases maintained by public administration agencies. The technologies presented include the use of GIS tools combined with vector data representing cadastral parcels, and raster data acquired by LiDAR technology. The study also employs descriptive data containing transactional information. The application of these new tools for obtaining spatial information provides real estate market operators with additional data that allows for more reliable market analysis. The methodology of this work has been divided into two parts, the first part related to the creation of a real estate database as a reference for the acquisition of spatial data. The second part was dedicated to the acquisition, processing and analysis of spatial conditions in the study area.

The study used the data on transactions to determine the parcels for which data on elevation situation were acquired. LiDAR data was then applied to the determined parcels to generate the DTM. The obtained terrain elevation model was processed by raster tools, which created maps of slope and maps of aspect.

Currently the data on the features of properties found in real estate price registers maintained by public administration agencies are becoming more accessible in result of the ongoing digitisation of administrative offices in Poland. However, these data do not contain information on slope and aspect – two real estate features that are crucial for surveying areas with varied relief. The presented analysis draws attention to new ways of acquiring spatial data and integrating it with existing databases. Finding ways to integrate data obtained from public administration agencies with modern geographic information systems (GIS) would improve the work not only of valuers, but also of many other real estate professionals (e.g. brokers, developers, bank analysts).

Keywords

GIS • real estate market analysis • terrain slope • exposure of cadastral parcels

1. Introduction

Spatial data are a basis for running environmental testing. It is impossible to analyse the environmental conditions without spatial data. Environmental analyses that are related to changes in land use, analysis of erosion threat or noise analysis are conducted thanks to access to data [Farhan and Nawaiseh 2015]. They allow us to model phenomena in digital space, guaranteeing reliable information on the environment. There are several spatial conditions shaping the results of environmental testing. Most frequently studied include relief, which determines the analyses related to the slope of the terrain or its exposure [Hickey 2000]. Thanks to these analyses it is possible to perceive the relationships that have a decisive influence on the perception of sites in terms of threat to the environment or recreational and investment areas [Goulden et al. 2016].

The development of modern data retrieval technologies has driven the development of data processing software. At the same time it has encouraged the progress in scientific research which has been able to take advantage of the technological advances. Environmental information modelling is at the stage of spatial data filtering, which follows the stage of obtaining the data necessary for environmental analyses. Currently, the biggest problem in data processing is not its acquisition, but appropriate filtering. One of the largest datasets are created by remote sensing data.

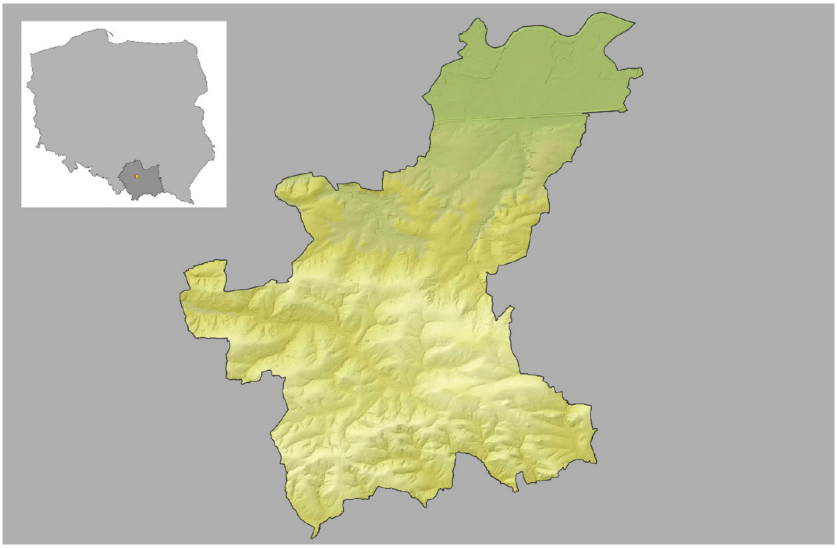
Collected by satellites, aircraft or unmanned aerial vehicles, these data provide information on relief and land cover. The collected data require the use of tools that guarantee efficient data processing, which include GIS tools [Guo and Du 2017].

One sector that is facing changes related to the use of spatial data is the real estate sector [Lin et al. 2021]. The dynamics of change in the real estate market largely depends on global events. The global economy recession and the Covid-19 pandemic directly affect the real estate market [Tomal 2021]. Cascading information flows are also among the factors significantly affecting the real estate market [Brzezicka et al. 2018]. All these factors force market actors to look for mechanisms that will allow them to diagnose the market changes linked to dynamic fluctuations, but also to identify the factors that influence the value of a property, while not changing over time. One of the actors involved in the real estate market processes is the valuer. This is a natural person holding professional qualifications in the field of real estate valuation, granted under the provisions of the Act of 21 August 1997 on real estate management. According to Polish law, a real estate valuer may prepare studies and expert opinions, which do not constitute an appraisal report, concerning the real estate market as well as real estate consultancy [Renigier-Biłozor et al. 2014].

Currently, data on real estate features found in real estate price registers maintained by public administration agencies are increasingly easily and widely available thanks to the progressive digitisation of administrative offices in Poland [Beręsewicz 2015]. However, the quality and transmission format of these data, in order to conduct a reliable market analysis, require an enormous amount of work on the part of property valuers themselves. Therefore, finding a way to integrate data obtained from public administration agencies with modern geographic information systems (GIS) would improve the work of not only valuers but also many other real estate professionals.

2. Study area

The study area lies within the municipality of Wieliczka, which is situated in the Wieliczka county, in the central part of Małopolskie Voivodeship in southern Poland. The relief of the Wieliczka municipality is varied. The southern part has very varied relief, while the northern part has a rather lowland character, due to it is location in the Vistula proglacial valley. The area of the Wieliczka municipality stretches across the basin of rivers Raba, Wilga and Serafa, which all flow into the Vistula, forming the northern border of the municipality. There are 41,000 registered parcels of land in the municipality. For the purpose of this paper, the data on 93 parcels were used, which were included in transactions in 2018. The location of the municipality of Wieliczka is presented in Figure 1.



Source: Author's own study

Fig. 1. Location of the Wieliczka municipality with an altitude map and against the Małopolskie Voivodeship

3. Methodology

The methodology was designed to demonstrate the possibilities of using modern technologies in real estate market analysis. Accordingly, it was also supposed to enable the analysis of real estate market in the Wieliczka municipality. Given the complexity of the whole process, it was divided into three stages: data acquisition, data processing and data analysis. Both OpenSource and commercial software were used in all stages.

The first stage was concerned with data acquisition. This study uses descriptive data consisting of information on transactions and graphical data represented by vectors of parcels obtained from the Wieliczka County Office. It employed the data from the price register on market transactions of purchase and sale of undeveloped land properties from the entire Wieliczka county in the period of 2015–2018, selected transactions pertaining only to the Wieliczka municipality (without the town of Wieliczka) from the period of 01.01.2018–31.12.2018, and used the current vector map of the whole Wieliczka county (data access: 31.10.2019). In this stage elevation data represented by LiDAR data from the resource of the Central Office of Geodesy and Cartography was also acquired. These data were collected for the purposes of the ISOK system (Informatic System of National Defence against Extraordinary Hazards) operating in Poland, whose task is to protect against extraordinary hazards (mainly floods), to minimise the social and economic effects of these phenomena and to support the decision-making process, including spatial planning. The data are available free of charge. They can be downloaded, for example, directly from www.geoportal.gov.pl or using the *Pobieracz Danych GUGiK* (*GUGiK Data Downloader*) plug-in available in the QGIS programme.

Second stage was related to processing both transactional and graphical data into a form enabling data analysis. Data obtained from the real estate price registers were selected for transactional data with regard to the property's designation in the local spatial development plan. Undeveloped land properties designated in the local spatial development plan for single-family housing were chosen. If there was no information on the designation of the property in the register, it was completed on the basis of data from the local spatial development plan that were available on the websites of the Wieliczka municipality and county.

In addition, the use of the parcels was verified by an orthophotomap. Transactions involving built-up land were rejected during the analysis of transactional data. Transactions records of several parcels of land located far from each other were also eliminated.

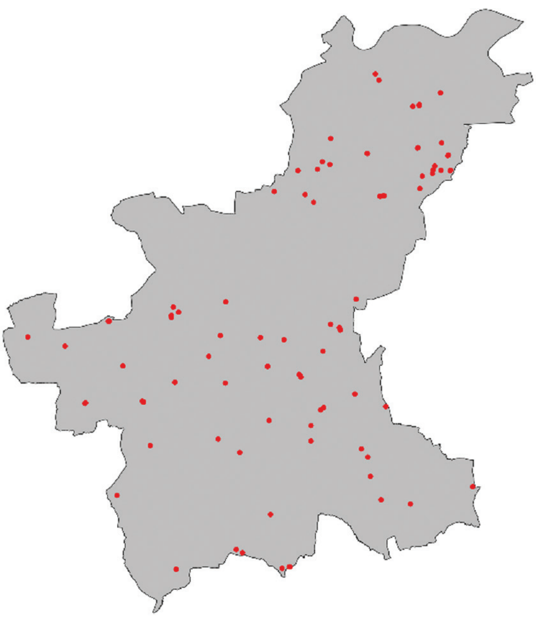


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Fig. 2. Transaction property locations

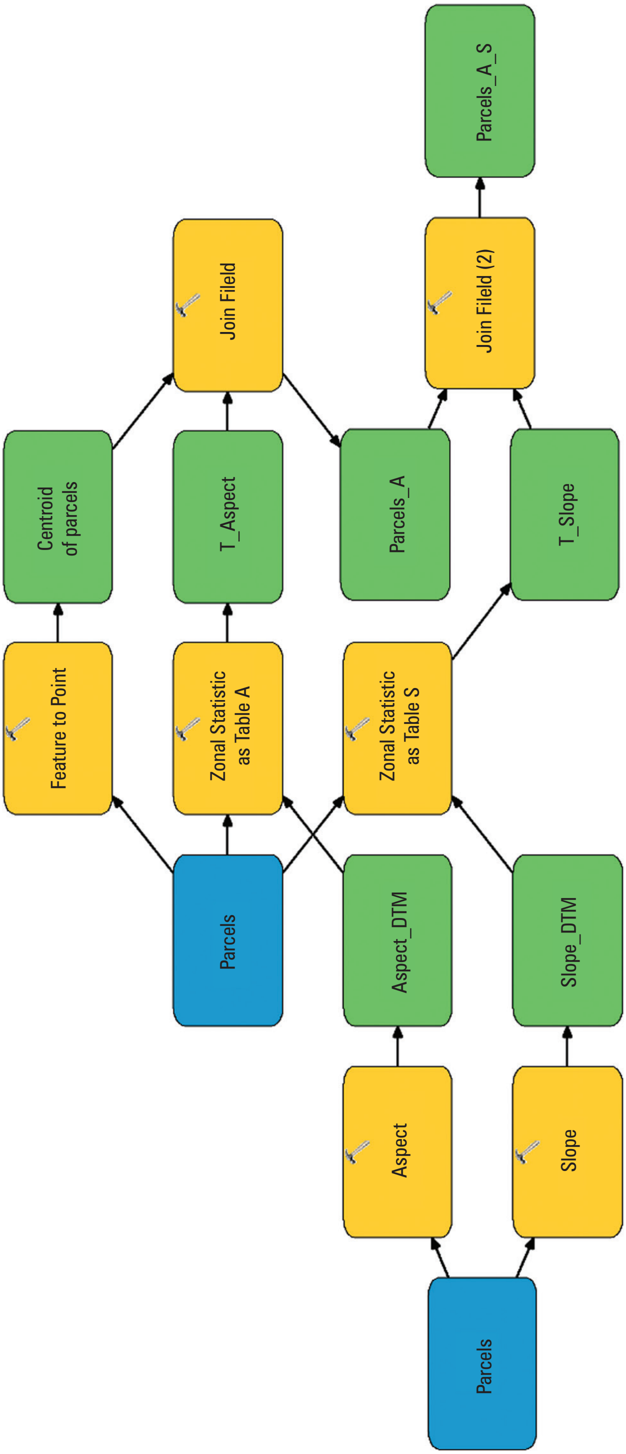

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Fig. 3. Elevation data processing scheme for registered parcels

Transactions involving investment land intended for service, service-residential and mixed development were also taken into account. The possibility of developing a single-family residential building was a necessary condition for taking a transaction under consideration. Finally, the data processing identified 93 transactions that were used in further stages of the study. Their location within the Wieliczka municipality is presented in Figure 2. Tools available in ArcGIS were employed to obtain information on the spatial conditions. LIDAR data were converted into raster format. First the data were imported into the *LAS DataSet* database, and then points from the cloud that did not belong to the *ground* layer were filtered out. The remaining points were processed with the *LAS DataSet to Raster* tool. The process of generating the digital terrain model (DTM) used the size of the terrain pixel equal to 1m as a parameter and the average value of all points located in the area of a single raster cell as a conversion value parameter. The resulting DTM layer was then processed by the *Slope* tool to model terrain slopes and by the *Aspect* tool to model terrain exposures. A unit consistent with degrees was chosen for both models.

The resulting models were then linked to the boundaries of the parcels involved in the transactions in the subsequent stages of the study, and zonal analyses were run for the objects. The minimum, maximum and average slope of the boundaries of parcels was calculated by the *slope* tool and the *zonal statistics* tool. The dominant exposure of the parcels was calculated with the same tools. Obtaining this information allowed the calculation of histograms showing the spatial structure of the data. The final step involved replacing the parcels by centroids and combining them with the slope and exposure data. The entire data processing was automated using the Model Builder tool of the ArcGIS software, which allows to apply the built model to other source data. The schema for processing the elevation data and combining it with the data is shown in Figure 3. The resulting elevation parameters were visualised on maps by the point symbol of the centroids.

4. Result and discussion

The methodology presented allowed to obtain elevation parameters for 93 transactions. The results were the subject of three analyses designed to demonstrate the possibilities of using spatial data in real estate market analysis.

The first stage of the analysis involved the assessment of spatial parameters, slope and exposure, that were related to the area of registered parcels included in the transactions. Each of them was determined by the parameters of average, maximum and minimum slope. Each of the slopes was classified according to the ranges of values: below 3°, 3–8°, 8–15°, 15–27°, above 27°. This classification makes it possible to identify unfavourable spatial conditions [Śleszyński 2009]. The data was summarised in the Table 1. An analysis of these parameters determining the slopes allows a general identification of the conditions prevailing in the transaction areas. Almost all the minimum slopes (98.92%) were in the range below 3°. The average slopes were dominated by values between 8° and 15° (66.57%), with the remaining values almost evenly distributed between slopes below 3°

(18.28%) and between 8° and 15° (15.05%). The last overview for the slope parameters concerned the maximum values that occurred on the ground surface delimited by the boundaries of the registered parcels. The greatest number was found for slopes between 8° and 15°, with a value of 40.86%. The second most common group was between 15° and 27°, with 33.33% of the total. Areas with slopes above 27° accounted for 15.1%. These areas are characterised by altitude conditions, which have an impact on the increase in costs due to the foundation of buildings or investment plans.

The analysis of the zoning parameters of the of land also involved land exposure. The dominant slope direction in the parcel was taken as one of the parameters. The exposure direction was dominated by the south and north-east directions, with an equal percentage share (23.66%). The second group consisted of the north, south-east and east directions falling within the range of 10–13%.

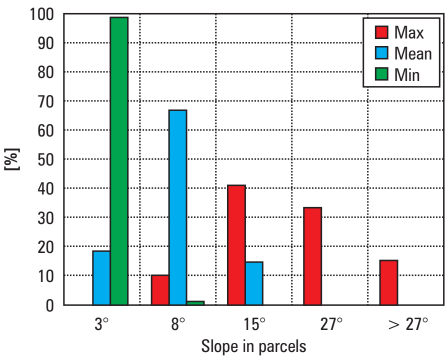


Table 1. Zonal statistic for slope in parcels

Slope	3°	8°	15°	27°	> 27°
Max	98.92	1.08	–	–	–
Mean	0.00	10.75	40.86	33.33	15.1
Min	15.28	66.67	15.05	–	–

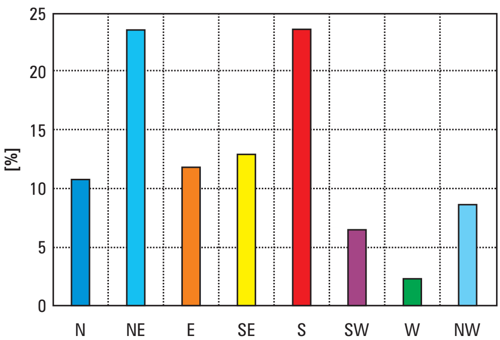


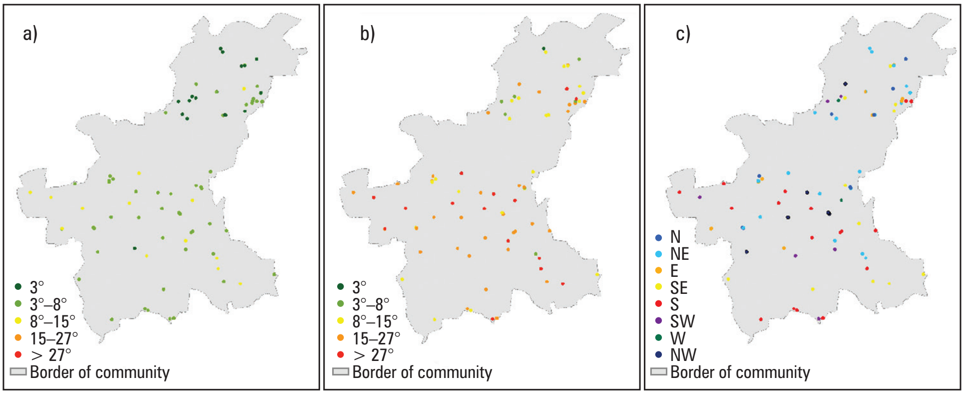
Table 2. Major aspects for parcels

N	NE	E	SE	S	SW	W	NW
10.75	23.66	11.83	12.90	23.66	6.45	2.15	8.60

Source: Authors' own study

Fig. 4. Elevation structure for registered parcels

A complete picture of the spatial conditions was obtained after the distribution of transactions was visualised and combined with spatial parameters. The distribution of ranges of average slopes is regular over almost the entire area of the Wieliczka municipality. In the northern part, the largest group consists of transactions with minimum slopes that do not exceed 3°. The parcels which were involved in transactions were most often located in areas where the average slope for the whole parcel area was below 8°. Such areas were found in the central and northern part of the Wieliczka municipality. In the southern area, the average slopes were higher and more often the maximum slopes in the parcel assumed values of 15–27°. The analysis of the distribution of dominant exposure directions confirmed that the exposure of parcels is dominated by the south and north-east directions. These transactions are found in the central part of the Wieliczka municipality. The visual analysis showed that the area of the entire municipality should be considered as diverse in terms of terrain. Conducting comprehensive analyses that take into account the various spatial factors is therefore necessary for correct determination of the conditions in the areas where transactions took place. The spatial distribution of the transactions and their spatial variation is presented in Figure 5.



Source: Authors' own study

Fig. 5. Centroid of average slope in parcels (a). Centroid of maximum slope in parcels (b). Centroid of major aspect in parcels (c)

5. Conclusions

The study showed that spatial data can be a valuable source of information for real estate market analysis. The high efficiency of obtaining spatial data is an important argument for popularising GIS tools among valuers.

The paper presents the possibilities of using ArcGIS, but the same effect can be achieved using OpenSource programmes, which include QGIS. Regardless of study area or available software, it is possible to run analyses that can improve the entire process of acquiring spatial data and integrating it with existing databases. The use of GIS tools results in a datasets that have both graphical and descriptive form. Currently, real estate market analyses are at a turning point, which forces a widespread use of spatial data in the process of identifying factors influencing property values. So far, the use of elevation conditions in these analyses was limited due to difficult access to their sources. The introduction of elevation parameters, in addition previously used information on the shape and area of parcels, creates opportunities for a more complete determination of real estate market characteristics. Real estate market analysis in the form of visualisations is an innovative tool in the valuer's work. They provide a quicker and more accurate way of obtaining relevant information about the local real estate market. If such a method of market analysis were to become widely available, the work of the valuer could be significantly improved. In addition, the quality of the property market information obtained using this method is improved due to its reliance on a large database and the use of modern IT tools. This shows the potential of GIS software, whether it is commercial or OpenSource software. The use of automated tools allows the presented methodology to be applied to any area.

Funding

This research was funded by the program "Incubator of Innovation 4.0" implemented as part of the non-competitive project entitled "Support for the management of scientific research and commercialization of the results of R&D works in research units and enterprises" under the Intelligent Development Operational Program 2014–2020 (Measure 4.4).

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