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GIS for Analysis of Residential Estate Market: Case Study**

Abstract: The increasingly rapid advances in technological development approaches to integrate property market valuation with the Geographical Information System (GIS). Application of the GIS software in the residential estate market is very helpful in visualizing information using maps and tables. In order to effectively manage the database on the real estate market, advanced IT technologies are necessary – the ones that provide mechanisms for entering, collecting, analyzing, and storing cadastral data. Solutions for real estate residential market modeling should be treated as an important element for the development of the spatial economy. From the property market valuation, we can determine a high or low market value based on the attribute data. In visualization, we can analyze the factors of the highest and lowest market values based on geographic data that is produced using ArcGIS. After that, the detailed analysis can also be determined using ArcGIS 10.5 software, such as using overlay and proximity analysis tools.

Keywords: GIS, SDM, residential real estate

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1. Introduction

The purpose of this article is to demonstrate the potential of GIS in order to effectively manage real estate market databases that provides mechanisms for entering, collecting, analyzing, and storing cadastral data [1]. Appraisers need quick access to relevant information to effectively do his job [2]. Each participant in the real estate market collects data on the real estate that was subject to market transactions. Depending on the type of real estate surveyed, this data may include transactions regarding a record plot, building, or premises (residential premises and premises designed for other purposes). In addition to analyzing the descriptive data, an appraiser should be able to locate the specific real estate in order to identify it spatially and obtain information about the real estate environment in order to select similar properties when assessing the value. Property valuation is no longer a traditional business that relies only on expert opinions of value. The profession is now facing greater transformation in the valuation process and methodology along with innovations in information technology (IT). Technology is having a profound effect on the profession as well as influencing the property valuation process, largely pressured by the needs of today's clients who demand a quick, easy, and more objective process to arrive at the opinion of value. The needs somehow motivate a dependency on automated valuation that allows clients to get faster and better results. Advancements in IT have changed how the process is carried out, leading to more-analytical applications within the valuation profession. The use of GIS technology [3, 4] seems to be an ideal solution for an appraiser, because it provides mechanisms for entering, collecting, analyzing, and storing real estate data. The Geographic Information System (GIS) allows for the more efficient and effective management of spatial data.

2. GIS for Analysis of Residential Estate Market

The Environmental Systems Research Institute (ESRI) [5] defines GIS as an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. One of the GIS's significant applications is a property location analysis in a comparison approach. For example, the GIS creates variables that expedite analysis within or outside the GIS environment. Spatial data that is subject to analysis in GIS may be understood as physical, economic, social, geographical, or historical objects. The location of objects as well as information about their attributes may be subject to change from time to time; therefore, time may also be a GIS component. As concluded by Kwiecień [6], attributes of GIS may be divided into two basic groups: descriptive (answering the question *what?)* and spatial (answering the question *where?)*. The GIS distinguishes points, lines, solid objects, and 2D objects (for instance, an area profile or record parcel

borderline). The objects in the system may be described with any type of information such as numbers, text, or graphic data stored in a tabular form. This data may be characterized by a number of parameters including (but not limited to) accuracy, variability, validity, reliability, or completeness. In the GIS, a database usually takes the form of a layered structure where each overlapping layer constitutes an independent set of one-class spatial objects. The layers may contain several types of information, while the objects located in each class have a separate set of records describing their spatial features. The layered structure enables a spatial review and analysis of the data and allows for the multi-level designing and analyzing of multi-function space systems. The layered structure of the database is shown in Figure 1.

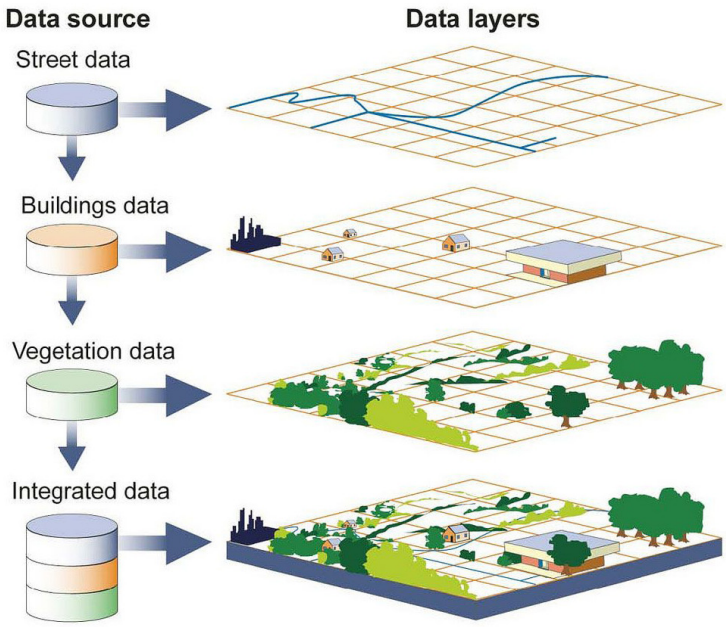

Fig. 1. Layered structure of Residential Estate Market database

Source: [7]

3. Example of GIS Database for Residential Estate with Road Noise Factor

3.1. Model Design

Designing the ArcGIS geodatabase with Enterprise Architect [8, 9] was used for the spatial database of residential real estate. It provides a UML profile for modeling ArcGIS concepts as well as the ability to generate ArcGIS schemas as

XML workspace documents, and it allows for the reverse engineering of legacy geodatabases into a visual UML mode. Visualization of the application schema for the spatial database for residential real estate written in the UML language is shown in Figure 2.

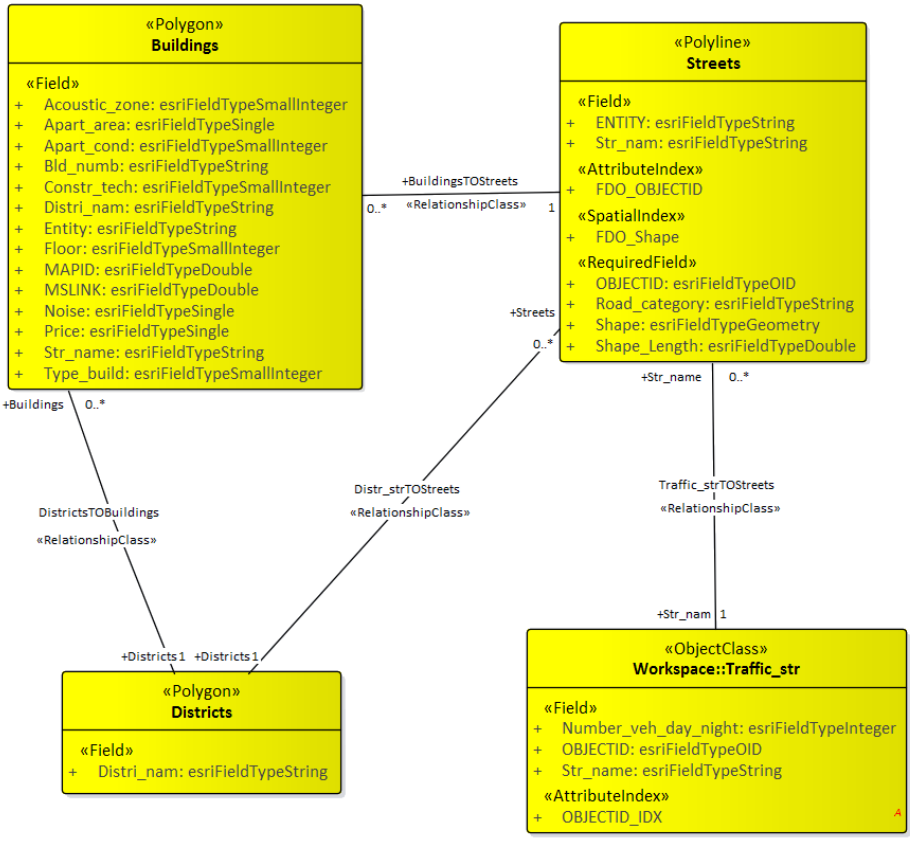

Fig. 2. UML Package diagram for spatial database of residential real estate

The source of spatial information for the property valuation system is cadastral parcels and buildings. Residential premises are characterized by a clear difference in relation to above-mentioned types of real estate. In the case of many apartments in one building, a flat in the database model is associated with the feature class *building* thanks to which it can be located spatially. In addition to all of the characteristics of the property (price, area, number of rooms, floor number, etc.), there may also be information about traffic noise in this table. However, traffic is defined in a different table (not as a feature class) in which objects have spatial attributes. Information

about the level of noise acting on the building (flat) due to road traffic will be possible via a specific relationship between a table named *traffic* and a feature class *building*. In the model of the database, there are also feature classes named *streets* and *districts* with mutual relationships. This allows for complex spatial analyses regarding the impact of noise on housing prices. At the end of the database design description, it is worth saying that this project defined the most basic attributes for the analysis of the impact of noise on housing prices. However, the proposed scope of the information described is not final, as it is possible to re-use the UML model scheme to further modify the objects and attributes.

3.2. Characteristics of the research area

The research area (1.24 km^2) named "A" was located in the northern part of Bydgoszcz (Poland) near the DK5 national road – Kardynała Stefana Wyszyńskiego Avenue (hereinafter called Wyszyński Street), an exit road from the city towards Gdansk. It is a part of the Bartodzieje housing estate district. This area is dominated by multi-family residential use with buildings from the 1980s (Fig. 3).

a) b)

Fig. 3. Study Site in context of city of Bydgoszcz (a); Wyszyńskiego Street (b)

Source: [10]

When analyzing the road layout of the study areas from the beginning of 2012 to the end of 2016, no transportation innovations consisting in the extension of the existing road system nor construction of new sections of roads were confirmed. Based on the SNM (Strategic Noise Map), only the noise generated by the existing traffic route has been identified. The spatial layout of this route on the background of the SNM map is shown in Figure 4.

The Strategic Noise Map was used as source data for noise placed in the database table *building*.

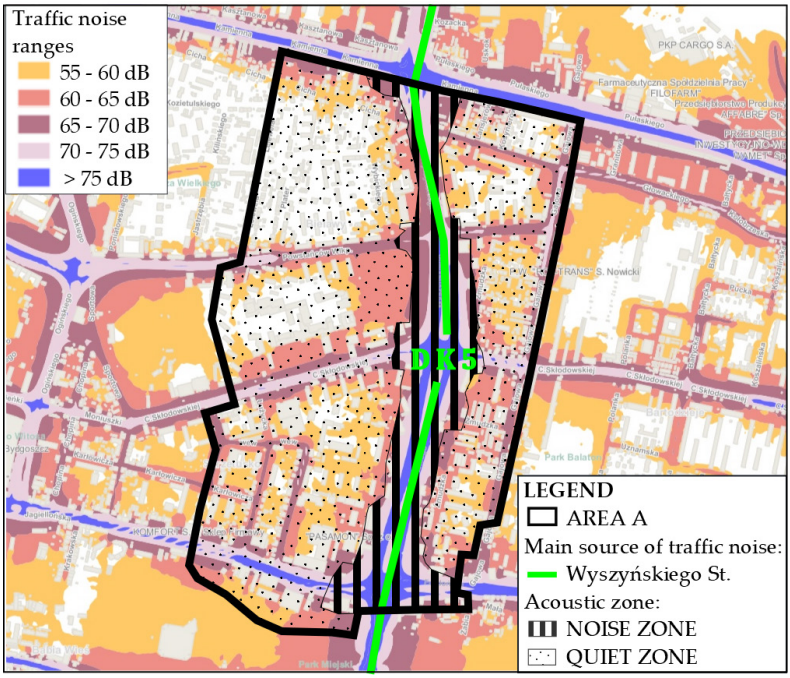

Fig. 4. Spatial range of acoustic zone with respect to main sources on ambient concentration road traffic noise emission map of L_{DEN} indicator

Source: [4, 10]

3.3. Results and Analysis

The results of the spatial analysis are shown in the ArcGIS 10.5 and Poland Orto photomap to display information about the residential estate market and its surroundings. Each piece of software belonging to the group described as desktop GIS has tools for finding, sorting, and analyzing the described and geographic information in a geodatabase. How we use the ArcGIS system for a spatial analysis is described below. ArcGIS allows us to search for data and then select records in the database according to the built SQL expressions. We can use comparison operators such as equal to (=), not equal to (<>), greater than (>), smaller than (<), greater than or equal to (>=), less than or equal to (<=), logical operators such as AND, OR, and NOT, and arithmetic operators; e.g., SELECT * from the Building WHERE Str_name = 'Aleje Kardynala Wyszynskiego' AND Noise > 65 AND Noise < 70 (Fig. 5).

This query allows for a spatial analysis regarding the location of buildings on Wyszynskiego Street, where car traffic generates noise within a range of 65 to 70 decibels, as well as other descriptive attributes of the localized building such as area, price, floor, etc. (Fig. 6).

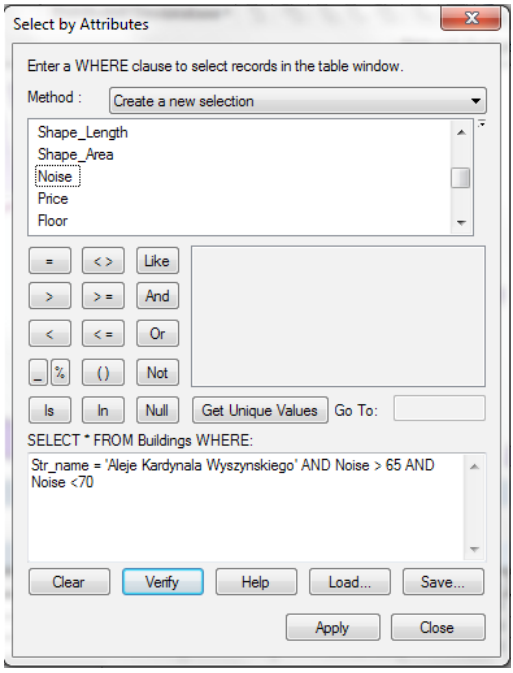

Fig. 5. Selection by attribute dialog box

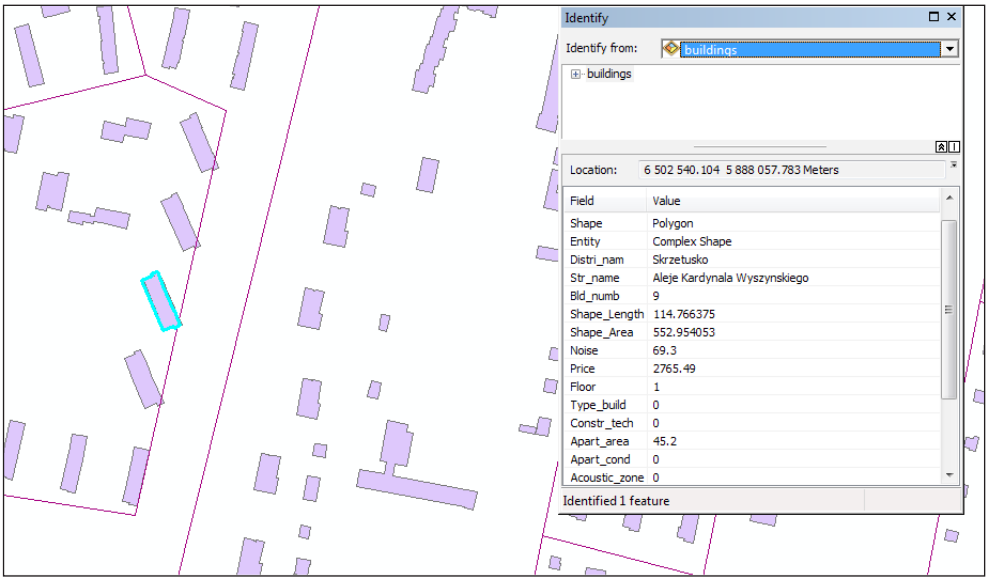

Fig. 6. Location and identification of selected property's attributes

4. Conclusions

In summary, it was found that the housing market can be displayed in the ArcGIS environment. The database model presented in the article is an example of designing a GIS database using the Enterprise Architect program, which is a modeling tool mainly using the UML language created by Sparx Systems. It contains a module for designing databases in the ArcGIS environment that can be implemented into this program. The author of this paper suggests that the proposed database model in ArcGIS can be a problem for people who have never had contact with ArcGIS software. Therefore, the intention of the author in the future is to work on creating a more user-friendly application that could facilitate the use of the database in spatial analyses of residential estate transactions.

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GIS w analizie rynku nieruchomości mieszkaniowych: studium przypadku

Streszczenie: Zastosowanie oprogramowania GIS na rynku nieruchomości mieszkaniowych jest bardzo przydatne do wizualizacji informacji przy użyciu mapy i tabel opisowych. Aby skutecznie zarządzać bazą danych na rynku nieruchomości, niezbędne są zaawansowane technologie informatyczne, które zapewniają mechanizmy wprowadzania, gromadzenia, analizowania i przechowywania danych katastralnych. Rozwiązania przeznaczone do modelowania rynku nieruchomości mieszkaniowych należy traktować jako ważny element rozwoju gospodarki przestrzennej. W procesie wyceny nieruchomości można ustalić wysoką lub niską wartość rynkową na podstawie danych atrybutów. Podczas wizualizacji można analizować czynniki o najwyższej i najniższej wartości rynkowej, opierając się na danych geograficznych pozyskanych za pomocą ArcGIS. Szczegółowych informacji dostarczają również narzędzia analityczne tego programu.

Słowa kluczowe: GIS, SDM, rynek nieruchomości mieszkaniowych