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# Digital System for Spatial Analysis of the Area and Development Directions

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**Abstract.** The idea of creating a digital system for spatial analysis of the area and development directions is to build a digital tool that would allow for a complete automation of administrative processes in spatial planning offices. Such procedures accompany the decision-making process with regard to the conditions for development (location) and are closely related to the automation and systematization of site analyses, which takes into account all aspects of spatial conditions listed in the Act on Spatial Planning and Development for Poland (minimum scope of the area covered by the analysis, land use, characteristic parameters of existing buildings, the height of the construction, the height to the eaves, the shape and material of the roof, its inclination, occurrence of roof dormers, technology of erecting the building, its intended use, building area and biologically active area). Another function of the system will be the possibility to perform analysis of local plans concerning the special development (the analyses take into account the records of plans already in operation in the area, the characteristics of utility areas and their transformations over the past years, which will allow to determine the expected development directions). The secondary feature of the system will also be the automation of obtaining a local plan extract from the existing spatial plans for a given location. Due to the use of a digital tool for the analysis, its impartiality together with the speed and precision of operation should be assumed. It will undoubtedly affect the quality and decision-making processes regarding the spatial development. The recipients of this tool will be primarily rural communes, where the scale of activities is not so large, compared to urban agglomerations, and due to the lack of local spatial development plans, in most of these areas, it forces the communes to create these plans in order to carry out procedures related to the issue of documentation related to conditions for development. The digital system for spatial analysis of the area and development directions will be based on the free of charge, QGIS software, along with the necessary plug-ins created for this purpose. This article is to show the way of creating such a system using "open source" software, along with publicly available data, downloaded from various mapping websites and WMS and WFS sources, which will contribute to creating objective analyses of spatial conditions and determining possible development directions for small and medium-sized rural systems.

## 1. Introduction

For each planning activity associated with both the creation of local spatial development plans and location decisions taken individually in order to determine the possibilities of land development, it is necessary to take into account the respect of spatial order, i.e. pay close attention to the harmony between the existing cultural landscape and the proposed new volume structures, while taking into account in an organized way all functional and spatial conditions of the area under analysis.



Although these activities are strictly regulated by legal acts, including the Act on Spatial Planning [1] which aims to systematize the principles of shaping spatial policy by local government units and government administration bodies, and the procedures for determining the allocation of areas for specific purposes and the principles of their development and development - adopting spatial governance and sustainable development as the basis for these activities.

It is worth noting, however, that in some cases there is a lack of objectivity in the course of conducting analyses and drawing conclusions. Like any other activity related to human intervention, it is burdened with the possibility of error or suspicion of subjective evaluation of the analysed areas, as well as unreliable evaluation of the state of the existing cultural landscape.

In order to ensure a completely objective assessment and certainty as to the correct performance of analyses of functional and spatial conditions for a given area, it appears necessary to create a digital system of spatial analysis of the area and directions of development, which would be based on the existing "open source" GIS software [2], along with the utilization of information contained in various types of "geoportals" together with additional "plug-ins" for the core software.

Contrary to sophisticated analytical systems, which link GIS with GPS technologies, remote sensing used in computer modelling of terrain, and proposed by Dr. Moore's TAPES systems or field analysis programs for environmental science, which are applied in case of large areas and complex spatial systems [3], the proposed system will be characterized by easy operation and limited possibility of analysis, focused only on a few strictly defined actions, which will ensure the correctness of operation of the entire system.

## 2. Basic assumptions

In order to ensure the proper performance of the system, the criteria for carrying out the analyses should be specified. The guidelines are established on the basis of the legal acts in force in a given country, which govern the regulations of spatial order creation. As far as the territory of Poland is concerned, we can name two documents, namely the Act on Spatial Planning and Development [1], which governs the rules regulating the development of local spatial development plans, and the Ordinance on the method of determining the requirements for new construction and land development in the absence of a local spatial development plan [4].

Under these legal acts, a detailed set of criteria may be formulated. In the case of analyses linked to the automatization of the building environment development process (determination of the character and function of the new development in the existing urban environment) the following shall apply:

- building line
- size of the development area in relation to the area of a plot or terrain
- size of the biologically active area (not built on or covered by a solid surface)
- width of the front elevation
- height of the upper edge of the front elevation, its ledge or attic
- roof geometry (the angle of inclination, the height of the roof ridge and the roof slope layout)
- function of existing buildings
- number of storeys

In relation to the processes accompanying the creation of local spatial development plans, the proposed system would be aimed at assisting analyses of possible directions of development of areas designated for development, taking into account the following criteria:

- usable area of the existing buildings, taking into account the percentage of individual functions of the buildings of the compact functional and spatial structure within the boundaries of the settlement unit, taking into account cadastral divisions
- the percentage of agricultural area in relation to the municipality's area
- percentage breakdown of the areas by their functions

With these criteria in place, site-specific information shall be implemented so that it can be used for analyses using "open source" GIS software and specially engineered "plug-ins".

### 3. Way of operation

The platform on which the digital system for spatial analysis of the area and development directions will be based, is "open source" GIS, QGIS version 3.0. QGIS - licensed under the terms of the GNU General Public License. It is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android, and which is not without significance, it is a free software.

In order for the intended system to function properly and meet the objectives set for it, it is necessary to first create a complete database of site information containing the necessary information to be used in further stages of spatial analyses.

For the empirical verification of the validity of the assumptions, an experimental area of the area covering the settlement units of the Kobylanka commune in the West Pomerania Voivodeship was selected. This territory is characterised by a variety of functions of individual areas, from areas of increased tourist value through strictly residential areas or areas of an industrial and logistic nature, to agricultural areas. Such a diversified area, in terms of both the function and the nature of the development, provides the basis for proper verification of the correct operation of the system.

The next step is to prepare a suitably formatted map base, that will be the framework for the further creation of the database. This should start with the use of publicly available data contained in map portals such as:

- Apple Maps
- OSM/Thunderforest
- Wikimedia Maps
- OSM/Stamen
- Bing Maps
- Google Maps
- Open Street Map

To obtain such information, an "Open Layers" plugin can be used, a device which is responsible for communication between QGIS and map portals. The Earth Explorer service can be used to enhance the terrain information. The next step aimed at obtaining as much information as possible about a given area is to use the plugin available at GIS-Support.pc "WMS Database", which enables access to many geodetic services, governmental and public organizations which share their data in this manner.

To complete and at the same time verify the correctness of the obtained cadastral data there is another LPIS plug allowing to check all parcels in Poland.

The gathered data can be used as a preliminary preparation of the map framework taking into account the buildings and communication systems. A pejorative factor of this type of portals is the sharing of data in the WMS Web Map Service format, which is a raster format, as well as the frequently not updated data concerning a given area.

This is followed by the import of data in vector formats WFS "Web Feature Service" which, unlike raster formats, do not contain the error element. Another "Quick OSM" plug can be used for this purpose. However, in the case of Poland, the most complete data can be obtained, through accessing the address of the database of a given region by the PODGiK "District Centre for Geodetic and Cartographic Documentation".

Once we have gathered all the information available from the above sources, we will obtain a land map with cadastral information, land registry and an outline of the existing buildings. Unfortunately, this is still not sufficient to fully achieve the objectives set for the "digital system for spatial analysis of the area and development directions". It is necessary to perform a field inventory together with a verification of the conformity of the obtained data with the factual state. On the basis of the above, it is possible to create a complete database necessary for carrying out analyses. To accomplish given

objectives, a template of an information card (Table 1.) was created, to be supplemented in the field for each plot covered by the study (in this case, the area of the Kobylanka commune). The card contains the necessary information, which are closely related to the assumed analysis criteria. The final result is the completed cards (Table 2.), which are the basis for the creation of a complete database (2500 information cards were prepared for the Kobylanka commune).

**Table 1.** Template of the information sheet, Source: author

Property data sheet					
Address details	City	.....			
	Street	.....			
	Police No.	.....			
	No. of the parcel	130/5			
Parcel information (underline)	Agricultural plot	Building plot	Industrial plot	Road / dirt road	Area of the plot
Information about the building	Number of storeys above ground	.....			
	a) Roof shape	.....			
	Height to eaves	.....			
	Height to roof ridge	.....			
	Lucarne	Yes/No			
	Roof pitch	.....			
	b) Roof covering material	.....			
	c) Building construction technology	.....			
Installation surface	.....				

a) Roof shape –1 Flat roof, 2 Pent roof, 3 Gable roof, 4 Jerkinhead roof, 5 Hip roof, 6 Multi hipped roof, 7 Gambrel roof, 8 Other

b) Roof covering material – 1 Flat roof, 2 Felt paper, 3 Bituminous tile, 4 Eternit, 5 Sheet metal, 6 Roof tiles, 7 Other

c) Building construction technology - 1 traditional (bricks, porotherm, concrete blocks, silicone, etc.) 2 wood frame, 3 steel frame.

Based on the completed information sheets, an XLS spreadsheet was created with structured data assigned to each parcel number corresponding to the numbering of parcels available in the QGIS table lists.

With a database created in this way, along with information on the records of local spatial development plans (if they exist) for individual areas, it is necessary to develop plug-ins responsible for:

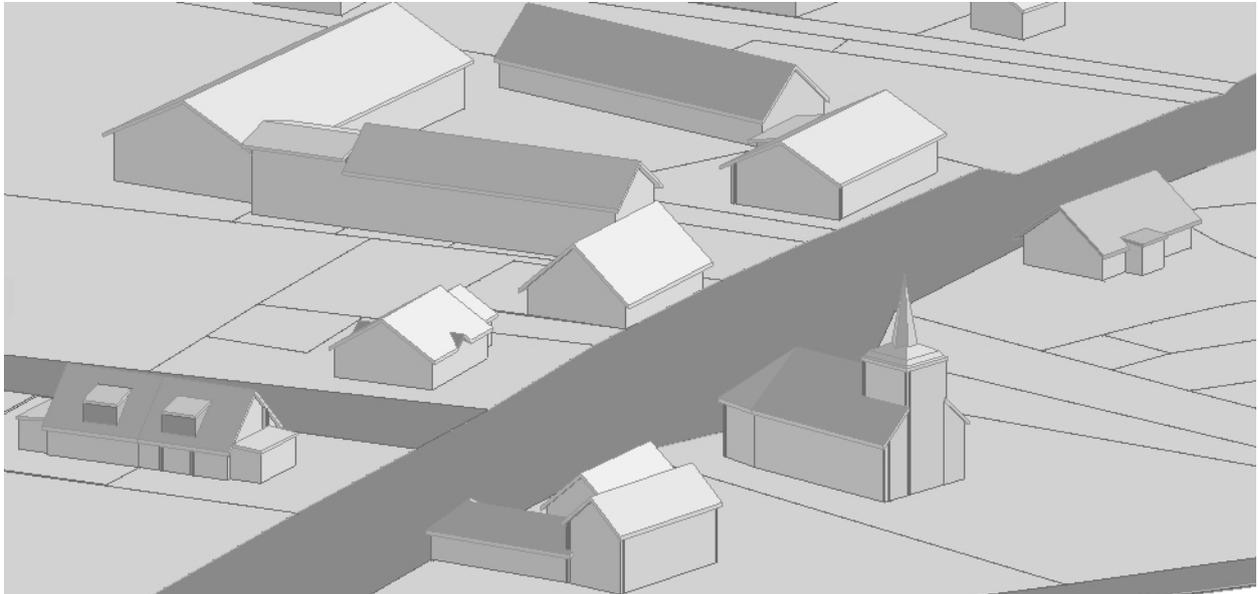
- analysis related to the procedure of obtaining development conditions which generates mean values of specific data included in the database from the area selected by the operator with the possibility of defining the scope of basic data. Ultimately, the process of determining the forms and functions of future development on free, undeveloped plots should be automated.
- graphical representation of the information of the prepared cards after each plot has been indicated.
- analysis of individual records of the local spatial development plan in order to automate excerpts and drawings for the selected areas.
- analysis of the relationships between the various land uses for the area defined by the operator.
- tool enabling supplementing the information about the plots in case of changing their parameters, or adding new ones during subsequent local inspections in a given area.

**Table 2.** Example of an information sheet Source: author

Property data sheet					
					
Address details	City	Kobylanka			
	Street	Osiedle Cichy Zakątek			
	Police No.	2			
	No. of the parcel	509/6			
Parcel information (underline)	Agricultural plot	<u>Building plot</u>	Industrial plot	Road / dirt road	Area of the plot 850 m <sup>2</sup>
Information about the building	Number of storeys above ground		1 + usable attic		
	a) Roof shape		3		
	Height to eaves		3,5 m		
	Height to roof ridge		6,5 m		
	Lucarne		Yes/No		
	Roof pitch		45 degrees		
	b) Roof covering material		6		
	c) Building construction technology		1		
Installation surface		125 m <sup>2</sup>			

It is recommended to use the Python programming language as the basis for creating the above tools due to simple and clear syntax understandable for a person who is not strictly educated in IT field, dynamic type system, large number of standard libraries and above all possibility of installing additional modules or creating own extensions.

As an additional option, it may be possible to generate an existing 3D building model with cadastral inclusion (Figure 1).



**Figure 1.** Example of a 3D model fragment of an existing building structure (Source: author)

#### **4. Results and discussions**

Creation of a digital system for spatial analysis of the area and development directions will allow to a large extent for automation of processes accompanying spatial planning activities, which will result in improvement of the quality of work results of planners, as well as significant reduction of administrative time for issuing decisions related to new developments.

Owing to the unification of the rules of performed analyses deprived of human factor, it can be assumed that decisions made in planning will be objective and, consequently, not be subject to appeals or disputes, which in turn has a significant impact on the course and time of administrative procedures, prolongation of which is often a decisive element for the success of future investments in a given area.

A straightforward operation of the system will eliminate the need to generate additional IT jobs, improving, the economic condition of the employment policy especially in small public administration units.

For the system to function even more efficiently, the database of the area covered by a given territorial unit should be constantly updated, which means that procedures need to be put in place for information exchange between the various administrative departments responsible for spatial planning, building, permits and completion of construction operations.

#### **5. Conclusions**

The rapidly developing technology and digitization of many areas of everyday life mean that, at some point, we will be condemned to shifting our decision-making responsibilities to computer systems, at least to some extent. The widespread availability of software, together with wide access to information, results in increasingly sophisticated data processing and analysis systems. For these reasons it is important to enable small administrative units to access modern IT solutions that will allow for cooperation with more technologically advanced centres of urban agglomerations, allowing for equal development of all centres.

#### **References**

- [1] Dz.U. 2003 No 80 item 717 of the Act of 27 March 2003 on spatial planning and development

- [2] QGIS is a Geographic Information System (GIS) licensed under the terms of the GNU General Public License. QGIS is the official project of the Open Source Geospatial Foundation (OSGeo). <https://www.qgis.org>
- [3] John P. Wilson (Editor), John C. Gallant (Editor) “*Terrain Analysis: Principles and Applications*” ISBN: 978-0-471-32188-0 Aug 2000
- [4] Dz.U.03.164.1588 Regulation of Minister of Infrastructure of 26 August 2003 on the method of determining the requirements for new buildings and land development in the absence of a local spatial development plan.