

Comparative Analysis on the Use of Raster and Vector Data in the Optimization Process of Rural Area Planning

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ABSTRACT

Rural area is a unique system of individual and interdependent features. In the geographical space, these features concern the suitability of the area and are the criteria of their optimization. Their multitudinous character makes the management of rural space a continuous and dynamic process of great significance. The instrument of this process is spatial planning determining the final development and land use. Particularly important in this process is the selection of geodata, as a direct indicator of the directions of land use. Digitization of spatial data, the underlying generated geographic information system (GIS) seems to be extremely useful in the process. The ability to analyze the information gathered by the addition of simple queries to databases enables the understanding of the accuracy of what may occur in the spatial distribution of phenomena, which in turn allows making planning decisions. Still, it remains difficult to determine which of the features stored in the system are the key planning information. The study shows an example of a hybrid method of analysis and selection of geodata necessary to optimize the process of spatial planning with the use of vector maps. As a result of the method, which is based on collecting data from raster maps, spatial planning process becomes a lot less time-consuming and laborious and the results of analysis can successfully fund information systems. The analysis proved to be an effective and important tool to achieve the efficiency of a hybrid method in the optimization process.

1. INTRODUCTION

At the present time, geographic information systems (GIS) are everywhere. In the mid-1980s, some very useful tools were developed in the system, which were used to manage, store data in an electronic form and to graphically display many thematic layers, containing data on location and attributes [10]. In the "Lexicon of geomatics", Gazdzicki (2002) defines GIS as a "System used to search, acquire, verify, analyse, transfer and make available spatial data; understood broadly, it includes methods, technical means – hardware and software, spatial database, organisation, resources and people interested in its operation" [3].

According to Roth (2013), the interaction of the whole process depends on three elements [11]:

- human factor (which arises from the user's perspective);
- visualisation (focusing on the interface);
- technical factor (focusing on the technical side of the issue).

It should also be added that the GIS system is compatible with statistical programs and spreadsheets [6], [2]. The system can be applied, for example, when inconvenient analogue data sets are replaced with digital sets [4]. Such a change is usually seen as a replacement of analogue maps with digital maps. According to Kuan et al. (2013), maps are a graphic

presentation of geographic and spatial information [5]. Although a raster map is a model of geographic space recorded as a two-dimensional table, called a pixel matrix [7], a vector map is a set of objects described by coordinates in a specific system of coordinates. A vector map can be used to store data for which high precision is required, such as points of the geodetic control network, plot borders and technical infrastructure network.

“Scanned raster maps are usually used as “visual context” for users” [8]. “Users are mostly interested in just one or a small number of neighbouring objects, but in order to locate them in space it is necessary to display geometrical data and textual annotations for a number of surrounding objects” [9].

2. THE HYBRID METHOD OF ANALYSIS AND SELECTION OF GEODATA NECESSARY TO OPTIMIZE THE PROCESS OF SPATIAL PLANNING

This paper presents an original method of analysis and selection of geodata, consisting of heterogeneous methods of optimization, which are hybrids structured in a series. This enables more precise and faster problem solving. This method combines methods of spatial assessment and valuation (Bajerowski's method), numerical taxonomy (Ward's method) and axioms of the theory of planning spatial use (totality axiom).

The basis for a specific method is a study conducted in the area covered by a local land use plan. The modified Bajerowski method has become the first component of the hybrid. According to the assumptions of the method, stock taking of geodata in a specific area is conducted using a topographic map and land register maps. If these are analogue maps, they are scanned and fitted in as a raster image. This helps to divide the area under examination into primary fields with dimensions 200x200 m. The same assumptions apply to vector maps, but the basic difference is that stock taking of geodata is automated.

According to Bajerowski (2003), the dimension of a zoning space is equivalent to the number of features of space which allow the position of an object in the space to be determined [1]. Properties that allow specifying the location of the object in this space are a list of features, and the test object is the primary field. The probability of the primary field belonging to a certain group of similar fields is determined by the type and number of features. Conducting stock taking in this way enables further analysis of the terrain by the Ward method. The Ward's method uses the incremental sum of squares. The increase in the total internal squared sum is due to the linkage of two groups. The main purpose of this procedure is to unify groups where variance within them does not increase drastically,

producing the most possible homogeneous clusters. Ward's technique also has the characteristic of dividing the various stations into regions with approximately the same size. This feature is especially useful because it ensures that each group has the minimum number of stations needed for the application of the appropriate regional estimation technique [12], [13]. The main task of the method is to group individual primary fields depending on the geodata occurring within them.

The third component of the method is totality axiom [1]. Owing to the assumption that each two combined wholes give the same functional whole and they differ only by the spatial range, the best or the poorest developed space can be identified in the area under study, without having to divide the area into subgroups. This is the final method, which enables combining the neighbouring primary fields (similar in terms of the spatial features within them) to create larger areas representing the same functional whole.

This study analyses the first component of the hybrid method. It shows how to conduct automatic cartographic stock taking using vector maps.

2.1. Stock taking of geodata from a raster map

This method has been presented with the use of an area covered by a local land use plan, situated in the commune of Stawiguda. Cartographic stock taking of features which occur in an area can be conducted on cartographic maps and land register maps, which have been scanned and fitted in as a raster image with the MapInfor 9.0 software. This enabled us to divide the area under study into 10 primary fields.

The prepared maps can be used to take stock of geodata whose occurrence in a specific primary field is presented on a matrix shown below.

2.2. Stock taking of geodata from a vector map

The process of obtaining data, described in chapter 2.1, can be automated by using vector maps. Analysis of the data recorded in a digital form was conducted by means of the program GeoMedia Professional 6.1., which enables the use of queries for attributes and thematic analysis. Assigning attributes is equivalent to recording semantic information on objects. It is integrally stored with the geometric data of a vector model [7]. If all the thematic layers were entered, it would make the result of the method presented here illegible; therefore, it was limited to the following four layers: water supply network, embankments, buildings and sewerage systems.

Subsequently, a 200 x 200 m grid was drawn into the map; it is within these squares that further analysis will be conducted. The following drawing presents the possibility of previewing different fields and checking their attributes. As we can see, the

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attributes of field no. 5 have been displayed and the analysis one can begin using the prepared map.

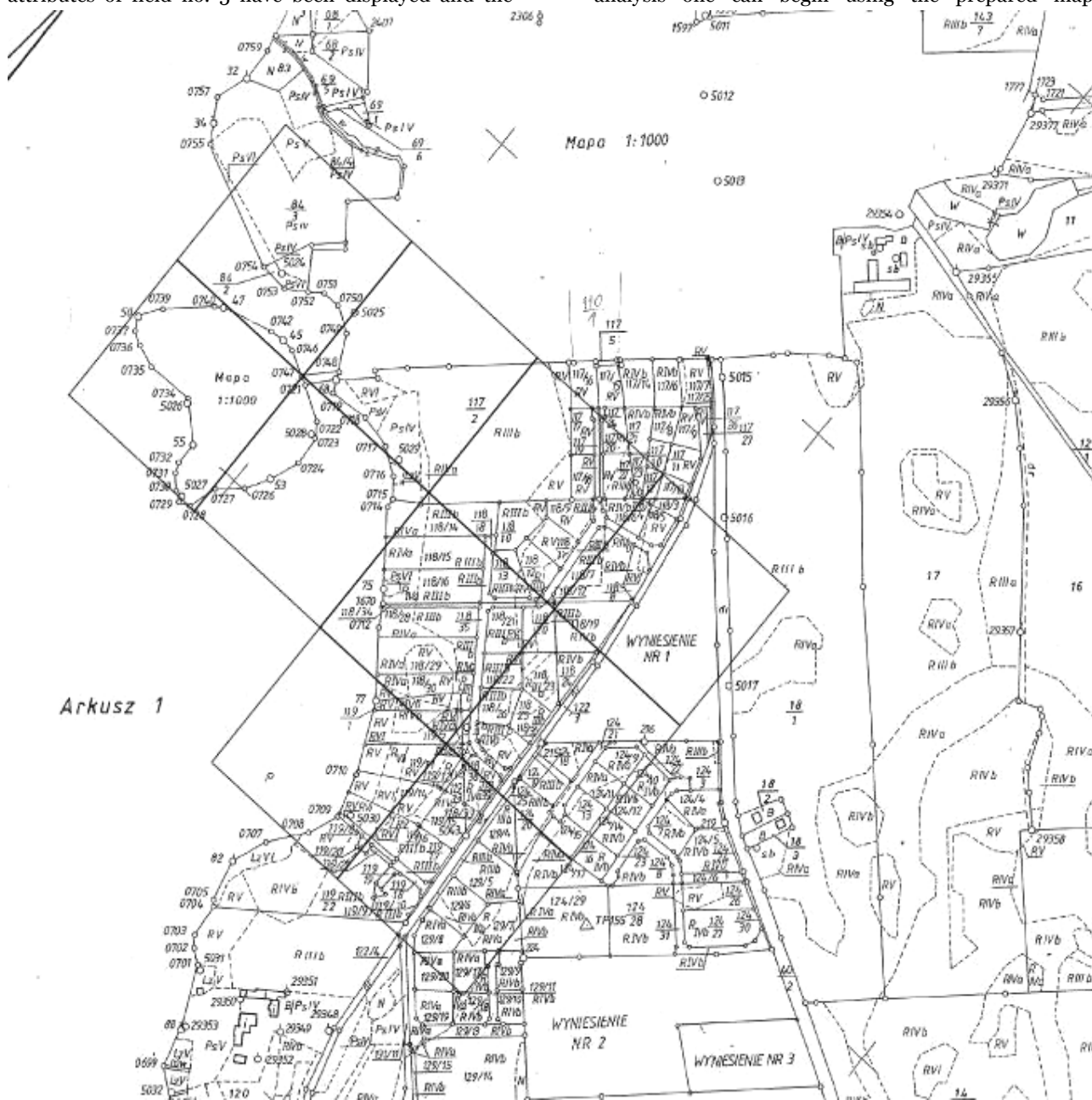


Fig. 1. An example of the division of the area under analysis, situated in Tomaszkowo, into primary fields (source: Prepared by the author based on a land register map 1:5000. County Office in Olsztyn PODGIK).

Table 1. A matrix of examples of space features on the presented area in basic fields.

No. of primary field / features	1	2	3	4	5	6	7	8	9	10
Water supply network	1	1	1	1	1	1	1	1	0	1
Embankments	1	1	0	1	0	0	0	1	1	1
Buildings	1	1	0	0	1	1	0	0	0	0
Sewage systems	1	1	1	1	1	1	1	1	1	1

The analysis can be done by aggregation of objects sought within the basic field. Aggregation allows for transferring objects from one class of objects to

another in the form of a dynamic query. The criteria of consolidation are chosen by the user himself by means of tabs in the AGREGACJA dialogue box. After

aggregation is completed, a functional attribute is added to each of the analysed layers. It allows one to determine whether the object lies within the basic field.

This can be done by means of a query:

`IF(COUNT(Detail.Compound.Geometry)>'YES';'No')`.

Object attributes in a basic field following BUILDING aggregation are presented graphically in the following illustration (fig. 3).

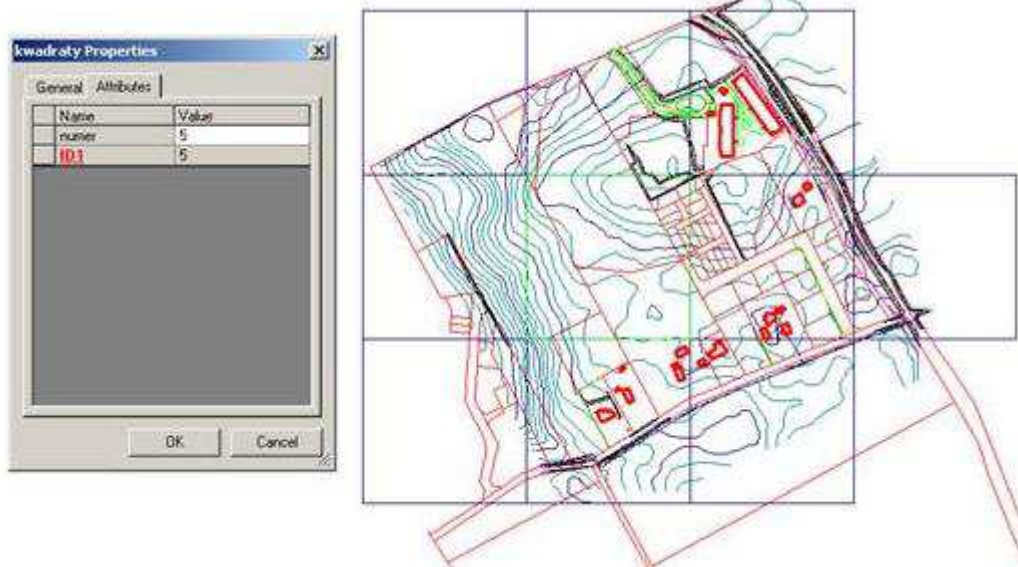


Fig. 2. Attributes of primary fields (square grid).

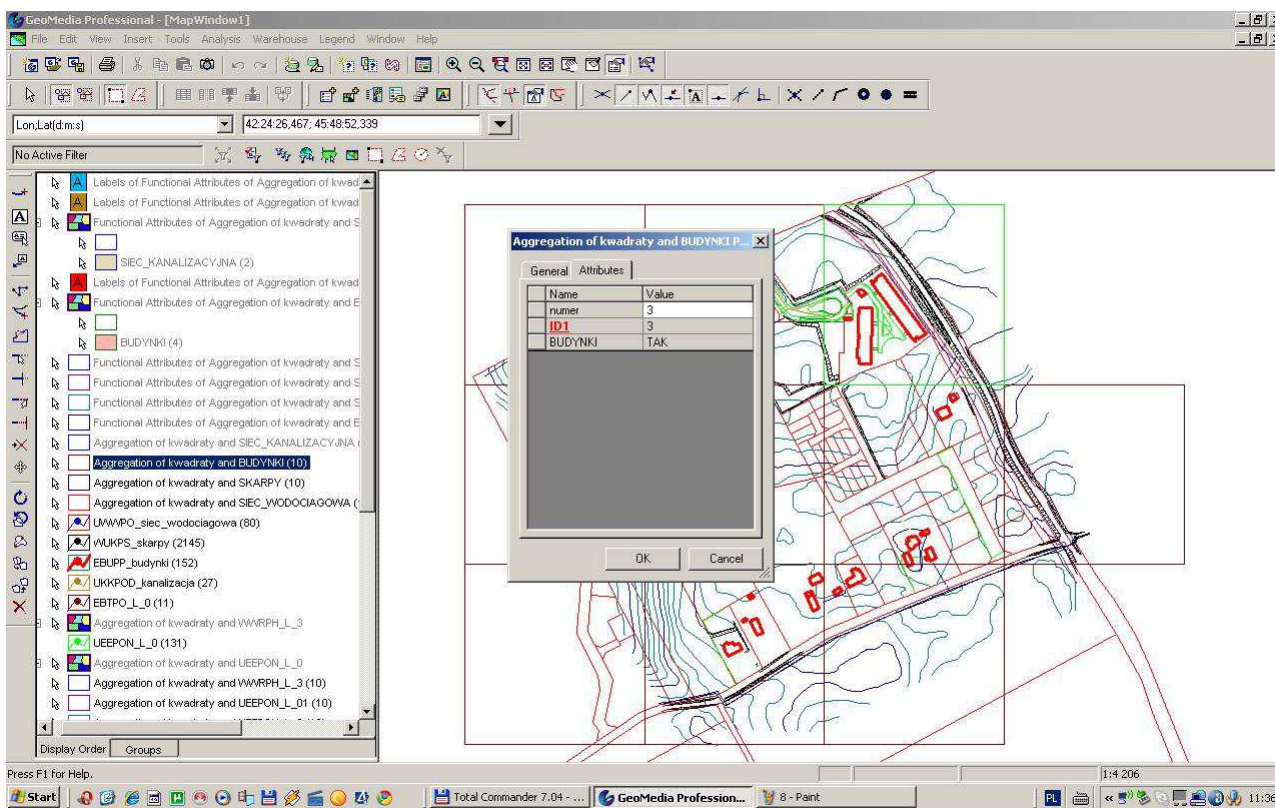


Fig. 3. Presentation of attributes of an object in the primary field after aggregation of BUILDINGS.

In order to make a better visualisation of the results, labels with the names of each attribute should be added on the map. A label can be added in two ways, as a query or as an object class. In both cases, attributes of the original objects are copied to the object label, the difference being that attributes in a query label are

connected dynamically (any changes made on original object attributes are reflected on a label object), whereas they are connected statically in a query label (changes in the attributes of the original objects do not affect the label of an object class). In the presented method, adding query labels was applied; to this end,

the query was used: IF(Input.BUILDINGS = "YES"; "BUILDINGS"; "").

This helped to determine whether a specific functional attribute (in this case: BUILDINGS) lies within the basic field. It should be stressed that when

the aggregation of several attributes is done, the best results are achieved by adding labels with the names of individual attributes on the label map, as shown in Figure 4. The final outcome of the labelling process is an automatic stock-taking of the area.

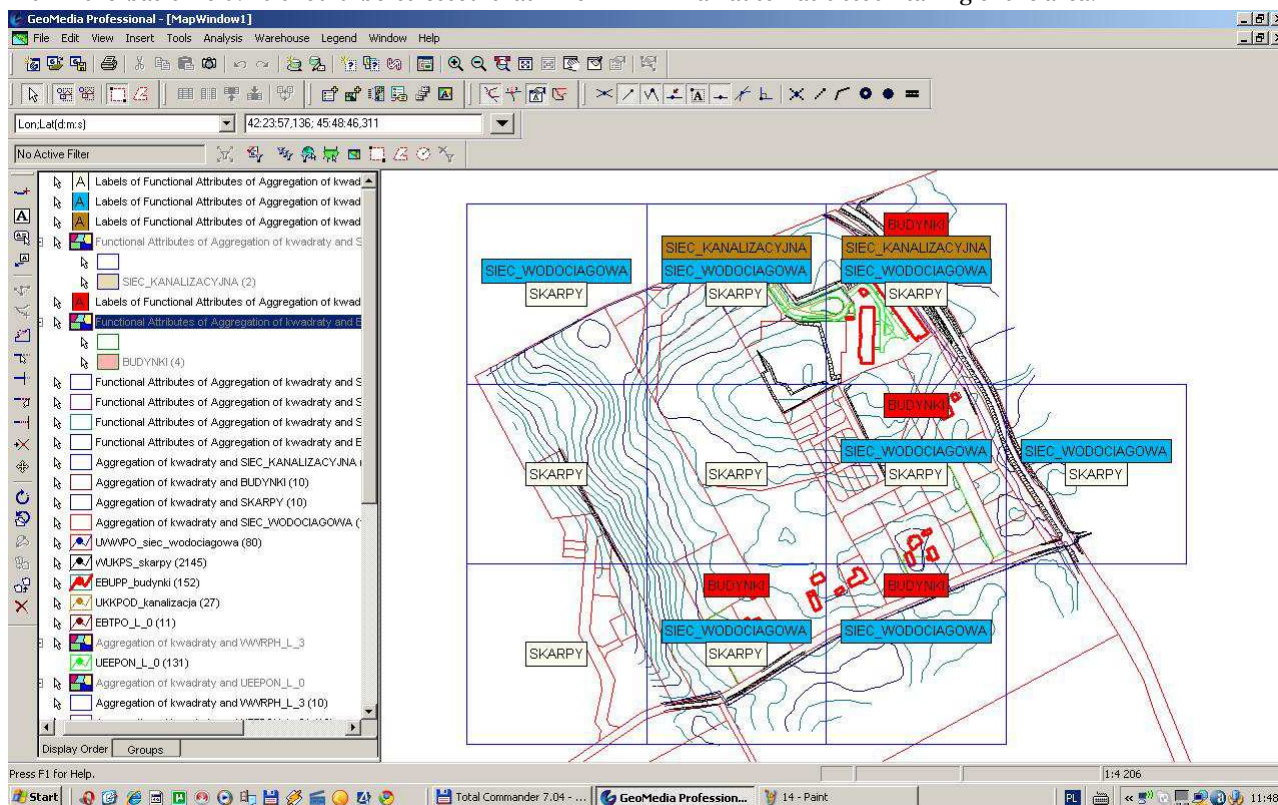


Fig. 4. Graphic presentation of attributes in the primary field.

3. CONCLUSION

The hybrid method of optimization process of spatial zoning developed by the author can be applied when identifying and finding places with particular importance in the process of creation and development of zoning functions. Applying the method in studies and analyses that precede spatial planning can properly facilitate decision making processes. The method can also prove useful in vectorisation of spatial data contained in thematic maps. Analogue maps which refer to a geodetic location of spatial objects have been mostly vectorised, but a huge amount of spatial data on the geographical dimensions of space (such as soil and agriculture data, nature data, sociological data) are still available only in an analogue form. The procedure presented here can greatly facilitate access to a lot of data which are frequently the basis for comprehensive spatial analyses.

By the application of a vector map, the stage of cartographic (manual) stock taking of attributes can be eliminated completely and replaced with fast automated analysis of an area. The advantage of working with such maps is that even in case of large areas data are noted in

the system of coordinates adopted for the layer, with no connections visible at places where they appear on primary sheets. Additionally, through the analysis of the collected information by adding simple queries to databases, patterns may emerge in the spatial distribution of phenomena and facilitate decision-making.

The main advantage of a vector is that it makes it possible to isolate individual objects to which information from databases can be connected. This is not possible with a raster map, with which cartographic stock taking of features occurring in an area is done by finding an object on the map.

Vector maps enable quick analyses of a specific area. With access to such a source of data, the hybrid method of optimization of zoning space becomes less time and labour-consuming and the produced analysis results can successfully be used as input for spatial information systems.

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