

Management of the post-industrial and degraded lands using ArcGIS: the Silesia region example

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Abstract. The basic legal regulations concerning the transformation of the post-industrial and degraded areas have been presented. The scope of data, resulting, among others, from The Act on Environmental Protection, relevant for the realization of the tasks in the scope of the mentioned above areas, has been specified. Due to the fact that these tasks should be realized using the IT system, a database was developed in the ArcGIS system containing, among others, the following data: a general assessment of the technical condition of development, information whether the area is a part of the mining or post-mining area, whether there are land deformations associated with the mining exploitation. The possibilities of using spatial analyses to support the realization of the tasks concerning the transformation of industrial and degraded areas have been presented.

1. Introduction

Due to restructuring changes regarding the mining industry, the issue of origination of the post-industrial and degraded areas becomes more and more important. Among the most important legal acts concerning this issue, the Environmental Protection Act of 27th April 2001 [1], should be mentioned. Article 17 of the Act imposes on the executive authorities of the province, county and commune an obligation to draw up, respectively, a provincial, county or municipal environmental protection program, in order to realize environmental policy [1]. The current Environmental Protection Program (EPP) of the Silesian Region includes the activities that are to be taken by 2019, taking into account the perspective up to the year 2024. The Environmental Protection Program does not directly indicate the tasks necessary for the post-industrial areas. However, it indicates the directions of activities in this scope. These activities mainly concern:

- maintaining and systematically updating the database of the post-industrial areas,
- the development of the scenarios for transformation of the post-industrial areas,
- including the issue of revitalization of the post-industrial and post-mining areas for the strategic objectives of the region, revitalization of the areas and facilities, including the post-industrial and degraded areas, into the areas/facilities with socio-economic functions and ensuring their availability,
- investment support in the field of the development of the post-industrial and degraded areas – the areas requiring reclamation [2].

The long-term goals specified in the program include among others, sustainable management of natural resources and the transformation of the post-industrial and degraded areas.



These goals can be implemented with the use of a system containing information and describing the area. These data include, among others: general assessment of the technical condition of the development, information whether an area is a part of the mining or post-mining area, determining whether there are land deformations related to mining exploitation, and whether such deformations are expected. Investments within the boundaries of the mining area involve the obligation to conduct the appropriate arrangements to determine the possibilities and the scope of threats occurrence in the area, intended for the location of the investment. Within the mining area, usually for several years after the expiration of the concession, there are surface effects caused by the exploitation of the deposit. In both cases, damage to the objects due to mining tremors may also occur.

The Environmental Protection Program takes into account the assumptions of many strategic documents of the country and the province. The examples of the documents are:

- Spatial Development Plan of the Silesian Region,
- Strategy of the Development of the Silesian Region, Śląskie 2020+,
- The Provincial Program for Transformation of the Post-industrial and Degraded Areas along with the Concept of the development of the IT tools and the forecast of its impact on the environment (WPPTPiZ).

The Spatial Development Plan presents the general characteristic of the region and the state of spatial development, indicating the important role of the post-industrial areas, including the post-mining areas. Due to the characteristic of environmental resource that the post-industrial areas are for the region, according to the Spatial Development Plan, trends of changes taking place in a society, economy and infrastructure will have a direct impact on the decrease in the area of degraded and devastated land and the revitalization of the post-industrial areas.

The Strategy for the Development of the Silesian Region, Śląskie 2020+ defines four groups of challenges. One of these groups includes activities related to the revitalization of the post-industrial and degraded areas [3].

The most important document concerning revitalization is the Act of 9th October 2015 on revitalization. From the point of view of using the evaluation, the possibilities of using the spatial information systems, including the ARCGIS system for the realization of the tasks in the scope of transformation of the post-industrial and degraded areas, has the Regional Program of Transforming the Post-industrial and Degraded Areas together with the Concept of the development of the IT tools and the forecast of its impact on the environment [4]. The main objective of this program was "to create the conditions and mechanism for the development of the post-industrial areas in accordance with the principles of the sustainable development." An indirect goal is, among others, to develop a management system of the degraded areas, which is to be used for revitalization. These objectives are in line with the objectives of the [2], in which the main environmental problems and threats are discussed in detail. The issues of the use of geographic information system in the scope of data concerning mining communities, are presented in the works of M. Szafraniec, J. Bandaruk and P. Zawartka [5, 6].

The article specifies the scope of data relevant from the point of view of implementation of the Environmental Protection Program in the area of the post-industrial and degraded areas. It has been proved that most of them are collected in the mining companies, which use the GIS class systems, hence they can be a source of support for the base supporting the implementation of the above mentioned tasks. In order to indicate the possibilities offered by the use of the typical GIS class function, the method of developing a database in the ArcGIS system was briefly presented, including the buildings damaged by the mining tremors, and the scope of the spatial analysis function, which can be used to support the tasks in the scope of transformation of the post-industrial and degraded areas was presented.

2. The scope of information on the post-industrial and degraded areas

One of the important, as mentioned, documents concerning the post-industrial and degraded areas is the Regional Program of the Transformation of the Post-industrial and Degraded Areas, along with the

Concept of the development of the IT tools and the forecast of its impact on the environment [4]. It determines the scope of information relevant for the implementation of the program. The Silesian Region is a European region with the largest number and large area of the post-industrial and degraded areas requiring reclamation. As at the end of 2013, this region took the third place in the country in terms of the amount of land for reclamation [2]. The obligation to conduct reclamation results also from the provisions contained in the geological license or the operation plan of the liquidated mining company.

The program's instrumentation consists of the Regional Spatial Information System, to collect information about the post-industrial and degraded areas. Its beginnings date back to 2003, when the study entitled "Implementation of the Regional Spatial Information System (RSIS- in Polish RSIP) in the Silesian Region for supporting regional and local planning, restructuring of the region and crisis management". In the following years, the project was implemented and in 2006, the Regional Spatial information System was finally implemented in the Silesian Region, which was a source of information for local government administration. Then, a regional node of the spatial information infrastructure was created, which was the Open Regional Spatial Information System, (ORSIS- in Polish -ORSIP). For this system, The ORSIP is a place for gathering reference data [7]. One of the subsystems of the ORSIS system is the portal which is the basic source of information on the post-industrial and degraded areas – the National Information Platform – Post-industrial and degraded Areas (OPI-TPP) [6]. It was built in accordance with the assumption of the National Land Information System and the provisions of the INSPIRE Directive. As at 20th December, 2014, 689 post-industrial areas were registered in the Silesian Region.

OPI-TPP aims to support the management of the development of the post-industrial areas and free access to information about the environment for the society. The recipients of the system services are, among others, the communes and district administration, which are to support making administrative decisions, and planning and creation of the revitalization programs [8].

In order to present clearly information that is required to take further action, a three-module form has been developed [4, 8]:

- Module I – contains the characteristic of the area and its immediate surroundings. This module is completed by the institution that owns the area.
- Module II – contains data generated from the database level of the Regional Spatial Information System of the Silesian Region. This module is operated by the database operator. It is not required to analyse or process data.
- Module III – contains expert information. The majority of information is generated as a result of interpretation of data covered by modules I and/ or II. Only some of them are the result of external data interpretation. The module has two parts:
 - III a – documentation data verified by a local vision,
 - III b – data obtained to supplement information on environmental threats through specialized area research, (e.g. inventories, expert opinions, measurements).

From the point of view of supporting the management of the post-industrial and degraded areas, using the ArcGIS system, the first module seems to be the most important one, for which it is necessary to prepare relevant data, and to have spatial analysis functions. The scope of data is presented in Chapter 3.

3. Database in ArcGIS

The chapter briefly presents the method of creating a spatial information system of database, in which important data from the point of view of the implementation of the environmental protection program was included, and thus WPPTPiZ. In order to determine the scope of data important for the implementation of the tasks in the scope of transformation of the post-industrial and degraded areas, the first module of the form, mentioned in the previous chapter was used, available on the National Information Platform- Post-industrial and Degraded Areas (OPI-TPP). The scope of the specified

spatial and descriptive attributes of the objects of the subject database includes the following information:

1. the proper name of the area or short description,
2. the general description of the forms of current land usage – production and production support, services, housing, etc. (with specification),
3. information about the administrative location of the area (in our case the building):
 - town,
 - street,
 - number,
4. general assessment of the technical condition of the buildings,
5. the indication of the activity type that caused the degradation of the area, (the influence of facilities located in or near the vicinity),
6. information whether the analysed area is a part of the mining area,
7. information whether the analysed area is a part of the post- mining area.

In addition to this information, the database contains data on:

1. the number of the spreadsheet,
2. the coordinates of the objects in the local system,
3. a distance from the epicenter,
4. a category of the mining area,
5. a category of static resistance of the object,
6. resulting damage.

The database was developed in the ArcGIS system. It includes buildings damaged due to the selected tremors induced by mining exploitation, conducted in one of the hard coal mines. The source materials were obtained from the mine. The data, mentioned above, was prepared in the form of a file in a Microsoft Excel spreadsheet. The fragment of the file containing the subject data on the objects being developed presents figure 1.

Lp.	The number of the registration sheets	The information about building (the type and description)	The category of a mining area	The category of static resistance	A technical condition of the object before the tremor	Caused damage		
						The enlargement of the existing damage	New damage	Huge damage
	1	2	8	9	10	11	12	13
1	506/09	Residential building	II	2	Good	Lack	The scratching of the plasters of the internal walls, in facets on the steel girders foot	Lack
2	412/09	Commercial residential building	III	3	Good	Lack	Plasters cracks on a plinth, scratching of the plasters of the internal walls, facets	Lack
3	17/2004	Residential building	II	Lack of information	Good	Lack	Scratches, cracks on the external plasters, internal plasters, facets and on the joints of the gypsum boards	Lack
4	163/01	A residential building with an outhouse	I	2	Good	Lack	Cracks of the plasters of the internal and external walls, facets	Lack
5	157/09	Residential building	II	2	Good	Lack	The scratching of the plaster, facets, dysregulation	Lack

Figure 1. A fragment of an Excel spreadsheet with the values of the object attributes.

In order to make database, the ArcMap and ArcCatalog applications were used. The auxiliary data was introduced in the form of a raster file, which presents the surface situation and the coordinates

grid of the local SG-ROW system. The local coordinate system grid was created using the Fishnet plug. The ArcCatalog application was used to connect the entered raster file to the created local crosses grid. Further development of the database was done in the ArcMap application. Import of data from previously prepared files was done. For reasons of clarity, objects damaged due to particular tremors were introduced into separate layers. After completing the loading of layers with the objects, the shape and color of displaying the objects were determined.

4. The functions of spatial analysis in the aspect of supporting the implementation of the tasks in the transformation of the post-industrial and degraded areas

The chapter presents the possibilities of using the developed database in order to realize the tasks resulting from EPP, concerning the post-industrial and degraded areas. These possibilities are presented in connection with the spatial analysis functions, available to the software. In the case of the post-industrial and degraded areas, one of the continuous tasks is to maintain and systematically update the database of the post-industrial and degraded areas (ORSIP, OPI-TPP).

The ArcGIS software gives the opportunity of realizing this task. It allows the analysis of descriptive and spatial data. Thanks to such operations, new, more important, from the point of view a specific application, new data sets, numerical values and logical values can be obtained.

One of the simple functions that can be used during the analysis is pointing. This function allows to display, for example, information about the type of an object, technical condition, a mining category, or damage that occurred after a tremor, (figure 2) entered into the database.

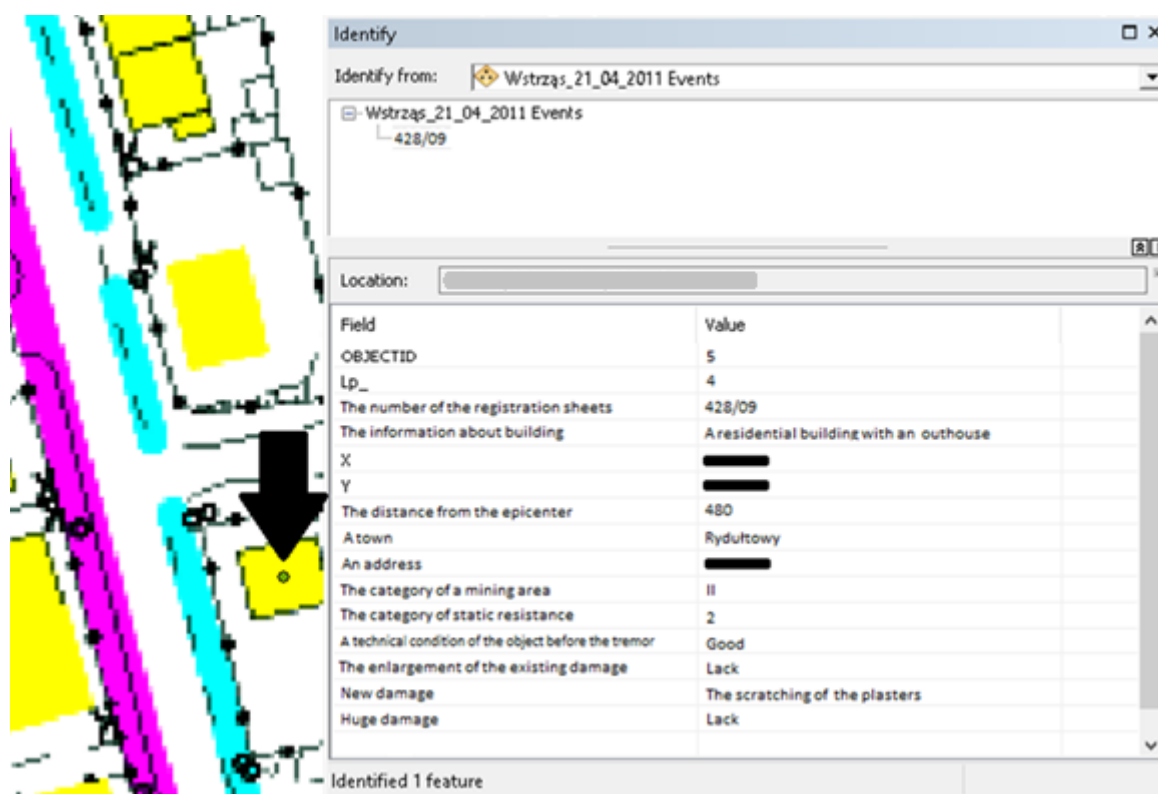


Figure 2. An example of using the pointing function.

The next function that can be used in the process of supporting the program realization is the selective search function. It allows, for example, to display objects located in the mining area, for example, of the II category or objects with a technical condition defined as satisfactory (figure 3, figure 4).

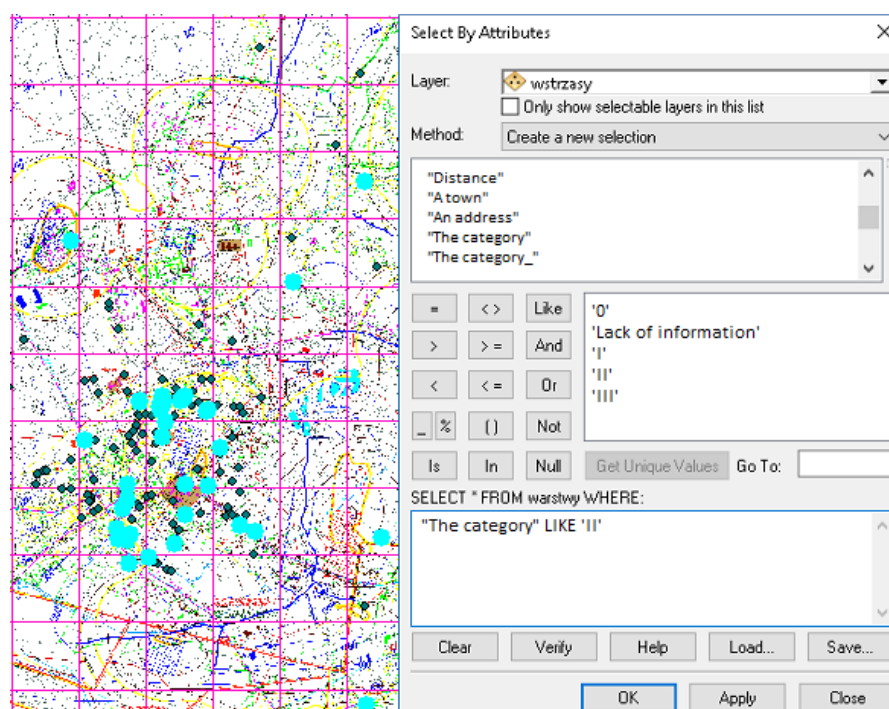


Figure 3. Objects located in the area with a mining category II.

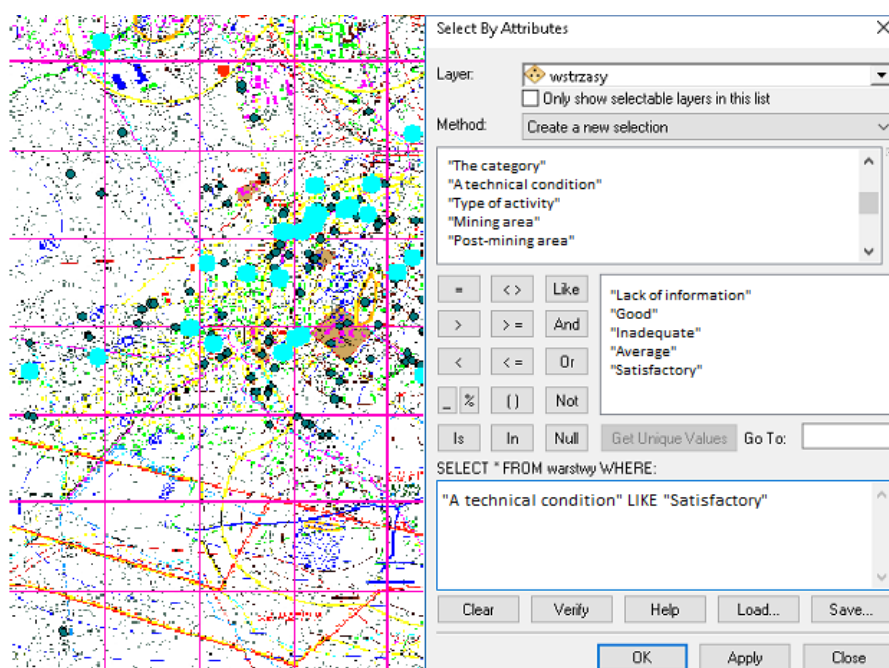


Figure 4. Objects with a satisfactory technical condition.

Among the significant functions it is possible to mention about the neighborhood function. Figure 5 shows the objects that are located at a specific distance from the epicenter of the tremor. It is possible to obtain information on the location of the objects at a specific distance from the boundaries of the area of the specified mining area category, etc.

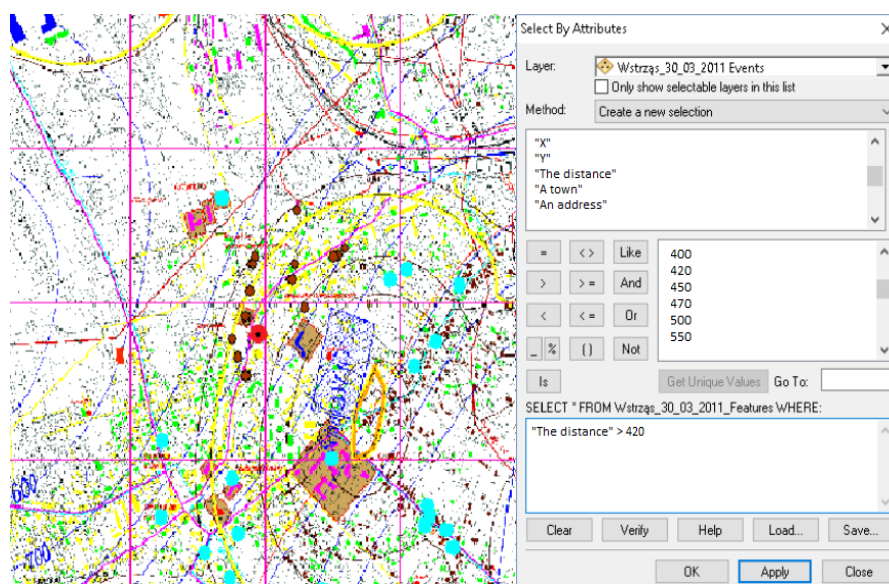


Figure 5. Objects located in the distance of more than 420 m from the epicentre of the tremor [9].

It is possible to perform the analysis of dependencies between various types of attributes. These dependencies can be presented in the form of graphs, e.g. the value of a descriptive attribute and the number of objects meeting a given condition, previously specified in the query, or the relationship between descriptive parameters. In this way, it is possible to analyse the technical condition of buildings and the categories of static resistance (figure 6).

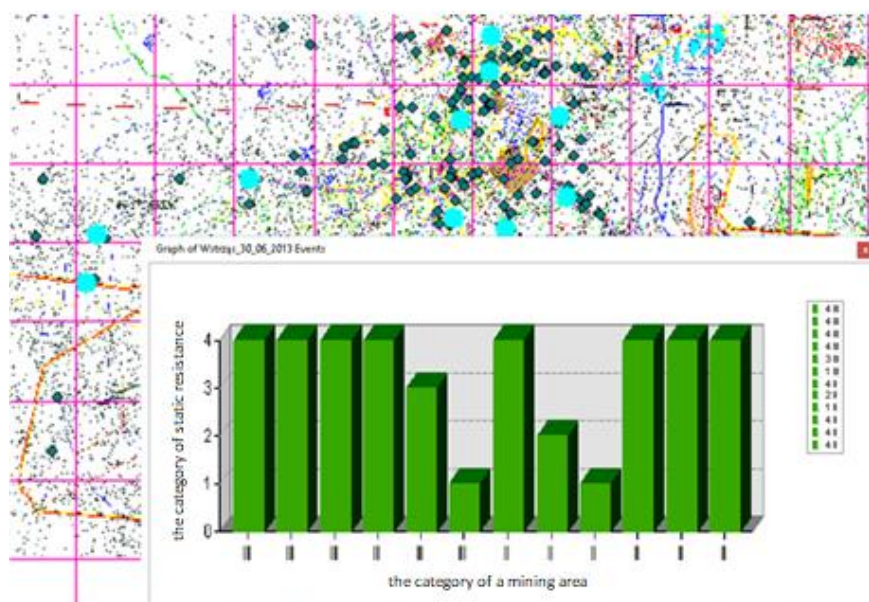


Figure 6. The category of the object resistance as a function of a technical condition.

There is also the possibilities of obtaining data in the form of documents, among others, in the form of reports, and the use of modules that enable statistical analyses. The functions discussed above are the example of the most commonly used. The software allows the use of a number of extended functions, allowing to improve the management of the post-industrial areas in order to realize tasks resulting from the EPP and the strategic documents discussed in Chapter 1, of the Regional Program

of Transformation of the Post-industrial and Degraded Areas. Among other things, to improve the initial and full valorization of the post-industrial and degraded areas, the classification of the post-industrial and degraded areas, the choice of the so-called priority areas and more efficient development of scenarios for the transformation of the post-industrial and degraded areas.

5. Conclusion

The issues related to the use of the GIS database for the realization of the tasks in the scope of transformation of the post-industrial and degraded areas should be considered very important, due to the legal regulations in force and the fact that restructuring changes in mining result in the creation of the new post-industrial areas. As it is clear from the present study, data relevant for the realization are also collected by mining entrepreneurs, hence it is advisable to obtain them to ORSIP system (OPI-TPP), directly from the databases they run, in particular if they are collected in the GIS class systems, operating in companies.

The ArcGIS system presented in the study, by equipping with a number of spatial analysis functions, allows to support the tasks realization in the scope of the management of the post-industrial and degraded areas in order to revitalize and restore these areas to economic trade, in particular it allows to improve the spatial planning process in the post-industrial and degraded areas, it allows to perform analyses and assessments of the post-industrial areas in terms of their possible transformation, and thus also to improve the process of systematic transformation of the post-industrial areas while limiting the risk of making an incorrect decision. It should be noted that investing within the boundaries of the mining area requires appropriate arrangements to determine the possibilities and the scope of threats occurrence in the area intended for the location of the investment.

It can be assumed that the use of a typical GIS class software in the solutions of the spatial information system intended for the management of the post-industrial and degraded areas would be more beneficial than currently used solutions.

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