

# Analysis of environmental-social changes in the surrounding area of KWB Turow in the historical context

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**Abstract.** Opencast mining of large-area lignite deposits impacts the environment, and the health and life of people living in the vicinity of the conducted mining activity. Therefore, the attempt was made to develop a methodology for identification of environmental and social changes in the Bogatynia municipality (south-western Poland), resulting from functioning of Turow lignite mine within its area. During the study of changes occurring over the years, the development of mining pit was noticed, as well as the transformations of this area and impact of the mining plant on the selected elements of environment and surrounding areas. Analogue and digital data were used for the preparation of cartographic compilations, the usefulness of which was analyzed in accordance with the guidelines contained in the standard [1]. The conducted cartographic studies allowed to learn the history of the mine together with identification of changes taking place in the municipality Bogatynia. The obtained results show the form and condition of the objects in the analyzed year, allowing for the interpretation of changes that occurred in the surrounding areas of the Turow mine. Due to the conducted activity of the mine and Turow power plant, both negative and positive aspects were noted in connection with the carrying out of mining activity in the Bogatynia municipality.

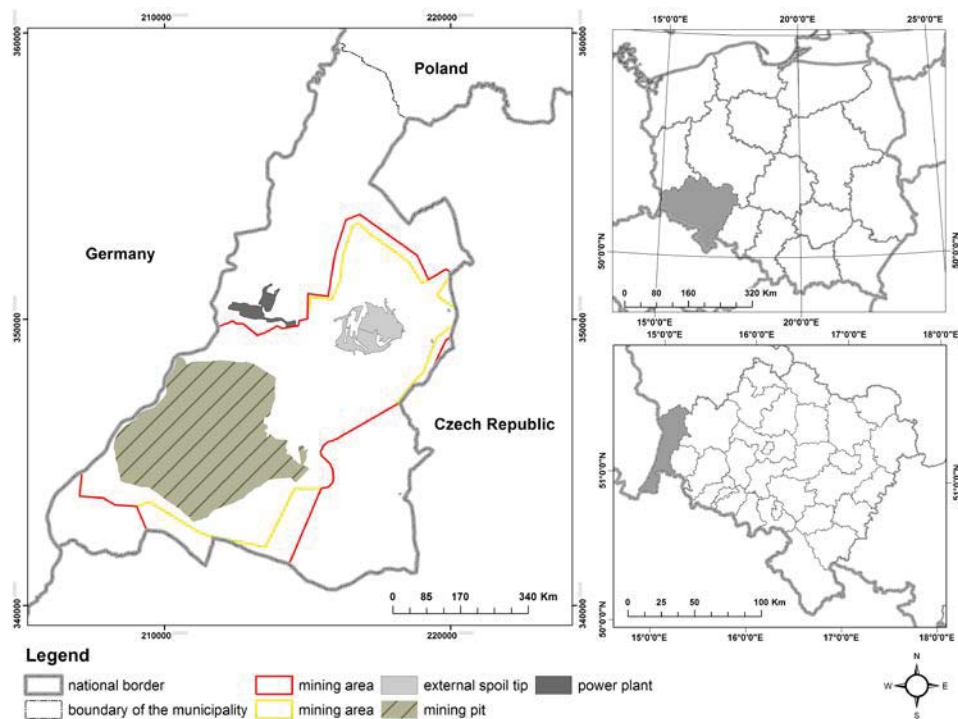
## 1 Introduction

The operation of large-area mining companies that exploit the deposits using opencast method has a significant impact on the environment and society. The consequences associated with the operation of such companies are visible in the landscape, affect the elements of environment located in or near the opencast area and impact the lives of residents in villages and cities located in the surrounding area. Large-area opencast mines in Poland include the following lignite mines: Adamow, Belchatow, Konin, Turow and Sieniawa. Within this study, the works have been undertaken to identify and analyze environmental and social changes in the Bogatynia municipality, which is located in south-western Poland (Figure 1), during the operation of lignite mining from KWB Turow within

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its area. The conducted study covered the years between 1890 to 2016, divided into several periods due to the availability of source materials.

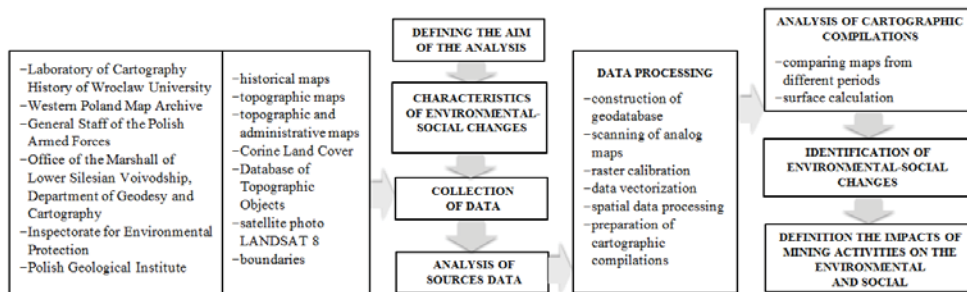


**Fig. 1.** Location of Turów Lignite Mine (own elaboration).

## 2 Materials and methods

In analysing environmental-social changes against historical background, it is important to define the time range examined. It is important to preserve temporal continuity, in addition to the data from the beginning and the end of the time frame, it is necessary to present transitional states in order to better analyse the changes taking place in the area analysed. Time frames were determined after analysing the data obtained in analogue and digital form. Accepted time forms should be referenced to one reference level, allowing identification of transformations that occurred in the time interval. When presenting historical data, the uniform boundaries of the surveyed area should be determined for each development period. This is complicated because the boundaries of the administrative units have changed, so determining the area to be investigated should determine the extent of impact of the investigated phenomenon. The solution to the problem of non-uniform borders may be the adoption of a radius of influence and, on that basis, the designation of the field under investigation or the acceptance as an area under investigation in each period of current administrative boundaries. The administrative boundaries of the municipality of Bogatynia were accepted. The impact of large-scale mining activity on particular elements of the environment and on society was characterized in the next step. Based on this characteristic, the structure of the geodatabase with objects changing under the influence of mining activity was determined. In order to fill the geodatabase, the derived source data was processed (scanning, calibration, vectorization of the analysed objects, calculating their surface area, calculating surface changes) and cartographic studies were performed for the

analysed time frame. The developed geodatabase and maps allowed to identify environmental and social changes caused by the exploitation of brown coal from the large-scale open-pit mine. Figure 2 shows the proposed methodology.



**Fig. 2.** Scheme of conduct in the methodology of analysis of environmental-social changes in the surrounding areas of KWB Turow in the historical context [2].

### 2.1 Identification of environmental-social changes

Each stage of deposit management interferes with the environment and affects the health and life of people. The character and size of these changes vary and depend on the type of exploited raw material, size of its extraction, applied mining technologies, transport and processing of minerals. The identification of environmental and social changes resulting from the large-area opencast mining of lignite was carried out on the basis of subject literature [3-8] and it's described in detail in Table 1.

**Table 1.** Environmental-social changes resulting from lignite mining using the opencast method.

Stage of mining activity	Environmental changes	Social changes
Searching and identification of the deposit	-change of ground surface -emission of communication pollution -emission of dust pollution -noise and vibrations	-emission of communication pollution -emission of dust pollution -noise and vibrations
Preparation works, supplementary works and mining	-transformations of terrain -change of geological structure -transformations of soils and lands -destruction and pollution of plant and animal systems -hydrological and hydrogeological transformations -emission of communication and dust pollution -noise and vibrations -exclusion of areas from the previous use	-transformations of terrain -change of land development -liquidation of crops and breeding -liquidation of residential infrastructure, transport and industrial infrastructure -change of real estate values -change of place of residence and lifestyle -emission of communication and dust pollution -noise and vibrations
Transport	-emission of communication pollution -emission of dust pollution -noise and vibrations	-emission of communication pollution -emission of dust pollution -noise and vibrations
Liquidation, reclamation and management	-transformations of terrain -transformations of soils and lands -transformations of flora and fauna -hydrological and hydrogeological	-transformations of terrain -emission of communication and dust pollution -noise and vibrations

	transformations -emission of communication and dust pollution -noise and vibrations	-change of land development
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## 2.2 Characteristics of the study subject

The history of first attempts to extract lignite from the Turow deposit dates back to 1740-1790. In XIX century, as a result of the flourishing of industry in these areas, the first mineshafts were created allowing for extraction of coal, which was supposed to become the new material used for energy production. Unfortunately, the water in the ground caused that the windshields were flooded in a short period of time and most of them stopped coal mining. In 1879, many changes were introduced to the mining system, because a lignite-fired power plant started its operation in Hirschfelde. Systematic extraction using the opencast mining method in the industrial scope started in 1904, at the time of “Hercules” company. Production of new mining machines was started in order to increase the efficiency of mining of the deposit, while the briquetting plant and railway line allowing for transport of coal to the power plant were created in 1911. In 1947, after the II World War, the mining plant was taken over by the Polish State Treasury. Further development of the mine took place in 1958, when the expansion of existing open pit was started, in order to create a modernized mining plant "Turow". At the beginning of 1958, the decisions were made to expand the plant and the district of Bogatynia became famous on a national scale. The next stage in development of the mine was the commencement of construction of the Turow Power Plant. At the beginning of 1990s, the tactics of modernization of the mining plant was introduced. Innovative machines and devices were introduced in the mine, which significantly contributed to the efficient extraction of lignite. The mining activity associated with environmental protection programs has been successively expanding. In 2001, the “Turow” Mining Plant was removed from the list of 80 companies that are the most harmful to the environment. Due to the concern for the environment, the mine implemented a nature protection program in 2004-2008, which resulted in the afforestation of the external spoil tip. In the subsequent years, as a result of policy associated with power supply sector and merging of companies engaged in energy production, KWB Turow became a part of the PGE Mining and Power company. Currently, the mining plant in Turow is one of the largest opencast mining companies in Poland. Coal extraction is estimated at 12 million tons/year with an overburden of 32 million m<sup>3</sup> [9-13].

## 2.3 Construction of geodatabase

Usefulness of the collected source materials in analogue and digital form was analyzed according to guidelines in the standard [1], which defines the basics of geographic data description, defines the description components of their quality and structure of the register contents containing data quality measures. This standard determines the rules for presenting data quality in further applications and describes the general procedures for their assessment. During the analysis of source data, it was assumed that the compilations, which lack parts of the municipality area, would not affect the outcome of the work. Areas that were not shown on analogue maps are located at the outskirts of Bogatynia municipality and the greatest impact of the mining plant is visible in its immediate vicinity. KWB Turow is located in the central part of the municipality, which was included in the entire collected source materials. It was also found that the information contained in the Corine Land Cover from 2006 is not very accurate, because they show real changes above 5 hectares, which can significantly affect the results of conducted analysis. Therefore, data from this database

were used only for the preparation of cartographic compilation from 2006 and were omitted in the analysis of changes. After analyzing the source data, the geodatabase [2] was prepared for individual years covered by the analysis, the structure of which is shown in Table 2.

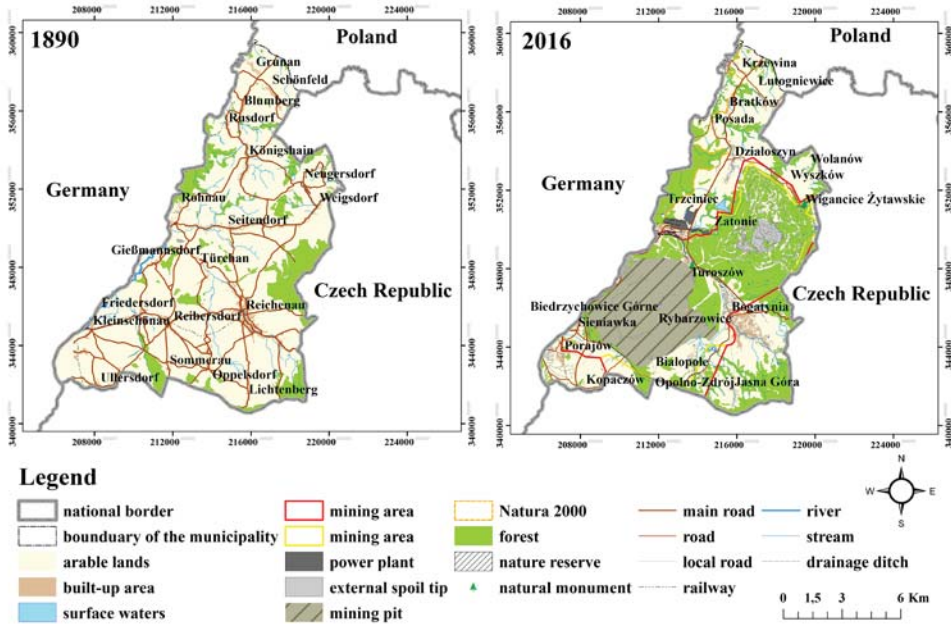
**Table 2.** Geodatabase prepared within the framework of research [2].

Object	Year									
	1890	1919	1936	1963	1981-1988	1999	2006	2010	2013	2016
road infrastructure	V	V	V	V	V	V	V	V	V	V
railway infrastructure	V	V	V	V	V	V	V	V	V	V
hydrographic network	V	V	V	V	V	V	V	V	V	V
surface waters	X	V	V	V	V	V	V	V	V	V
built-up areas	V	V	V	V	V	V	V	V	V	V
arable lands	V	V	V	V	V	V	V	V	V	V
forests	V	V	V	V	V	V	V	V	V	V
mining pit	V	V	V	V	V	V	V	V	V	V
external spoil tip	X	X	X	V	V	V	V	V	V	V
power plant	X	X	X	X	V	V	V	V	V	V

Where: V - means the occurrence of an object in a geodatabase, X - means no object in geodatabase for a given year.

## 2.4 Preparation of cartographic compilations

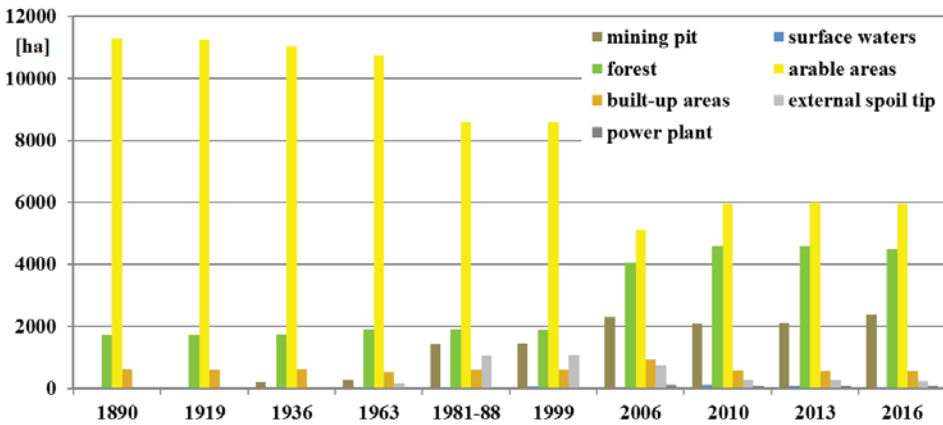
During preparation of cartographic compilations, the definition of presentation principles of individual objects presented in the compilations is of great importance. It's essential to use appropriate symbols, fonts and colours in order to present the studied phenomenon in the best possible way. The study [2] determines the style of presentation of objects for cartographic compilations prepared in order to analyze the environmental-social changes caused by the activity of Turow mine, depicting the state of development of the Bogatynia municipality in the years: 1890, 1919, 1936, 1963, 1981-1988, 1999, 2006, 2010, 2013 and 2016. Examples of cartographic preparations for 1890 and 2016 are shown in Figure 3.



**Fig. 3.** State of development of the Bogatynia municipality in 1890 and 2016. Based on [2].

### 2.5 Analysis of the impact of mining activity

The area of analysis adopted for each examined year consists of current administrative borders of the Bogatynia municipality (2016). The state of development for individual years was compared with the state of municipality development from 2016. The following forms of land development were selected for the analysis: mining pit, external spoil tip, power plants, standing surface waters, forests, arable lands and built-up areas. Using the tools available in GIS systems, the areas of land development forms were calculated for analyzed years, which are presented in figure 4.



**Fig. 4.** Changes of land development in the Bogatynia municipality in analyzed years.

By analyzing the data obtained from calculations, it can be noticed that over the years, the mining pit has been continuously expanded. The greatest dynamics of changes can be observed between 1963 and 1980s. This may result from the fact that during this time

interval, the lignite-fired "Turow" power plant was created. The first stage of its construction was completed in 1965 and in the following years, it was expanded with subsequent blocks in order to produce greater amount of energy. In 1971, the second stage of power plant expansion was completed. The subsequent years are associated with modernization of the facility, ensuring more favourable and more efficient generation of electricity. The third phase of development was implemented in 2000. The high demand for lignite by the Turow power plant resulted in increased amounts of extracted raw material and, consequently, expansion of the mining pit. Such method of information analysis shows the difference between the state of mining pit in 1890 and the area occupied by it in 2016. The activity of large-area opencast mine caused great changes in the landscape of Bogatynia municipality. The expanding opencast mine took up further parts of arable lands, reducing their number. The greatest dynamics of changes in arable lands can be observed between 1963 and 1980s, as well as 1999 and 2010. Also, the greatest differences in the surface of mining pit occurred within those years. On the basis of these changes, it can be stated that the expansion of mining pit was a direct factor impacting the reduction of arable lands. However, the conducted mining activity did not significantly contribute to the reduction in forest areas. Changes between the individual periods are small and there can be observed a large dynamic of changes only between 1999 and the state of forest in XXI century. Increase in the number of forest areas results from the works associated with forest reclamation carried out by the mine. Young forest was created on the area of external spoil tip within few dozen years, which covers the eastern part of the Bogatynia municipality. The works associated with the restoration of these lands to their original state have been ongoing since the 1960s. Since 2010, the number of forest areas has been decreasing. This phenomenon is related to the expansion of mining pit in the direction of the village of Białopole, where the mining activities cause degradation of the forest occurring in these areas. By analyzing the values of surface occupied by the built-up areas, there can be seen a downward trend. Due to the fact that the expanding mining pit is occupying further parts of the land, many households were degraded. A slight increase in the number of these areas can be seen only in 1936. This may be associated with immigration of people, who have been employed in the mine, which was developing during that period. In 1963, there can be seen a rapid reduction in built-up area, caused by the interpretation of built-up areas by authors of the source data. Based on comparison of maps from different periods, it was found that other elements were recognized during these years as built-up area. As a result of expansion of the mine, many local residents were displaced and such towns like Rybarzowice, Biedrzychowice-Gorne ceased to exist. Many residential areas were degraded and the best example is the current state of Zatonie village and Wigancice Zytawskie village, which reduced their area. In the early years of operation, the overburden was tipped by the mining company. Since 1963, there has been created an external spoil tip in the north-west direction from the mining pit. The spoil tip occupied the largest area in 1980s and 1999. In the later periods, this area has been already reclaimed, therefore in Figure 4, it is visible that there was a decrease in the area occupied by the overburden. The area, on which the spoil tip was located in the previous years, still occupies a similar surface (2016), but instead of the tipped material, there's a young forest now.

The occurrence of large-area mining activity within the municipality affects the society living in the municipality, in which this activity is located. Each mine is obliged to pay fees related to the performance of exploitation works. The budget of municipality receives 60% of the value of paid exploitation fee. The study [2] includes calculation of the amount of exploitation fees received by the budget of the Bogatynia municipality. The greatest amount of the proceeds from exploitation fees was paid to the municipality budget in 1977 and it amounted to approx. 24,92 million. This amount significantly contributed to the improvement of economic conditions of the municipality, which affected the living comfort

of population residing in this area. These funds were spent on own needs of the municipality. The mine is also one of the largest employers of local residents.

In connection with activity of the mine, both negative and positive aspects associated with the mining activity in the Bogatynia municipality were noted. By comparing the number of these aspects, there can be seen a balance between these activities. Nevertheless, not all factors affect the life quality of society and the state of natural environment in the same way. In order to carry out a more detailed analysis, it was proposed to assign weights to the effects of mining activity of Turow mine, according to the key proposed in the study [2]. The results of this analysis are presented in Table 3.

**Table 3.** Analysis of impact of the KWB Turow mining activity [2].

Positive aspects	Weight	Negative aspects	Weight
reclamation of post-mining areas	37	emission of pollutions	42
provision of jobs	25	emission of noise	40
possibility to acquire energy	23	degradation of forest and agricultural areas	39
proceeds to the municipality budget	18	change of water ratios	35
lower energy costs for municipality residents	19	landscape changes	31
opportunity for development of smaller companies	17	degradation of built-up areas	29
subsidizing public investments	15	displacement, emigration of population	20
<b>Sum of weights:</b>	<b>154</b>		<b>236</b>

### 3 Summary

The presence of large-area opencast mining activity in the Bogatynia municipality in the form of Turów lignite mine caused many changes in the existing landscape, contributed to changes in land development and affected the everyday life of residents of this area. By studying the phenomenon of changes that took place over the years, the development of mining pit, transformations of land and impact of the mining plant on the nearest surrounding area can be observed. The source data used for the analysis allowed to acquire knowledge about history of the mine and identification of changes occurring in the Bogatynia municipality. The maps prepared in the framework of research present the form and state of identified areas in the analysed years, allowing for the interpretation of changes that occurred in the vicinity of conducted mining activity.

On the basis of conducted analysis, the predominance of negative effect of the mining activity was found. Such outcome results from the fact that most of the positive activities of the mine are economic factors and in this comparison, the economic-market conditions were assigned the weight of the lowest value range. The highest value of weights was assigned to the factors related to expansion of the mine by occupying forest areas, agricultural areas and build-up areas, along with the emission of pollution and noise. This contributed to the predominance of negative effects of large-area opencast mining in the Bogatynia municipality.

The cartographic compilations done in the framework of the work allows to know the history of the Bogatynia municipality and to identify changes that have taken place in the forms of land development over the years. Geodatabases from the analysed years with vector data created on the basis of archival analogue maps allow for dissemination of the cartographic records describing the history of analysed area and enable the analysis of environmental-social changes.



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