Tourist Attractiveness Analysis of Relicts of the Former Construction and Mining Works within Lower Silesia

Justyna Gorniak-Zimroz 1, Marta Lisiewicz 1

1 Wroclaw University of Science and Technology, Faculty of Geoengineering, Mining and Geology, 27 Wybrzeze Wyspianskiego St., 50-370 Wroclaw, Poland

justyna.gorniak-zimroz@pwr.edu.pl

Abstract. The article describes the results of research focused on the analysis of tourism accessibility and attractiveness of selected objects of the former construction and mining works, located in Lower Silesia. 18 objects were selected for the research. Based on the literature review, 12 criteria have been defined; they have an impact on increasing the tourist attractiveness of the object. These are natural qualities, cultural attractions, green areas, road infrastructure, railway infrastructure, airport infrastructure, bus communication, accommodation facilities, catering base, price of visiting the object, opening hours of the object and object promotion. For these criteria, a point scale was developed to determine the degree of importance of a given criterion. For the first 9 criteria, a multi-criteria evaluation of the attractiveness of objects using two methods was carried out: weighted sum method taking into account the weightings of the AHP criteria and Map Algebra without taking into account the criteria weights. The resultant cell values of the resulting raster were classified as imaging areas: low (class IV), average (class III), good (class II) and very good (class I) tourist attractiveness. Comparing the results obtained in two methods, the classification of 15 objects in the same classes was obtained. Taking into account the inclusion of weights for individual criteria, the results obtained from the weighted sum method were selected for further analyses. In the final analysis of tourist attractiveness of objects of the former construction and mining works, the classification of objects according to the other three criteria was also taken into account, adding up the points for each object. Finally, the obtained results of the analyses and the attractiveness of objects of the former construction and mining works were combined. The results of analyses might be helpful for tourists to choose tourist facilities for sightseeing.

1. Introduction

Tourist attraction [1, 2] is a feature of the region and its purpose is to attract users by providing them with unforgettable and pleasant way to spend free time. Such attraction should be prepared in a manner enabling the use of all its potential, in order to provide tourists with the appropriate level of infrastructure and services associated with their needs. According to this definition, the research conducted in the work of [3] aimed to analyse the tourist attractiveness of selected objects in the form of relicts of the former construction and mining works (inactive mines, adits, underground tourist routes, tunnels and caves), located in the south-western part of Poland, in the Sudetes with the Sudeten Foreland (figure 1). The size of selected area amounts to 9,400 km², which constitutes 3% of Poland's area. This area is characterized by diverse geological structure, which shapes terrain surface that is attractive for the tourist, including low and medium mountains, piedmonts, uplands, structural basins and numerous
depressions, along with plains and valleys. There are also numerous protected areas within its borders, in the form of national parks, landscape parks, Natura 2000 areas, protected landscape areas and nature reserves.

Figure 1. Location of research objects in the context of the map of Poland and Lower Silesia, along with the protected areas.

Objects selected for research consist of remnants of the former construction and mining works that have been conducted in Lower Silesia since the thirteenth century (Gold Mine in Złoty Stok, Gold Mine “Aurelia”, Walimskie Adits along with underground complex “Rzeczka”, Silver Mine “Silberloch Walim”, Coal Mine "Nowa Ruda", Underground City "Osówka", Klódzko Stronghold Countermine Corridors, Bear Cave in Kletno, Old Uranium Mine in Kletno, Old Mine of the Science and Art Centre in Wałbrzych, railway tunnel under Mały Wołowiec, Mine "Liczyrzepa" - adits in Kowary, Nickel, Chrysoprase and Opal Mine in Szklary, Radochowska Cave, underground of the Książ Castle, Museum and Tourist Centre "Olbrzym", Museum of Military Technology Reise-Molle S III). These objects in themselves constitute an attraction for a tourist, because they are a source of knowledge about the development of construction and mining technique implemented in this area. However, also important are additional factors that increase attractiveness of such places. Without appropriate facilities in the form of infrastructure, additional attractions and services associated with the needs of tourists, such places may be omitted by tourists. When going on a trip, every tourist wants to ensure his/her meals and often intends to use accommodation in order to spend more time on sightseeing, or to just take a break from everyday life in other interestingly located place. This article presents the results of assessment of the tourist accessibility and attractiveness of selected objects of the former construction and mining works, compared to other objects that increase tourist attractiveness.

2. Methodology

In order to analyse the attractiveness of relicts of the former construction and mining works, the methodology schematically presented in figure 2 was proposed, which is based on multi-criteria evaluation of data, in which the selection of optimal solution is conditioned by many criteria. In his paper, Eastman [4] described the Multi-Criteria Evaluation (MCE) as a process supporting the decision-making, which is defined by the following dependence:
where:

\[ w_i \in [0,1] \]  

\[ \sum_{i=1}^{n} w_i = 1 \]  

Figure 2. Methodology for assessing the attractiveness of relics of the former construction and mining works.

Weighting of criteria was carried out with the use of AHP (Analytic Hierarchy Process) method, which was presented by Satty [5, 6, 7] and which consists of hierarchical analysis of a given issue. This method is aimed at obtaining a comparative scale as a result of pair comparison of determined criteria. Values of the priority vector were obtained from the dependency [5, 6, 7]:

\[ M = \begin{bmatrix} a_{11} = 1 & a_{12} & a_{1n} \\ a_{21} & 1 & a_{2n} \\ \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & a_{nn} = 1 \end{bmatrix} \]  

where:

\[ M \] – square matrix of comparisons with \( n \) elements of \( a_{ij} \),  
\[ a_{ij} \] – value of the preferences of compared pair of criteria.

\[ w_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \]  

where:

\[ w_{ij} \] – values of standardized matrix.

\[ w_i = \sum_{j=1}^{n} w_j a_{ij} \]  

where:

\[ w_j = \frac{\sum_{i=1}^{n} w_{ij}}{n} \]  

\[ i,j = <1,n> \]  

\[ w_i \] – vector of partial priorities.

After analyzing the works of [1, 3, 8-10], the criteria affecting the attractiveness of a tourist object were selected. They include: natural qualities (NQ), cultural attractions (CA), green areas (GA), road
infrastructure (RoI), railway infrastructure (RaI), airport infrastructure (AI), bus communication (BC), accommodation facilities (AF), catering base (CB), price of the object (PO), opening hours of the object (OH), object promotion (OP), and the values of their comparisons were determined. The weights were determined for 9 criteria (NQ, CA, GA, RoI, RaI, AI, BC, AF, CB) that have the greatest impact on attractiveness of the analysed object, for which preferences were determined by subsequent pair comparison of all criteria, with the use of scale from the range 1-9, where evaluations from the range 1-4 constituted the advantage of the second element over the first element, 5 - meant that the pair is equal, while the range 6-9 constituted the advantage of the first element over the second element. Such obtained values were used to create a matrix of comparisons (table 1), and then the weights of individual criteria according to the AHP methodology were determined (table 2). Based on the obtained results, it was found that the most important criterion is natural qualities NQ (weight 0.18), cultural attractions CA (weight 0.17), green areas GA (weight 0.15), road infrastructure RoI (weight 0.10), bus communication BC (weight 0.10), railway infrastructure RaI (weight 0.09), airport infrastructure AI (weight 0.09), accommodation facilities AF (weight 0.06) and catering base CB (weight 0.06).

### Table 1. Matrix of comparisons [3]

| No. | Criteria                | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
|-----|-------------------------|----|----|----|----|----|----|----|----|----|
| 1   | Natural qualities - NQ  | 5  | 6  | 7  | 8  | 8  | 8  | 8  | 9  | 9  |
| 2   | Cultural attractions - CA| 4  | 5  | 6  | 8  | 8  | 8  | 9  | 9  | 9  |
| 3   | Green areas - GA        | 3  | 4  | 5  | 8  | 8  | 8  | 9  | 9  | 9  |
| 4   | Road infrastructure - RoI| 2  | 2  | 2  | 5  | 6  | 7  | 5  | 7  | 7  |
| 5   | Railway infrastructure - RaI| 2 | 2  | 2  | 4  | 5  | 6  | 4  | 7  | 7  |
| 6   | Airport infrastructure - AI| 2 | 2  | 2  | 3  | 4  | 5  | 3  | 8  | 8  |
| 7   | Bus communication - BC  | 2  | 2  | 2  | 5  | 6  | 7  | 5  | 7  | 7  |
| 8   | Accommodation facilities - AF| 1 | 1  | 1  | 3  | 3  | 2  | 3  | 5  | 5  |
| 9   | Catering base - CB      | 1  | 1  | 1  | 3  | 3  | 2  | 3  | 5  | 5  |
| SUM |                         | 22 | 25 | 28 | 47 | 51 | 53 | 47 | 66 | 66 |

### Table 2. Obtained values of the priority vector [3]

| No. | Criteria                  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | Priority vector |
|-----|---------------------------|----|----|----|----|----|----|----|----|----|------------------|
| 1   | Natural qualities - NQ    | 0.23| 0.24| 0.25| 0.17| 0.16| 0.15| 0.17| 0.13| 0.13| 0.18             |
| 2   | Cultural attractions - CA| 0.18| 0.20| 0.21| 0.17| 0.16| 0.15| 0.17| 0.13| 0.13| 0.17             |
| 3   | Green areas - GA          | 0.14| 0.16| 0.18| 0.17| 0.16| 0.15| 0.17| 0.13| 0.13| 0.15             |
| 4   | Road infrastructure - RoI | 0.09| 0.08| 0.07| 0.11| 0.12| 0.13| 0.11| 0.11| 0.11| 0.10             |
| 5   | Railway infrastructure - RaI| 0.09| 0.08| 0.07| 0.09| 0.10| 0.11| 0.09| 0.11| 0.11| 0.09             |
| 6   | Airport infrastructure - AI| 0.09| 0.08| 0.07| 0.06| 0.08| 0.10| 0.06| 0.12| 0.12| 0.09             |
| 7   | Bus communication - BC    | 0.09| 0.08| 0.07| 0.11| 0.12| 0.13| 0.11| 0.11| 0.11| 0.10             |
| 8   | Accommodation facilities - AF| 0.05| 0.04| 0.04| 0.06| 0.05| 0.04| 0.06| 0.08| 0.08| 0.06             |
| 9   | Catering base - CB        | 0.04| 0.04| 0.04| 0.06| 0.05| 0.04| 0.06| 0.08| 0.08| 0.06             |
| SUM |                          | 1.00| 1.00| 1.00| 1.00| 1.00| 1.00| 1.00| 1.00| 1.00| 1.00             |

### 3. Analysis of results

Input data for the research was obtained from public administration (Regional Centre for Geodetic and Cartographic Documentation in Wroclaw, General Directorate for Environmental Protection) and mining enterprises, as well as institutions engaged in revitalization and restoration of the functioning of relicts of the former construction and mining works. After the analysis and assessment of data in the GIS environment, a database of relicts and criteria was developed. A vector class was developed for each criterion, and using the Multiple Ring Buffer tool, the distance of criterion from construction and mining object was determined for each class. Table 3 presents the characteristics of selected criteria and importance of a given criterion on the point scale, in order to determine the degree of attractiveness, by
giving them a score of 0-3, where value 0 means no impact on attractiveness and value 3 means a major impact on attractiveness of the construction and mining object.

**Table 3. Criteria affecting the tourist attractiveness of the object, along with a scoring determining their importance [3]**

| Criterion                        | Description of the criterion                                      | Scoring |
|----------------------------------|------------------------------------------------------------------|---------|
| Natural qualities – NQ           | Areas valuable in terms of nature at a distance > 1000 m          | 0       |
|                                  | Areas valuable in terms of nature at a distance < 1000 m          | 3       |
| Cultural attractions - CA        | Cultural attractions at a distance > 3000 m                       | 0       |
|                                  | Cultural attractions at a distance from 3000 to 2000 m            | 1       |
|                                  | Cultural attractions at a distance from 2000 to 1000 m            | 2       |
|                                  | Cultural attractions at a distance < 1000 m                       | 3       |
| Green areas - GA                 | Green areas not covered by protection at a distance > 1000 m     | 0       |
|                                  | Other green areas not covered by protection at a distance < 1000 m| 3       |
| Road infrastructure - RoI        | Distance from the road > 1000 m                                  | 0       |
|                                  | Distance from the road from 1000 to 500 m                        | 1       |
|                                  | Distance from the road from 500 to 200 m                         | 2       |
|                                  | Distance from the road < 200 m                                  | 3       |
| Railway infrastructure - RaI     | Railway stop at a distance > 2000 m                              | 0       |
|                                  | Distance from the railway stop 2000 to 1000 m                    | 1       |
|                                  | Distance from the railway stop 1000 to 500 m                     | 2       |
|                                  | Distance from the railway stop < 500 m                           | 3       |
| Airport infrastructure - AI      | Distance from the airport > 5000 m                               | 0       |
|                                  | Distance from the airport < 5000 m                               | 3       |
| Bus communication - BC           | Distance from the bus stop > 1000 m                              | 0       |
|                                  | Distance from the bus stop from 1000 to 500 m                    | 1       |
|                                  | Distance from the bus stop from 500 to 200 m                     | 2       |
|                                  | Distance from the bus stop < 200 m                               | 3       |
| Accommodation facilities - AF    | Accommodation points at a distance > 2000 m                      | 0       |
|                                  | Accommodation points at a distance from 2000 to 1000 m           | 2       |
|                                  | Accommodation points at a distance < 1000 m                      | 3       |
| Catering base – CB               | Catering points at a distance > 1000 m                           | 0       |
|                                  | Catering points at a distance from 1000 to 500 m                 | 1       |
|                                  | Catering points at a distance from 500 to 300 m                  | 2       |
|                                  | Catering points at a distance < 300 m                            | 3       |
| Price of the object - PO         | Price of a normal ticket above 20 PLN                            | 0       |
|                                  | Price of a normal ticket in the range of 15-20 PLN               | 1       |
|                                  | Price of a normal ticket in the range of 10-15 PLN               | 2       |
|                                  | Price of a normal ticket below 10 PLN                            | 3       |
| Opening hours - OH               | Seasonally                                                       | 0       |
|                                  | Year-round                                                       | 3       |
| Object promotion - OP            | No advertisement of the object                                   | 0       |
|                                  | There’s an advertisement of the object                           | 3       |

Vector data prepared in such manner was changed into raster, obtaining input data representing the criteria, along with the determination of their significance for further analyses. Figure 3 shows the method of preparing the data for further analyses in the case of criterion of Road Infrastructure – RI. The colours of obtained reclassified raster data were selected in such manner that the areas presenting the best attractiveness are marked with a graded green colour, while the worst attractiveness is marked by red and orange colours.
Figure 3. Criterion of Road Infrastructure - WP: vector data (a), buffers (b), raster data (c) and raster data after reclassification (d) [3]

The research included performance of multi-criteria evaluation of data with the use of two methods: Weighted Sum Method with assigned weights of the criteria obtained with the use of AHP method (figure 4a) and Map Algebra without assigning weights to the criteria (figure 4b), considering each tourist object separately and determining the obtained type of accessibility and attractiveness. The obtained results of analyses were classified according to four classes: class IV - low accessibility and attractiveness (red colour), class III - average accessibility and attractiveness (orange colour), class II - good accessibility and attractiveness (light green colour) and class I - very good accessibility and attractiveness (green colour).

Figure 4. Multi-criteria evaluation of data performed with the use of Weighted Sum Method (a) and Raster Calculator (b), along with the location of analysed objects [3]
By comparing two methods of analysis, 8 construction and mining objects were obtained in the area with very good accessibility and attractiveness (class I). These include: Gold Mine in Złoty Stok, Gold Mine “Aurelia”, Underground Tourist Route Coal Mine “Nowa Ruda”, Klodzko Stronghold – Countermine Corridors, Underground Tourist Route in Klodzko, Old Mine of the Science and Art Centre, Underground of the Książ Castle, Museum of Military Technology – Reise – Molke S III. In the areas with good accessibility and attractiveness (class II), 6 tourist facilities were assigned in both methods: Silver Mine “Silberloch Walim”, Underground City "Osówka", Underground Tourist-Education Route in the Old Uranium Mine in Kletno, railway tunnel under Mały Wołowiec, Underground Tourist-Education Route of the Mine "Liczyrzepa" - adits Kowary, Museum and Tourist Centre "Olbrzym", Museum Włodarz. One tourist object - Nickel, Chrysoprase and Opal Mine in Szklary is located in an area with average accessibility and attractiveness (class III). None of the analysed objects were located in the area classified in IV class with low availability and attractiveness. In the case of several tourist objects, the accessibility was differently assessed by two methods. In the case of Weighted Sum Method, the Walimskie Adits Underground Complex “Rzeczka” is located in the area with very good accessibility in class I, while in the Map Algebra without giving weights to the criteria – with only good accessibility in class II. Subsequent two objects: Bear Cave in Kletno and Radochowska Cave, according to the Weighted Sum Method are located in an area with good accessibility – class II, while according to the Map Algebra Method, they are located in an area with average accessibility – class III. 15 objects in the same class were obtained by comparing two methods with each other. In the scope of compared methods of data analysis, only three tourist objects were classified according to different classes of objects. Considering the fact that in the case of the Weighted Sum Method, the weights for individual criteria were taken into account, which were obtained with the use of AHP method, it can be assumed that this method is more precise, because the importance of individual criteria of attractiveness and tourist accessibility in relation to each other was determined more precisely. Both methods of analysis are soft methods and they present the degree of impact of 9 determined criteria on the attractiveness and accessibility of objects of the former construction and mining works.

In order to carry out further analyses of accessibility and attractiveness of the construction and mining objects, the results obtained with the use of Weighted Sum Method were selected. In the final analysis, the last 3 criteria from table 3 were taken into account, which relate to: price of the object PO, opening hours of the object OH and object promotion OP. For this purpose, based on the database of tourist objects of the former construction and mining works, as well as determined sub-criteria along with the assigned scoring, the sums of corresponding points were determined in line with the adopted scale, according to 3 other criteria for each tourist object. Combining the results of performed analyses, the objects of former construction and mining works were classified in the following manner: class I - Gold Mine in Złoty Stok, Walimskie Adits Underground Complex “Rzeczka”, Underground Tourist Route Coal Mine “Nowa Ruda”, Klodzko Stronghold Countermine Corridors, Underground Tourist Route in Klodzko, Old Mine of the Science and Art Centre, Museum of Military Technology - Reise - Molke S III; Class II - Underground City "Osówka", Underground Tourist-Education Route in the Old Uranium Mine in Kletno and Radochowska Cave. As a result of multi-criteria evaluations, the underground of the Książ Castle is located in the area with very good accessibility, but in the classification for 3 criteria, it received an average score, therefore in the final assessment it was classified in the area with good accessibility (class II). In the multi-criteria evaluation, the Nickel, Chrysoprase and Opal Mine in Szklary received the weakest accessibility and attractiveness (class III), and in the additional classification of 3 criteria, it received the lowest score (class IV). Figure 5 presents the location of construction and mining objects analysed in this paper, along with their division into classes, obtained as a result of combining multi-criteria evaluation and classification according to the remaining 3 criteria from table 3.
4. Conclusion
This research included the performance of analysis of the accessibility and attractiveness of objects in the form of relics of the former construction and mining works, which are located in the subprovince region of Sudetes with Sudeten Foreland, in Lower Silesia. The observations were focused on 18 objects, whose database was developed based on information collected from enterprises, as well as building and mining institutions. This research was aimed at performing the assessment of their accessibility and tourist attractiveness. On the basis of literature data, a group of 12 criteria that have impact on increasing the attractiveness of objects was identified (table 3). Subsequently, an additional point scale was developed, which determines the degree of importance of a given criterion. In order to increase the accuracy of multi-criteria evaluations, the weighting was conducted for the first 9 criteria, which have the greatest impact on the attractiveness of objects, with the use of AHP method. Multi-criteria evaluations were performed with the use of two methods: Weighted Sum Method taking into account the weights of criteria determined on the basis of literature using the AHP method and Map Algebra without taking into account the weights of criteria. The values of raster cells were classified according to four classes. As a result of both spatial analyses, 15 tourist objects were obtained, which were in the same class of objects. Only 3 objects differed in the obtained accessibility and attractiveness class in the case of comparing two variants of analyses, but the results from the Weighted Sum Method were taken into account for further observation. At the end, the objects were classified according to the remaining 3 criteria, which related to: price, opening hours and object promotion, summing up the points for each object. As a result, by combining Multi-Criteria Evaluation and classification according to the remaining 3 criteria, the objects were obtained, which are located in the area with very good accessibility and tourist attractiveness. The results of obtained classification are presented in figure 5. The conducted analyses were aimed at presenting the areas within the subprovince of Sudetes with the Sudeten Foreland, with the best and the worst possible accessibility and tourist attractiveness. The degree of importance of individual criteria that have impact on the assessment of attractiveness and tourist accessibility were taken into account. The results of analyses were used to determine tourist objects associated with the former construction and mining activity, which are located in areas with well-developed communication infrastructure, surrounded by areas that are valuable in terms of nature, as well as cultural objects with well-developed catering base and accommodation facilities, and also less
important features were taken into account, which include: price, opening hours and object promotion. All the criteria that were taken into account contributed to the performance of multi-criteria evaluations and assessment of accessibility of the relicts. The result of assessment may make it easier for a potential tourist to select a tourist object for sightseeing, along with its facilities in the form of criteria.

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References
[1] Z. Kruczek, “Tourist attractions. Phenomenon, typology, research methods”, Proksenia, Kraków, work in Polish, 2011.
[2] J. Walsh-Heron, T. Stevens, “The management the visitor attractions and events”, Prentice Hall, New Jersey, 1990.
[3] M. Lisiewicz, “Analysis of the availability of the tourist base of Lower Silesia”, non-published master’s thesis, which was prepared in the Faculty of Geoengineering, Mining and Geology of the Wroclaw University of Science and Technology, work in Polish, 2017.
[4] J.R. Eastman, “INDRISI 32 Release 2”, Guide to GIS and Image Processing, vol.2, Clark Labs Clark University, USA, 2001.
[5] L. T. Saaty, “The analytic hierarchy process – what it is and how it is used. Mathematical Modelling”, Elsevier, vol.9 (3-5), pp.161-176, 1987.
[6] T.L. Saaty, “How to make a decision: The Analytic Hierarchy Process”, European Journal of Operational Research, vol.48, pp. 9-26, 1990.
[7] S. Drobne, A., “Multi-attribute Decision Analysis in GIS: Weighted linear Combination and ordered Weighted Averaging”, Informatica vol.33, pp. 459-474, 2009.
[8] J. Kaczmarek, A. Stasiak, B. Włodarczyk, “Tourist product”, Polskie Wydawnictwo Ekonomiczne, Warszawa, work in Polish, 2005.
[9] Z., Kruczek, “Turnout in tourist attractions”, Polska Organizacja Turystyczna, Warszawa, work in Polish, 2014.
[10] M. Duda-Seifert, “Criteria for assessing the tourist attractiveness of architectural objects in the light of literature”, Turystyka Kulturowa, vol.4, pp. 74-75, work in Polish, 2015.