ZESZYTY NAUKOWE POLITECHNIKI POZNAŃSKIEJ
Nr 86 Organizacja i Zarządzanie 2022

Jan BLACHOWSKI*, Monika HAJNRYCH**, Paweł TRYBAŁA***, Marek TANKIELUN****

MULTI-CRITERIA METHODOLOGY FOR EVALUATING UNIVERSITY CAMPUS FACILITIES USING THE AHP APPROACH

DOI: 10.21008/j.0239-9415.2022.086.04

Wroclaw University of Science and Technology carries out a project titled "University of New Opportunities". Within the frames of this project a Digital Accessibility Guide (DAG) is developed with the aim to provide comprehensive information on the university's facilities with special emphasis on people with disabilities. The Analytical Hierarchy Process (AHP) methodology was applied to select the 25 facilities to be included in the DAG. The proposed methodology included development of a hierarchical structure of the model, the determination of seven evaluation criteria, adoption of a scoring scale (1–5) of sub-criteria for each criterion, and their pairwise comparison by an interdisciplinary group of experts. The selected criteria comprised of the functions and services of buildings, the number of users, communication and architectural accessibility, the number of indications in the accessibility survey and the number of classrooms. The final ranking of facilities was created based on the evaluated characteristics of nearly fifty buildings and the results of the AHP evaluation of the selection criteria and their weights. The consensus of the expert group involved in the pairwise comparison was 2.8% and the weighted score of the facilities ranged from 4.68 to 1.29 with a median of 2.16. The applied approach structured the decision problem in accordance with the multicriterial decision analysis approach. The proposed methodology for selecting the University's strategic facilities is universal and may be used in other universities.

Keywords: AHP, multi-criteria analysis, campus, digital accessibility guide, Wroclaw University of Science and Technology

* Wydział Geoinżynerii, Górnictwa i Geologii Katedra Geodezji i Geoinformatyki, Politechnika Wrocławska. ORCID: 0000-0003-2630-3459.
** Wydział Geoinżynerii, Górnictwa i Geologii Katedra Geodezji i Geoinformatyki, Politechnika Wrocławska. ORCID: 0000-0002-0263-8732.
*** Wydział Geoinżynerii, Górnictwa i Geologii Katedra Geodezji i Geoinformatyki, Politechnika Wrocławska. ORCID: 0000-0002-6486-1147.
**** Centrum Innowacji i Biznesu, Dział Rozwoju i Wdrożeń, Politechnika Wrocławska.

1. INTRODUCTION

Wrocław University of Science and Technology (WUST) carries out a complex structural project aimed at improving the accessibility of the University for people with disabilities by increasing the competences of people participating in higher education, corresponding to the needs of the economy, labor market and society, as well as supporting organizational changes. The project is composed of 13 work packages, one of which includes the introduction of new information Within and navigation (communication) solutions on the University's campus. this work package the development of a digital accessibility guide (DAG) for the campus of WUST has been planned. The main activities of this task are structured as follows: selection of 25 strategic facilities (buildings) of the University's campus, development of the DAG structure, collecting and preparing data regarding the availability of facilities, as well as developing materials describing the rules of evacuation, preparing interactive presentations on the location of a given facility together with its transcription, supplementing the existing websites of Wrocław University of Science and Technology with the collected and processed information, and publication of the DAG on a dedicated Internet platform. More information on these tasks can be found on the project's webpage https://pns.pwr.edu.pl/projekt.

Thus, the aim of our study has been to propose a methodology for the selection of 25 university buildings that will be included in the digital accessibility guide. In this paper the methodology for selection of the strategic facilities has been described together with the results of the applied approach.

Because of the nature of this task, i.e. the selection of a specific number of facilities from the set of all considered objects (the set of candidates) for inclusion in the DAG, the multi-criteria decision support method (MCDM) approach also known as Multiple-Criteria Decision Analysis (MCDA) was adopted. These are operations research methods related to decision theory, which solve specific problems related to making optimal decisions. Multi-criteria analysis is used to support the decision-making process in situations where the choice is made between many variants. In this process, it is important to properly select evaluation criteria and define weights for them (Kukułka and Wirkus, 2017). According to the authors, the selection criteria should reflect the specific aspects of the decision problem, such as costs, time, environmental requirements, implementation, etc. The purpose of using the multi-criteria decision analysis approach is to select the optimal variant from the point of view of the adopted criteria. In the last few decades, a number of methods have been developed and used in a wide range of decision issues. These cover: management, marketing, finance, industry, medicine, administration, transport, political science, sociology, military and many other ones (Bhushan and Rai, 2004; Vaidya and Kumar, 2006; Marovic et al., 2020). Among the developed multi-criteria decision support methods, according to the authors, the following are of greatest interest: PROMETHEE, ELECTRE, TOPSIS, ANP and AHP (Roy, 1990; Palicki, 2013; Trzaskalik T., 2014; Khan and Ali, 2020; Marovic et al., 2020; Stypka and Flaga-Maryańczyk, 2016).

For our study, the Analytical Hierarchy Procedure (AHP) proposed by Saaty (1980) was selected. The decision was based on a survey of the available literature. For example, according to a study by Huang et al. (2011) that analyzed a number of scientific articles, the AHP method is considered the most significant among the MCDM. The AHP method enables the decomposition of a complex decision problem and the construction of a ranking for a finite set of variants. It has been used in many areas, including selection, resource allocation, cost-benefit analysis, ranking, prioritization and decision support (Hejmanowska and Hnat, 2009; Blachowski, 2015; Blachowski et al., 2016; Muhsen et al., 2018; Russo and Camanho, 2015). Many authors offer a comprehensive review of AHP applications. Noteworthy publications include the works by: (Zahedi, 1986; Vaidya and Kumar, 2006; Subramanian and Ramanathan, 2012; Khan and Ali, 2020).

To the best of our knowledge the proposed approach has not yet been used to select facilities from a set of university campus buildings for the purpose of developing a DAG. AHP applications described in the literature include an assessment of the condition of historic buildings (Zuraidi et al., 2018a; Zuraidi et al., 2018b), construction project management (Erdogan et al., 2019), tender procedures for the maintenance of public university buildings (Chua et al., 2015), and the selection of an intelligent building system (Wong and Li, 2008). The method of hierarchical analysis of the decision problem was also used to model the accessibility of services for people with disabilities (Alzouby et al., 2019), to support decisions regarding the development of housing for people with disabilities (Lakhani and Zeeman, 2016), in the choices of an agritourism farm taking into account the special needs of people with disabilities (Górski, 2019), or in the assessment of transport solutions in relation to the needs of people with disabilities (Kruszyński and Żak, 2017).

2. MATERIALS AND METHODS

2.1. WUST Campus

The main campus of Wrocław University of Science and Technology is located close to the Wroclaw city center, at “wyb. Stanisław Wyspiański” street, the other smaller campuses are located in different parts of the city. The newest university infrastructure development, the Geocentrum complex is situated on the opposite, to the main campus, bank of the Odra River. The general location of campus facilities in the city is presented in Fig. 1.

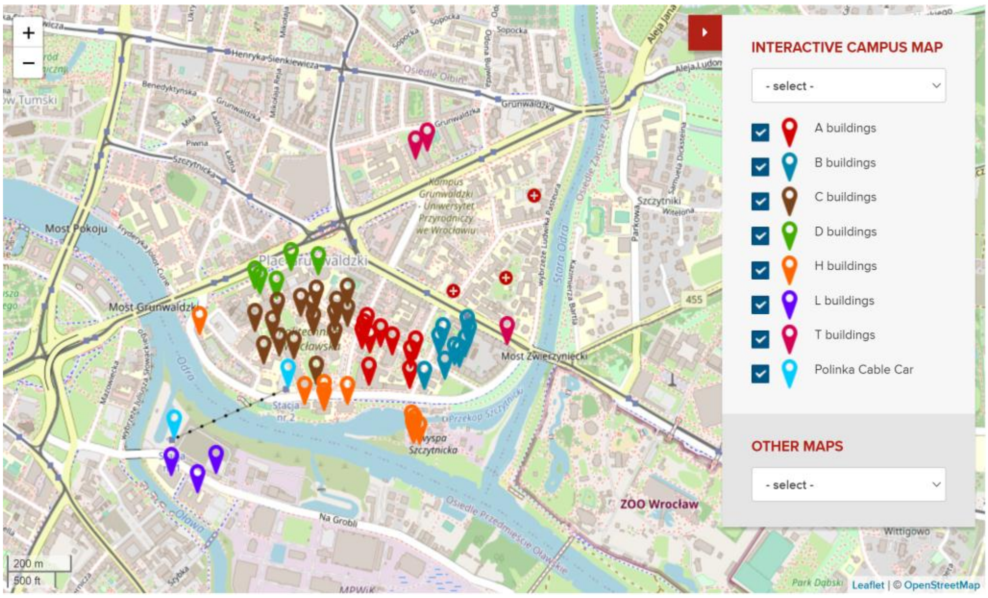

Fig. 1. Location of the main Wroclaw University of Science and Technology campus facilities (source https://pwr.edu.pl/en/university/campus-map)

According to the newest "Facts and Figures" published on WUST's website (https://pwr.edu.pl/en/university/about-us/general-information), there are 119 different buildings. The university has: 791 educational laboratories, 253 research laboratories, 20 431 students, 338 doctoral students and 483 PhD candidates in the Doctoral School, as well as over 4 000 employees, including about 2 196 academic staff.

According to the records of the University's accessibility and support for people with disabilities unit, there were 404 students with different forms of disabilities in 2021. The largest share, 115 students, had disabilities related to the impairment of the musculoskeletal system, 43 students had vision impairments, and 81 students were classified as other.

2.2. Materials

The above-mentioned aim of the study has been to critically evaluate and select a set of 25 buildings for the purpose of developing the digital accessibility guide that will support students and employees, in particular people with disabilities. This research was intended to indicate whether the Analytical Hierarchy Procedure (AHP) is a suitable method that will achieve the assumed goal.

For the purpose of the analysis the data were acquired from the following WUST administrative units: the university's unified student service system (*jednolity system obsługi studenta*, JSOS), the accessibility and support for people with disabilities, administrative and economic department, as well as collected during audits of each of the considered buildings.

For the purpose of visualizing the results a Geographic Information System (GIS) vector format feature layer was used in ArcGIS Pro software licensed to Wroclaw University of Science and Technology.

The AHP MS Excel based template developed by (Goepel, 2013) and Google based forms were used to facilitate the data collection and calculation procedures.

2.3. Methods

The general procedure in the AHP method has been described in numerous publications, e.g. by Saaty (1987), and consists of the following main steps: (a) constructing a hierarchical structure of the decision-making process, (b) determining the preferences of the decision maker (experts), (c) calculating the weights for all elements of the AHP model, (d) examining the consistency of the preference matrix and (e) creating the final ranking.

In our scenario, the adopted procedure involved the following tasks: (1) defining the goal; (2) determining the decision criteria; (3) structuring the decision problem at appropriate levels constituting the goal, criteria, sub-criteria and variants; (4) comparing elements with each other and at each level; (5) calculations of eigenvalue, consistency index (CI), coefficient of consistency (CR) and normalized values for each criterion; (6) creating the final ranking for the eigenvalues, CI and CR that meet the conditions described in the AHP theory; and (7) choosing the facilities from the candidate sets based on the results of analysis.

(1) The overarching goal of the analysis was to select 25 facilities from a candidate set of 46 buildings of the Wroclaw University of Science and Technology campus.

(2) To determine the criteria and to perform the AHP procedure nine experts representing employees, doctoral students and students of the Wrocław University of Science and Technology participated in the study. Representatives of the following university units were involved: accessibility and support for people with disabilities, current and former rector's proxy for people with disabilities, digital accessibility coordinator, architectural accessibility coordinator, head of one of the university's departments, as well as two students and one PhD candidate.

(3) The constructed hierarchical structure for solving the problem using the AHP approach is shown in Fig. 2. The goal of the analysis is situated at the highest level of the hierarchy, the decision criteria at the intermediate levels (2-3), and the candidate set of facilities is at the lowest level.

(4) The elements, in our case these are criteria and sub-criteria, were compared with each other, in order to establish their significance. The procedure requires (1)

$$\frac{n(n-1)}{2} \tag{1}$$

pairwise comparisons, where n is the number (1 .... n) of the considered elements at each of the AHP hierarchy levels.

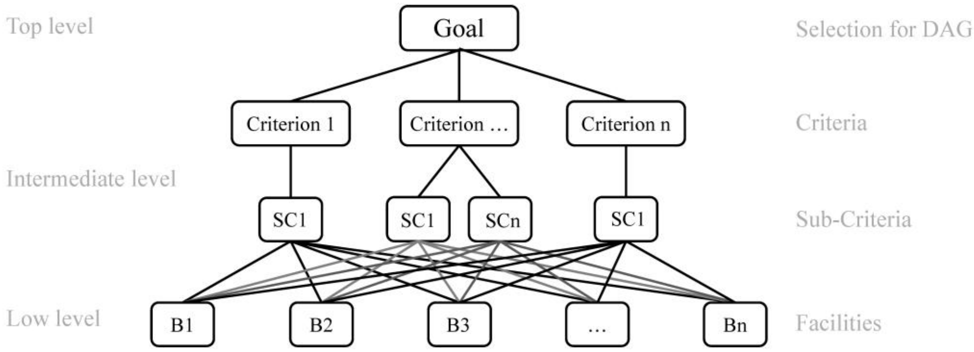

Fig. 2. The adopted hierarchical structure of the AHP procedure applied in the study (Blachowski and Hajnrych, 2021)

The construction of the matrix of preferences (comparisons) is performed according to the following rules: the diagonal elements of the matrix are equal to each other, the value of the element *a* with respect to the element *b* is the reciprocal of the value of the element b with respect to the element *a* (Saaty T., 1980; Saaty T., 2008) e.g. a_{21} and a_{12} according to (2)

$$M = \begin{matrix} a_1 = 1 & a_{12} & a_{1n} \\ a_{21} & 1 & a_{2n} \\ a_{n1} & a_{n2} & a_{nn} = 1 \end{matrix} \tag{2}$$

(5) The values of the normalized matrix are determined from the equation (3) and the priority vectors indicating weights of elements from equation (4).

$$w_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{3}$$

$$w_i = \sum_{j=1}^{n} w_j a_{ij} \tag{4}$$

where (5)

$$w_j = \frac{\sum_{i=1}^{n} a_{ij}}{n} \tag{5}$$

The comparisons are made from actual measurements or, more often, using a grading scale that reflects the preferences of decision-makers (Saaty T., 1980). This was our case. Individual preferences are determined by relative grades expressed as numerical values, usually using a 1 to 9 scale, where 1 means the above-mentioned equivalence of the compared criteria, and 9 indicates that the first of the compared elements is most strongly preferred over the second one. The grading system used is shown in Tab. 1. Intermediate values of 2, 4, 6, 8 between the above evaluations can also be used.

Table 1. The grading scale in the AHP method (based on Saaty T., 2008)

Grade (intensity of importance	**Definition**	**Description**
1	Equal importance	Judgement favors both criteria equally
3	Moderate importance	Judgement slightly favors first criterion
5	Strong importance	Judgement strongly favors first criterion
7	Very strong importance	First criterion is favored very strongly over the other
9	Extreme importance	There is evidence that the first criterion is favored over the other one

Next, the consistency of the assessments of experts participating in the study is checked. It involves calculating the Consistency Ratio (*CR*) according to the formula (6).

$$CR = \frac{CI}{RI} \tag{6}$$

where:
CI – is the consistency index,
RI – is a random index.

According to the AHP theory, matrices for which the value of this coefficient is higher than 0.10 (10%) should be re-evaluated.

(6) Based on the results of assigning weights to the scores of facilities in each of the criteria the weighted score of each element is calculated and (7) the ranking is determined.

3. RESULTS

The group of experts involved in the study defined 8 evaluation criteria. These criteria were used to rank the candidate facilities and select the 25 most suitable for the DAG. The criteria (C) are:

– function of facility (C1),

– additional services provided in the facility (C2),
– number of users (C3),
– number of users with disabilities (C4),
– number of classrooms (C5),
– communication accessibility (C6),
– architectural accessibility (C7),
– number of indications in the survey on the accessibility of the facilities (C8).

A 5-point rating scale was adopted for the criteria C2 to C8. With the value of 5 representing the highest number and the value of 1 the lowest number in each of these criteria. For the C1 criterion, 7 sub-criteria were defined. These are: dean's office (sub-criterion 1, SC1), library (SC2), central administration unit (SC3), seat of student union (SC4), didactic activities in classes/laboratories (SC5), student activity zone (SC6), organized events (SC7).

The additional services considered in C2 included: photocopying point, ATM, shop, post office, vending machine, catering point. The value for the criterion was assigned on the basis of the sum of services, using a scale of 1–5.

The C3 values for each facility were determined based on data from the university unified student service system (*jednolity system obsługi studenta, JSOS*) representing the average number of users in the academic year prior to the study. The values for each facility were classified into 5 classes and the appropriate value was assigned to a given building.

The C4 values were determined based on data from the accessibility and support for people with disabilities and the *JSOS* system. Again the values were classified into 5 classes and the appropriate value was assigned to a given building.

For C5 the data representing the number of rooms and laboratories where didactic activities take place in a given facility were obtained from the *JSOS* system.

The C6 was defined as the distance to public transport stop determined in GIS with the value of 1 representing distance greater than 250 m and 5 lower than 250 m.

The C7 was determined on the results of accessibility audit. The values of 1 to 5 were assigned to each facility based on the results of the following questions: is the building clearly marked? is the main entrance to the building adapted to the needs of people with disabilities?, is there a concierge directly at the main entrance?, is there an information board at the entrance?, is there an elevator in the building?, is there a car park in the immediate vicinity of the building? And are there designated spaces for people with disabilities in the car park?

The last, C8 values were determined by the results of a survey on the accessibility of the facilities with the number of indications of a given facility as a building with barriers.

The candidate group of facilities comprised of 46 university buildings. Each facility in a candidate set was assigned a value (1–5) in each criterion (C1-C8). The weights of criteria and sub-criteria were determined based on the results of questionnaires prepared by each of the experts in the group following the AHP methodology described in section 2.

The results of this step are shown in Table 2 and Table 3 representing the calculated weights of criteria and sub-criteria for criterion 1.

Table 2. Criteria weights determined in the AHP procedure

Criterion number	**Weight [%]**
C1	17.3%
C7	14.7%
C4	14.7%
C8	14.5%
C3	12.3%
C6	10.4%
C5	8.5%
C2	7.6%

Table 3. Sub-criteria for C1 weights determined in the AHP procedure

Sub-criterion number	**Weight [%]**
SC5	43.2%
SC1	16.1%
SC6	11.9%
SC2	11.7%
SC7	9.5%
SC4	3.8%
SC3	3.7%

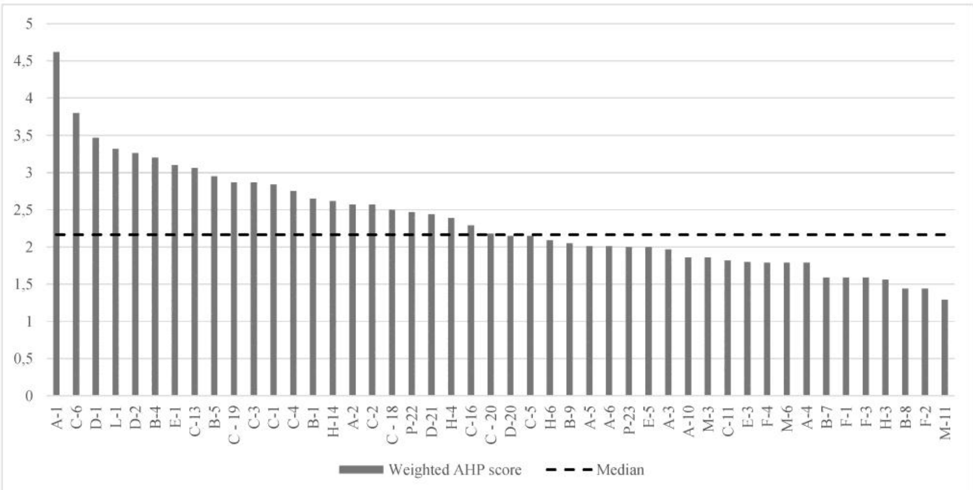

Fig. 3. Graphical representation of the final AHP weighted score for the set of candidates facilities

The consistency ratio (CR) for the assessment of criteria weights is 2.1% and the group's consensus value is 52.1%. For the assessment of C1's sub-criteria weights the CR is 2.8% and the group's consensus is 81.7%. The results for the set of candidate facilities are presented in the graphical form in Fig. 3.

The final ranking of the selected facilities is presented in Table 4.

Table 4. The final ranking obtained in the AHP procedure

Ranking	**Campus building symbol**	**AHP weighted value**
1.	A-1	4.62
2.	C-6	3.80
3.	D-1	3.47
4.	L-1	3.32
5.	D-2	3.26
6.	B-4	3.20
7.	E-1	3.10
8.	C-13	3.06
9.	B-5	2.95
10.	C-19	2.87
11.	C-3	2.87
12.	C-1	2.84
13.	C-4	2.75
14.	B-1	2.65
15.	H-14	2.62
16.	A-2	2.57
17.	C-2	2.57
18.	C-18	2.50
19.	P-22	2.47
20.	D-21	2.44
21.	H-4	2.39
22.	C-16	2.29
23.	C-20	2.18
24.	D-20	2.15
25.	C-5	2.15

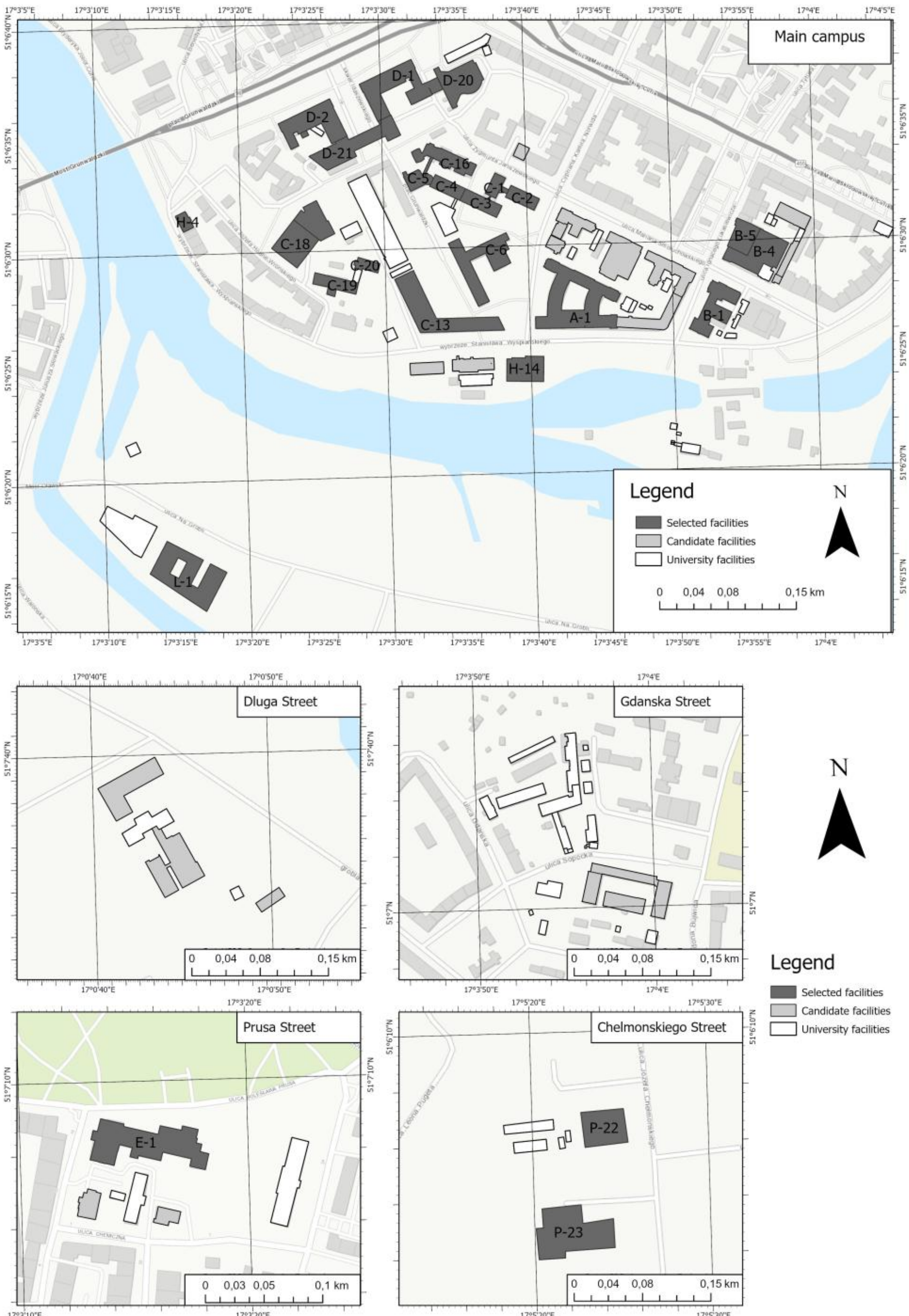

Fig. 4. The location of the selected buildings of the Wroclaw University of Science and Technology campus

The location of the selected buildings of the Wroclaw University of Science and Technology campus as well as the location of the remaining buildings in the candidate set is presented on a map in Fig. 4.

According to the experts' judgements the most important criterion is the function of a building (17.3%). Next, three criteria received comparable weights. These are: (C7) – architectural accessibility of the building (14.7%), (C4) – number of users with disabilities (14.7%) and (C8) – number of responses in the survey of barriers (14.5%). The criterion considered to be the least important was (C2) – additional services with 7.6% of the total weight.

In the assessment of sub-criteria importance for the (C1) – function of a building, the experts decided that the (SC5) teaching function (didactic activities in classes/laboratories) is the most important with 43.2% of the total weight. It is followed by (SC1) – location of dean's office (16.1%) and two sub-criteria with similar weights, (SC6) location of student activity zone (11.9%) and (SC2) – location of library (11.7%). The least important functions, according to the experts' judgements, are (SC4) – seat of the student union (3.8%) and (SC7) – university administration unit (3.7%).

The weighted scores describing the facilities in the candidate set are in the range between 1.29 and 4.62. The theoretical maximum value is 5 and the obtained median value is 2.16. These values reflect the characteristics of individual buildings described on a point scale (1–5) in each of the 7 selection criteria and the weights of these criteria determined in the AHP method procedure.

3.1. Comments

The A-2 building, which was ranked 16th in our results, has been substituted for the next one in the ranking, i.e., the physical education P-23 building. This was due to its planned modernization that will continue beyond the timescale of the Project. In addition, 5 more objects with different characteristics that made it impossible to include it in the analysis of buildings, were included in the DAG. These are, the 2 stations of the University's cable car, the "Polinka", as well as open-air facilities such as the Alley of the Professors, the Odra Boulevard and the vicinity of the student dormitories "Wittigowo".

4. CONCLUSIONS

The presented study is probably the first one, which utilizes one of the MCDM methods, the AHP, in the selection of university campus buildings for the purpose of developing digital guides for users with disabilities. The adopted approach has allowed for a multicriteria and multifaceted analysis and assessment of Wroclaw

University of Science and Technology campus facilities aimed at selecting the most appropriate ones to be included in the development of the Digital Accessibility Guide.

The consensus of the expert group in the assessment of the 7 criteria was relatively low, which indicates a variety of opinions and the inclusion of different perspectives in the analysis. The obtained consistency ratio of the comparison matrix was 2.8%, which in turn indicates that the weights of the criteria and the final ranking were correctly assessed.

The AHP method has proved to be a reliable and efficient support in complex decision making processes, such as the selection of buildings based on a set of differentiated criteria.

On the other hand, the AHP method also has limitations in its application, such as the assumption of full comparability of elements in the model, difficulties in taking into account the dependencies between partial objective functions and the need to involve and guide the group of engaged experts.

REFERENCES

Alzouby, A.M., Nusair, A.A., Taha, L.M. (2019). GIS based Multi Criteria Decision Analysis for analyzing accessibility of the disabled in the Greater Irbid Municipality Area, Irbid, Jordan. *Alexandria Engineering Journal*, 58(2), 689069, doi: 10.1016/ j.aej.2019.05.015.

Bhushan, N., Rai, K. (2004). *Strategic decision making: applying the analytic hierarchy process. Strategic Decision Making: Applying the Analytic Hierarchy Process*. Springer London, doi: 10.1007/b97668.

Blachowski, J. (2015). Methodology for assessment of the accessibility of a brown coal deposit with Analytical Hierarchy Process and Weighted Linear Combination. *Environmental Earth Sciences*, 74, 4119-4131, doi: 10.1007/s12665-015-4461-0.

Blachowski, J., Rybakiewicz, W., Warczewski, W., Malczewski, P. (2016). Application of multi-criteria analysis in GIS for optimal planning of house development areas. Case study of Wrocław Functional Area. *Roczniki Geomatyki*, XIV, 5(75), 561-571.

Blachowski, J., Hajnrych, M. (2021). *Analiza AHP. Wybór 30 obiektów do Cyfrowego Przewodnika PWr*, Wroclaw University of Science and Technology, unpublished.

Chua, S.J.L., Ali, A.S., Alias, A.B. (2015). Implementation of Analytic Hierarchy Process (AHP) decision making framework for building maintenance procurement selection: Case study of Malaysian public universities. *Eksploatacja i Niezawodność – Maintenance and Reliability*, 17(5), 7-3018.

Erdogan, S.A., Šaparauskas, J., Turskis, T. (2019). A Multi-Criteria Decision-Making Model to Choose the Best Option for Sustainable Construction Management. *Sustainability*, 11, 22-39, doi: 10.3390/su11082239.

Goepel, K.D. (2013). Implementing the Analytic Hierarchy Process as a Standard Method for Multi-Criteria Decision Making in Corporate Enterprises – A New AHP Excel Template with Multiple Inputs. Conference: International symposium of analytic hierarchy process, at Kuala Lumpur, doi: 10.13033/isahp.y2013.047.

Górski, K. (2019). Zastosowanie metody AHP do wyboru typu gospodarstwa agroturystycznego. *Przegląd Budowlany*, 9, 108-112.

Hejmanowska, B., Hnat, E. (2009). Wielokryterialna analiza lokalizacji zabudowy na przykładzie gminy Podegrodzie. *Archiwum Fotogrametrii, Kartografii i Teledetekcji*, 20, 109-121.

Huang, I.B., Keisler, J., Linkov, I. (2011). Multi-criteria decision analysis in environmental sciences: Ten years of applications and trends. *Science of the Total Environment*, 409, 3578–3594, doi: 10.1016/j.scitotenv.2011.06.022.

Khan, A.U., Ali, Y. (2020). Analytical Hierarchy Process (AHP) and analytic network process methods and their applications: a twenty-year review from 2000-2019. *International Journal of the Analytic Hierarchy Process,* 12(3), doi: 10.13033/ijahp.v12i3.822.

Kruszyński, M., Żak, J. (2017). Analiza i ocena wielokryterialna wybranych, innowacyjnych rozwiązań transportowych wobec potrzeb osób z niepełnosprawnością i starszych. *Zeszyty Naukowe Politechniki Poznańskiej*. *Seria Organizacja i Zarządzanie*, 75, 141-162, doi: 10.21008/j.0239-9415.2017.075.11.

Kukułka, A., Wirkus, M. (2017). Metody wielokryterialne wspomagania decyzji oraz ich zastosowanie w opracowaniu metody oceny niepotokowych procesów produkcyjnych. In: R. Knosala (red.), *Innowacje w zarządzaniu i inżynierii produkcji, t. I*, Opole: Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, 612-623.

Lakhani, A., Zeeman, H. (2016). Analytic Hierarchy Process To Inform Disability Housing Development: Two Applications. Proceed. International Symposium on the Analytic Hierarchy Process, London, U.K., August 4 – August 7, doi: 10.13033/isahp.y 2016.037.

Marović, I., Tijanić, K., Šopić, M., Car-Pušić, D. (2020). Group decision-making in civil engineering based on AHP and PROMETHEE methods. *Przegląd Naukowy – Inżynieria i Kształtowanie Środowiska*, 2(4), 474-484, doi: 10.22630/PNIKS.2020.29.4.41.

Muhsen, A.A., Szymański, G.M., Mankhi, T.A., Attiya, B. (2018). Selecting the Most Efficient Maintenance Approach Using AHP Multiple Criteria Decision Making at Haditha Hydropower Plant. *Organizacja i Zarządzanie*, 78, 113–136, doi: https://doi.org/ 10.21008/ j.0239-9415.2018.078.09 (20.05.2023).

Palicki, S. (2013). *Metody prospektywnej oceny następstw rewitalizacji obszarów miejskich*, Warszawa: Texter.

Politechnika Nowych Szans (2022). Project's website, Retrieved from: https://pns.pwr.edu.pl/projekt (20.05.2023).

Roy B. (1990). *Wielokryterialne wspomaganie decyzji*, Warszawa: WNT.

Russo, R., Camanho, R. (2015). Criteria in AHP: A Systematic Review of Literature. *Procedia Computer Science,* 55, 1123-1132, doi: 10.1016/j.procs.2015.07.081.

Saaty, R.W. (1987). The analytic hierarchy process-what it is and how it is used. *Math Model*, 9(3-5), 161-176.

Saaty, T.L. (1980). *The analytic hierarchy process*. USA: McGraw-Hill.

Saaty, T.L. (2008). Relative measurement and its generalization in decision making why pairwise comparisons are central in mathematics for the measurement of intangible factors the analytic hierarchy/network process. *Revista de la Real Academia de Ciencias Exactas. Serie A. Matemáticas*, 102, 251-318. Retrieved from http://www.rac.es/ ficheros/doc/00576.PDF (20.05.2023).

Stypka, T., Flaga-Maryańczyk, A. (2016). Możliwości stosowania zmodyfikowanej metody AHP w problemach inżynierii środowiska. *Ekonomia i Środowisko*, 2(57), 37-53.

Subramanian, N., Ramanathan, R. (2012). A review of applications of Analytic Hierarchy Process in operations management. *International Journal of Production Economics*, 138(2), 215-241.

Trzaskalik, T. (2014). Wielokryterialne wspomaganie decyzji. przegląd metod i zastosowań. *Zeszyty Naukowe Politechniki Śląskiej, Seria: Organizacja i Zarządzanie*, 74, 239-264.

Wong, J.K. W., Li, H. (2008). Application of the analytic hierarchy process (AHP) in multi-criteria analysis of the selection of intelligent building systems. *Building and Environment*, 43(1), 108-125, doi: 10.1016/j.buildenv.2006.11.019.

Wroclaw University of Science and Technology Facts and Figures. Retrieved from: https://pwr.edu.pl/en/university/about-us/facts-and-figures (23.09.2022).

Vaidya, O., Kumar, S. (2006). Analytic Hierarchy Process: An Overview of Applications. *European Journal of Operational Research*, 169(1), 1-29. doi: 10.1016/j.ejor. 2004.04.028.

Zahedi, F. (1986). The Analytic Hierarchy Process – A Survey of the Method and Its Applications. *Interfaces*, 16, 96-108. doi: 10.1287/inte.16.4.96.

Zuraidi S.N.F., Rahman, M.A.A., Akasah, Z.A. (2018a). *Analytical hierarchy process (AHP) approach to the selection of heritage building element*. MATEC Web of Conferences, 250, doi: 10.1051/matecconf/201825005001.

Zuraidi S. N.F., Rahman, M.A.A., Akasah, Z.A. (2018b), *The Development of Condition Assessment for Heritage Building*. E3S Web of Conferences, 65, doi: 10.1051/e3sconf/ 20186501007.

WIELOKRYTERIALNA METODOLOGIA OCENY OBIEKTÓW KAMPUSU UNIWERSYTECKIEGO Z WYKORZYSTANIEM PODEJŚCIA AHP

Streszczenie

W ramach realizowanego na Politechnice Wrocławskiej projektu „Politechnika Nowych Szans" tworzony jest Cyfrowy Przewodnik, którego celem jest udostępnienie użytkownikom informacji o obiektach uczelni z uwzględnieniem potrzeb osób z niepełnosprawnością. Wybierając 25 najważniejszych obiektów, które znajdą się w Cyfrowym Przewodniku, dokonano ich oceny metodą hierarchicznej analizy problemu decyzyjnego AHP. Metoda obejmowała opracowanie przez interdyscyplinarną grupę ekspertów struktury hierarchicznej modelu, wyznaczenie siedmiu kryteriów oceny, opracowanie skali punktacji (1–5) lub podkryteriów, a następnie znaczenia. Przyjęte kryteria obejmowały m.in. funkcje i usługi budynków, liczbę użytkowników, dostępność komunikacyjną i architektoniczną, liczbę wskazań w ankiecie dostępności oraz liczbę sal dydaktycznych. Na potrzeby analizy dane zostały pozyskane od jednostek administracyjnych Politechniki Wrocławskiej, a także w trakcie audytów każdego z analizowanych budynków. Na podstawie analizy charakterystyk blisko pięćdziesięciu obiektów uczelni oraz wyników oceny kryteriów wyboru i ich znaczenia utworzono ostateczną listę rankingową. Konsensus grupy ekspertów wyniósł 2,8%, a ważona punktacja obiektów zawierała się w zakresie 4,68-1,29 przy medianie 2.16. Zastosowane podejście pozwoliło na ustrukturyzowanie i zobiektywizowanie analizowanego problemu decyzyjnego. Zaproponowana metoda wyboru obiektów strategicznych uczelni ma charakter uniwersalny i może być wykorzystana w analizie kampusów innych uczelni wyższych.

Słowa kluczowe: AHP, analiza wielokryterialna, Politechnika Wrocławska, Kampus, Cyfrowy Przewodnik