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Research paper

Analysis of a data set in a multi-criteria assessment of variants of a building development

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Abstract: One of the most important things to do at the stage of preparing an investment process in the construction business is to develop a few possible solutions and then to choose the variant which best fulfils the expectations of various groups of stakeholders. Making a decision about which variant to select depends on how it satisfies a number of criteria, which in turn reflect the requirements set for the planned investment. The process analysing variant solutions employs multi-criteria analysis methods. In order to make analyses and to identify the importance of measurable and non-measurable criteria, surveys and interviews are carried out to acquire the information on the role of the previously defined criteria. Opinions given by experts tend to be divergent due to differences in education, professional background as well as various professional and private experiences. This article reviews data processing methods, and discusses an example of a procedure, which is part of a more extensive analysis of the route of a planned road. The case presented in this paper focuses on the evaluation of five criteria from the category 'impact on the natural environment', which are significant in such development projects. The calculations involved in this assessment proved to be time- and labour-consuming, while raising a number of doubts concerning the stage of data aggregation. Hence, the objective of this study has been to develop a method that will enable more efficient data processing while taking into account all assessments.

Keywords: decision-making, expert assessments, multicriteria decision analysis

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1. Introduction

In the construction industry, efforts are made to limit the negative impact of building developments on the environment and the society. To this end, several variants of each development are made, which in itself is a complicated process that requires correct and careful preparation. Making the final decision depends on the highest possible fulfilment by the chosen variant of the set criteria, which reflect the requirements that the planned development should satisfy. Therefore, the process of evaluating variant solutions is supported by multi-criteria analysis methods [1–3]. The first step involves an analysis of the situation, that is the determination of factors which have influence on the decision-making process. This task is set for experienced experts. Decision-making difficulties mostly concern the selection of adequate criteria which will make it possible to meet the set expectations. Each decision gives rise to a number of consequences, hence it is important to define the priorities as well as the ultimate goal [4–6]. During the procedure employed for making an evaluation of variant solutions, it often turns out that the criteria adopted earlier are insufficient and the outcome of the assessment does not apply to all aspects of the investment. It is then necessary to return to the initial phase of the decision-making process. Such studies generate a huge amount of information, which needs to be prepared for further calculations, and an appropriate, experience-based approach is necessary to evaluate the usefulness of particular data for the subsequent steps of the procedure [7–9].

A common problem in a multi-criteria analysis is the identification of valid criteria and subsequently to determine their importance. Criteria can be highly diverse depending on the planned development and on the investor as well [10]. The choice of criteria calls for consultations with a group of experts, which may give rise to issues connected with dependence or conflict relations [11, 12]. Once the experts have expressed their opinions, the final step, possibly most difficult one, in the whole process of evaluating variant solutions is to order a set of data. There are many aggregation methods, each of which creates difficulties and generates results that can be questionable [13, 14]. It is best when evaluations made by experts are similar. The extent to which they are convergent can be evaluated on the basis of an analysis of the consistency of results. One of the basic methods for data processing is their averaging. The highest impact is then attributed to assessments made most often. Another method is to calculate a median of the available results. In many cases, extreme values, i.e. ones which are significantly different from most results or from the average of assessments, are discarded from an analysis However, when this happens, the achieved results do not always reflect faithfully the overall situation and the analysed phenomenon [15, 16]. Hence, in many instances, it is necessary to summarise the assessments using more advanced methods. There are numerous methods and approaches, but it is not easy to state which objectively is the most effective one as it is difficult to evaluate the degree of uncertainty [17]. Various approaches are used to model uncertainty. A numerous group of aggregation methods has been developed under the umbrella of the theory of probability [18]. The linear weighted aggregation method is employed very often. Nevertheless, opinions of experts are often expressed as scores, and the results are frequently inconsistent and do not coincide. Then, a problem arises how to verify the degree of coherence of all opinions. It is also possible to determine the level of acceptance of divergence among opinions. An example of such an analysis is shown in Fig. 1, where it is seen that the values 1, 5 and 6 should be discarded because they are above the acceptance level, which was denoted as *L1*. It is very useful information, which can also be replaced by an intuitive approach.

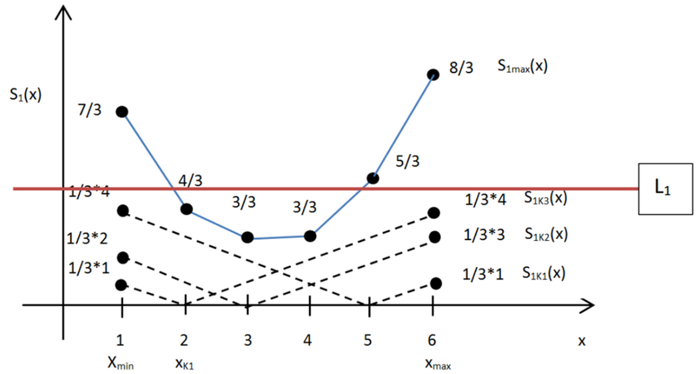

Fig. 1. Level of acceptance of divergence of the analysed opinions [13]

Multi-criteria methods deal with large, heterogenous sets of data that are difficult to process. Having processed these data, the choice of the best option is far from being obvious due to the large amount of information as well as the diversity of answers given by experts, which are difficult to arrange in groups. A large data set is a relative term and refers to a set of information that cannot be processed using commonly available, traditional methods. It is referred to as Big Data. Such a resource of information requires the development of advanced technologies, hence machine learning techniques are becoming very important in this regard [19, 20]. An example of such a multi-criteria task is the subject of this article.

2. Research methodology

When making an assessment of variants of a building development, criteria of different character are taken into consideration. As a rule, they depend on the type of a building (e.g. commercial, sports, industrial or road facilities). However, there are groups of criteria that almost always appear, such as economic, technical, location or environmental conditions. Especially the latter have been steadily gaining importance in Europe and worldwide [21–24].

The legal documents of the European Union concerning the process of preparation and execution of building developments are: Directive 2021/42/EC of the European Parliament and Council of 27 June 2011 on the assessment of the effects of certain plans and programmes on the environment, Directive 2021/92/EC of the European Parliament and Council of 13 December 2021 on the assessment of the effects of certain public and private projects on the environment, Directive 2009/147/EC of the European Parliament and Council of 30 November 2009 on the conservation of wild birds, and Directive 92/43/EEC of the European Council of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora [21, 22].

Being a member state of the European Union, Poland is obligated to implement the regulations contained in EU directives into the national legal system. In the hierarchy of all legal acts binding in Poland, the most superior one is the Constitution of the Republic of Poland, which makes provisions for the protection of the environment, guided by the principle of sustainable development, and stating that the environmental protection is the responsibility of public authorities. Each citizen has a right to obtain information about the state and protection of the environment. Apart from the Constitution, the key role in the Polish system of legal acts is played by a set of regulations governing the relationships between investments and the natural environment. They compose the legal framework for the extensive and complicated system of environmental assessments made for planned developments. It is impossible to obtain a decision on environmental conditions, which means that it is impossible to obtain building permits for a given development, unless the building design comprises solutions ensuring that environmental effects of the planned development will be as small as possible. This applies to any kind of a building development, including the construction of roads, which in Poland has gained great momentum over the last dozen of years or so [23, 24]. In wealthy and highly developed countries, networks of roads are generally well-established and few new roads are now being constructed. However, in developing and moderately developed countries, including Poland, the road networks are at the stage of being expanded. This presents the administration, management, engineers, designers and contractors with the challenge of reconciling the growth of a grid of roads with the increasingly stringent requirements for environmental protection.

The problem of choosing the most advantageous variant for the construction of the road section was analysed. First, a group of experts, which included environmental protection inspectors, clerks representing the architecture and construction administration as well as building supervision offices, construction engineers, conducted a comprehensive analysis of the planned investment and, as a result, determined a set of the most important factors that should cover the entire life cycle of the facility. A group of experts developed a set of four major criteria: transport and connection, economic, environmental and socio-planning ones. Within each group, the most important subcriteria were distinguished.

For the road development case considered in this study, three possible routes for a new road were developed, all taking into consideration environmental requirements. Because of the importance of environmental factors, the analysis focused on these criteria.

The following variants were designed:

Variant V1 – better in terms of transportation requirements, less expensive but calls for changes in the natural and social environment,

Variant V2 – not so good in terms of transport, moderate costs but does not entail any changes in the social environment,

Variant V3 – friendly to the natural and social environment, most expensive and disadvantageous in terms of transportation.

This article focuses on the assessment of five subcriteria from the environmental set of criteria 'impact on the natural environment', which are significant in the implementation of this type of a building development. This is part of a broader analysis that is beyond the scope of this work. The list of the analysed criteria is given in Table 1.

Table 1. Analysed criteria from the group 'impact on the natural environment'

No.	Specification of criteria included in the study	Scale of scores	Number of obtained answers
1	C1 – intrusion into protected areas	1–5	57
2	C2 – length of road crossing forests		
3	C3 – number of trees to be felled		
4	C4 – intersecting with animal migration trails		
5	C5 – intersecting with watercourses		

In order to make a detailed analysis, a survey was carried out, addressed to different social groups. The respondents included:

- environmental protection officers – 11 persons,
- clerks representing the architecture and construction administration as well as building supervision offices – 9 persons,
- construction engineers – contractors, designers, inspectors – 16 persons,
- local community and other beneficiaries – 21 persons.

3. Results

The study consisted of two stages. At first, 57 respondents assessed the importance of each subcriterion applied to the construction of a road on a 1–5 scale, where 1 meant that a given criterion was of little importance, and 5 – that is was very important. Next, the same persons made an assessment of each of the three variants, assigning scores also from 1 to 5 to each subcriterion, where 1 indicates the adverse impact of the factor on a given variant, and 5 – meets the criterion.

3.1. Determination of the importance of subcriteria

The assessments made by the experts in order to determine the importance of the subcriteria for the execution of the planned building development are complied in Table 2.

It is best for the person making an evaluation when the responses gathered from respondents are coherent and clearly indicate how important a given criterion is. However, such a situation appears extremely rarely. Answers given by consulted experts are typically diverse and this arises from the differences in their education, professional background, various professional and private experiences. And this is precisely what happened in our study, where the resulting assessments were discrepant. There are criteria where one answer clearly dominated (Fig. 2a, d), where the answers followed the Gaussian curve (Fig. 2b, c), or there the distribution of answers demonstrated the prevalence of low assessment scores (Fig. 2e).

Table 2. Experts' assessments of the importance of subcriteria from the environmental impact group

No.	Criterion of the assessment	(1p) Not very impor-tant	(2p)	3p)	(4p)	(5p) Essential	Sum of re-sponses
1	C1 – intrusion into protected areas	3	16	25	9	4	57
2	C2 – length of road crossing forests	7	19	21	7	3	57
3	C3 – number of trees to be felled	1	12	20	18	6	57
4	C4 – intersecting with animal migration trails	9	28	14	3	3	57
5	C5 – intersecting with watercourses	20	26	6	4	1	57

The above figures show that it is not always possible to determine the importance of a given factor on a scoring scale based on these diagrams. The curation and processing of these data were the next stage of our study. Assessments provided in the survey were submitted to a further procedure in order to arrange the importance of the factors according to the arithmetic means. This procedure is very often used in practice.

According to the respondents, the highest importance among the environmental factors considered for the analysed investment was possessed by the number of trees to be felled and the necessity to interfere with protected natural areas, whereas the least important was the fact that the planned road would intersect with animal migration routes and watercourses. The division of the respondents into groups showed that environmental protection officers assigned the highest scores, which is understandable as they are experts in this field and consider environmental factors associated with their profession as very important. The environmental factors were also important for the society, while construction engineers assigned lower scores to these factors. Having discarded 10% of extreme answers, the results obtained were similar in a ranking order to the ones gathered in Table 3. This way of data aggregation may result in some of the significant assessments provided by individual respondents not given proper consideration. The arithmetic mean does not take into account discrepancies among individual assessments.

Table 3. Ranking of environmental subcriteria according to the arithmetic

Position in the rank list	Criterion	Mean of scores
1	C3 – number of trees to be felled	3.281
2	C1 – intrusion into protected areas	2.912
3	C2 – length of road crossing forests	2.649
4	C4 – intersecting with animal migration trails	2.368
5	C5 – intersecting with watercourses	1.947

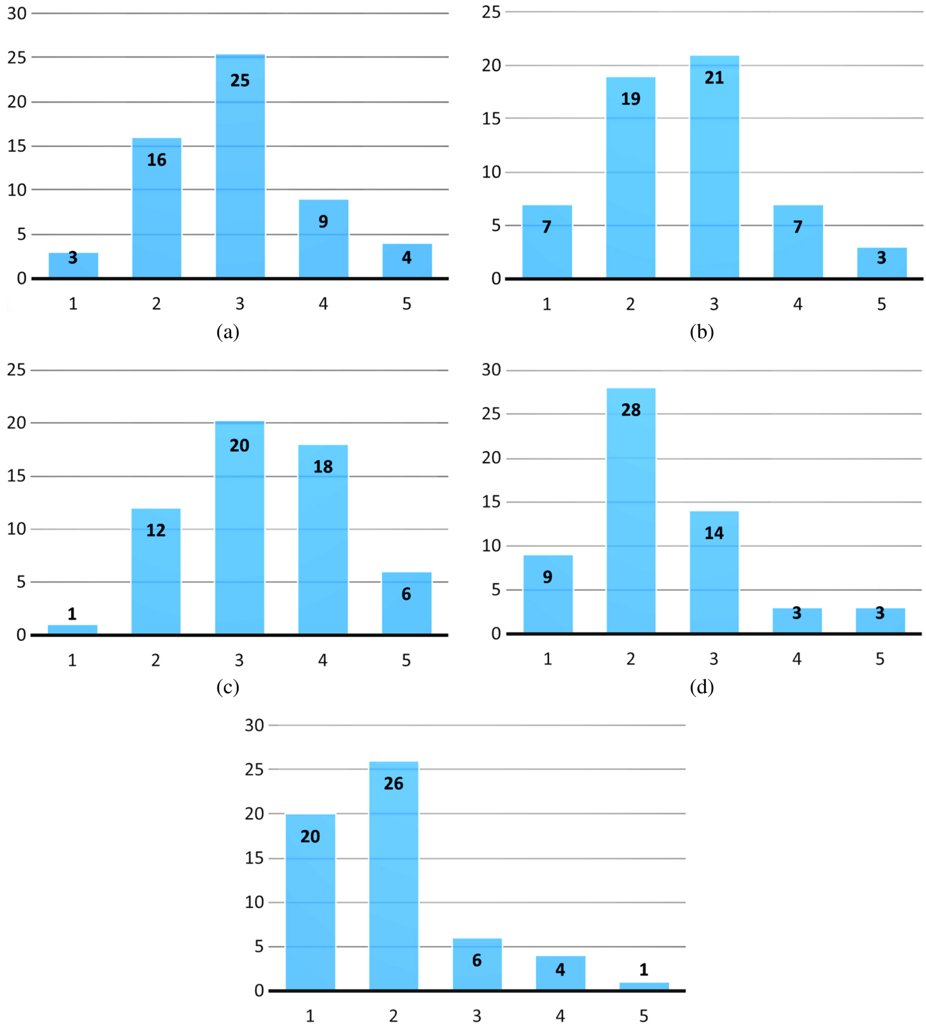

Fig. 2. Distributions of answers for the subcriteria from the environmental impact group; (a) Distribution with clear dominance of one answer (C1), (b) Distribution following the classical Guassian curve (C2), (c) Distribution following the classical Gaussian curve (C3), Distribution with clear dominance of one answer (C4), (e) Distribution with dominance of low scores (C5)

Another way to verify results of surveys is to calculate the median and dominant, as shown in Table 4. Based on these figures, it is difficult to distinguish one, most important criterion, as the first three of the five identified criteria reach the highest, identical values of both the median and dominant, whereas the other two factors achieve the value 2 for both the median and dominant. It is worth noting that this rank list, despite its very modest diversity, indicates the same tendency as demonstrated in the previous analyses.

Table 4. Median and dominant for the analysed environmental subcriteria

No.	Subcriterion	Median	Dominant
1	C1 – intrusion into protected areas	3	3
2	C2 – length of road crossing forests	3	3
3	C3 – number of trees to be felled	3	3
4	C4 – intersecting with animal migration trails	2	2
5	C5 – intersecting with watercourses	2	2

Having analysed in great detail the responses given in the survey, an attempt was made to assign one assessment to each of the subcriteria in order to continue the determination of the importance of the three road development variants. While observing the distribution of results in the diagrams, the choice of any single variant is burdened by a number of doubts. For the subcriteria where one answer dominated (Fig. 2a, d) – subcriterion C1, C4, this was the ultimate choice. Unfortunately, this meant that the other opinions were invalidated. However, a consensus of all respondents is practically unachievable and therefore it was decided to assign unambiguous assessments following discussions with the group of experts. It was remembered that this excerpt is part of a broader analysis in which the respondents were people from different professional groups, and this part refers only to factors related to the environment. Therefore, in dubious cases, analyses were made where assessments made by environmental protection officers were given the multiplier x2 as they were the group of professionals with the most experience in this field. This approach resulted in clear peaks for criteria C2, C3 and C5 in the response distribution graphs, indicating a dominant assessment. Before the results were complied, each was submitted to a detailed analysis in terms of the responses given by the surveyed persons, and based on that analysis the final results were set in Table 5.

Table 5. Final assessment for each criterion

Criterion	Assessment
C1 – intrusion into protected areas	3
C2 – length of road crossing forests	3
C3 – number of trees to be felled	4
C4 – intersecting with animal migration trails	2
C5 – intersecting with watercourses	2

Based on the above analysis, it follows that the greatest weight among the environmental factors in the choice of a variant of the road development discussed in the present case study is attributed to factor C3 – the number of trees to be felled. The intrusion into legally protected natural areas as well as the length of the road running through forests are also important. The least significant proved to be the intersection with animal migration trails and watercourses. It is worth noting that this ranking list was produced after the aggregation with basic statistical methods and the range from 1 to 5 turned out to be too narrow.

3.2. Assessment of the variants

Knowing the importance of each factor, an analysis of the evaluation of the three variants of the planned road development was made in the second stage of the study. First, experts' opinions on variant V1 were compiled (Table 6). The lower the assessment, the more adverse the impact of a given criterion on the variant. For example, if variant 1 affects to a large extent factor C1 – intrusion into protected areas, then the respondents assigned the value 1, that is the investment does not meet the expectations in this respect (building the road would entail the intrusion into protected natural areas, i.e. it would be detrimental to the environment). When the score is 5, it means that the factor does not limit the implementation of a given variant (building the road will not entail intrusion into protected areas).

Table 6. Experts' opinions – variant 1

No.	Criteria of assessment	(1p) The option fulfils the criterion at least	(2p)	(3p)	(4p)	(5p) The option fulfils the criterion to the maximum extent	Sum of answers
1	C1 – intrusion into protected areas	6	7	22	20	2	57
2	C2 – length of road crossing forests	3	13	25	15	1	57
3	C3 – number of trees to be felled	10	30	15	2	0	57
4	C4 – intersecting with animal migration trails	0	13	22	19	3	57
5	C5 – intersecting with watercourses	0	8	28	19	2	57

In order to verify the extent to which variant 1 satisfies a given subcriterion for each of them, an arithmetic mean was calculated based on data in Table 6 and the results are shown in Table 7.

Table 7. Ranking of subcriteria based on the arithmetic mean for variant V1

Position in the ranking order	Criterion	Average of scores
1	C5 – intersecting with watercourses	3.263
2	C4 – intersecting with animal migration trails	3.211
3	C1 – intrusion into protected areas	3.070
4	C2 – length of road crossing forests	2.965
5	C3 – number of trees to be felled	2.158

The above table proves that the choice of variant 1 would entail the most the felling of trees, but would be the least detrimental in terms of intersecting with watercourses and animal migration trails.

A careful analysis was made, same as in the initial stage of the study, regarding the criteria from the environmental group, and the final evaluation of variant 1 now included the arithmetic mean of each criterion and the significance of each factor relative to the global initial analysis, summarized in Table 5. The importance of variant V1 was calculated using the product of these two values. As a result, the final assessment for the first variant solution of the planned road development was achieved (Table 8).

Table 8. Final assessment for variant V1

Criterion	Final assessment	Average of scores	Result
C1 – intrusion into protected areas	3	3.070	9.210
C2 – length of road crossing forests	3	2.965	8.895
C3 – number of trees to be felled	4	2.158	8.632
C4 – intersecting with animal migration trails	2	3.211	6.422
C5 – intersecting with watercourses	2	3.263	6.526
Sum:			**39.685**

The same analysis was carried out for variant 2. The assessments provided by the survey participants were set in Table 9, afterwards arithmetic means were calculated (Table 10).

Table 9. Expert's opinions – variant V2

No.	Criteria of assessment	(1p) The option fulfils the criterion at least	(2p)	(3p)	(4p)	(5p) The option fulfils the criterion to the maximum extent	Sum of answers
1	C1 – intrusion into protected areas	0	8	27	17	5	57
2	C2 – length of road crossing forests	1	13	29	13	1	57
3	C3 – number of trees to be felled	1	18	28	10	0	57
4	C4 – intersecting with animal migration trails	0	14	28	15	0	57
5	C5 – intersecting with watercourses	0	5	34	18	0	57

Table 10. Ranking of subcriteria based on the arithmetic mean for variant V2

Position in the ranking order	Criterion	Average of scores
1	C1 – intrusion into protected areas	3.333
2	C5 – intersecting with watercourses	3.228
3	C4 – intersecting with animal migration trails	3.018
4	C2 – length of road crossing forests	3.000
5	C3 – number of trees to be felled	2.825

The above results reveal that the choice of variant 2, same as variant 1, would necessitate the felling of a large number of trees, but this variant would least affect the legally protected natural areas. Same as for variant 1, variant 2 was submitted to the final evaluation, and the results were complied in Table 11.

Table 11. Final assessment for variant V2

Criterion	Final assessment	Average of scores	Result
C1 – intrusion into protected areas	3	3.333	9.999
C2 – length of road crossing forests	3	3.000	9.000
C3 – number of trees to be felled	4	2.825	11.300
C4 – intersecting with animal migration trails	2	3.018	6.036
C5 – intersecting with watercourses	2	3.228	6.456
Sum:			**42.791**

Variant V3 underwent the same data processing. Assessments made by the surveyed experts were set in Table 12, and the results of our calculations of arithmetic means are contained in Table 13.

The third variant, unlike the first and second one, the road development would have the most adverse effect on the protected natural areas, but would least collide with animal migration trails. Results of the final evaluation of variant 3 are set in Table 14.

The final assessments of the three variants regarding the criteria associated with the impact on the environment are summarized in Table 15.

The calculations demonstrate that variant 3 is the most advantageous one in terms of the environment, as it satisfies the set environmental criteria to the highest degree, which confirms the descriptions assigned to the variants at the onset of the study, namely "variant V 3 – friendly to the natural and social environment, most expensive and least advantageous for transportation purposes". The case discussed in this article is a fragment of the globally pursued problem of analysing the problem of the choice of a development variant with respect to many criteria, not only the environmental ones, and this will be our next research goal.

Table 12. Expert's opinions – variant V3

No.	Criteria of assessment	(1p) The option fulfils the criterion at least	(2p)	(3p)	(4p)	(5p) The option fulfils the criterion to the maximum extent	Sum of answers
1	C1 – intrusion into protected areas	3	6	9	32	7	57
2	C2 – length of road crossing forests	0	3	9	25	20	57
3	C3 – number of trees to be felled	0	3	3	37	14	57
4	C4 – intersecting with animal migration trails	0	0	3	42	12	57
5	C5 – intersecting with watercourses	0	0	11	31	15	57

Table 13. Ranking of subcriteria based on the arithmetic mean for variant V3

Position in the ranking order	Criterion	Average of scores
1	C4 – intersecting with animal migration trails	4.158
2	C2 – length of road crossing forests	4.088
3	C3 – number of trees to be felled	4.088
4	C5 – intersecting with watercourses	4.070
5	C1 – intrusion into protected areas	3.596

Table 14. Final assessment for variant V3

Criterion	Final assessment	Average of scores	Results
C1 – intrusion into protected areas	3	3.596	10.788
C2 – length of road crossing forests	3	4.088	12.264
C3 – number of trees to be felled	4	4.088	16.352
C4 – intersecting with animal migration trails	2	4.158	8.316
C5 – intersecting with watercourses	2	4.070	8.140
Sum:			**55.860**

Table 15. Final assessment for all variants

	Variant 1	Variant 2	Variant 3
Sum of scores after taking into account weights	39.685	42.791	55.860

4. Conclusions

The case presented in this paper was based on a survey completed by 57 persons, who first evaluated the validity of criteria and then decided which variant of a road construction investment satisfied these criteria the best, which eventually enabled the selection of a variant on the basis of environmental factors. The calculations proved to be time- and labor-consuming, while raising many doubts during the aggregation of data. However, it is worth mentioning that in practice there is usually a much higher number of respondents and a larger diversity of criteria, which could prove to be impossible to be processed with traditional methods. Hence, the purpose of further research is to develop a method which will facilitate a more efficient processing of data while simultaneously taking into account all assessments provided in a survey.

The case presented in this paper as well as the authors' own observations demonstrate that processes involved in the construction business oftentimes necessitate solving multi-criteria problems. There is a broad range of methods for solving such problems, and many researchers have analysed various aspects of such approaches as well as problems they are applied to. Difficulties emerge as early as the stage of working out valid criteria. Practical implementation of multi-criteria analysis methods looks somewhat different from how they are presented in theory. The process of the acquisition of data as well as collaboration with experts create many difficulties. Moreover, many methods are mathematically complicated and the results are not always easily readable. A particularly difficult step is to determine the list of criteria and to assign values to these parameters. This process is carried out on the basis of experts' opinions, which often compose a large, heterogenous set of data that is difficult to process. The ways and approaches to data aggregation also raise many doubts and discussions among scholars. At present, because of the rapid development of computer assisted methods, it is precisely the computer aided decision making domain that gains popularity as it enables high automation of decision-making processes. Yet, it should be borne in mind that the final choice should always be made by the decision maker and therefore emphasis is laid on the term 'computer aided', and not 'computer made' decisions. A combination of traditional and computer assisted methods can generate significant benefits in the selection of variant solutions based on a variety of criteria. However, the synergy between these two approaches is a research subject that surpasses the problem area chosen for this article.

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Analiza zbioru danych w wielokryterialnych ocenach wariantów przedsięwzięć budowlanych

Słowa kluczowe: podejmowanie decyzji, oceny ekspertów, analiza wielokryterialna

Streszczenie:

Na etapie przygotowania procesu inwestycyjnego w budownictwie jedną z ważniejszych czynności jest przygotowanie kilku wariantów rozwiązania i dokonanie wyboru spełniającego w najwyższym stopniu oczekiwania różnych grup interesariuszy. Opracowanie rozwiązań alternatywnych z jednej strony narzucają przepisy (tam, gdzie mamy do czynienia z finansowaniem ze środków publicznych), z drugiej zaś strony jest postępowaniem logicznym optymalizującym proces inwestycyjny dla inwestorów prywatnych. Podjęcie decyzji o wyborze rozwiązania z reguły jest uwarunkowane spełnieniem wielu kryteriów, które odzwierciedlają wymogi stawiane przed planowaną inwestycją. Dlatego też w procesie oceny wariantów zastosowanie znalazły metody analizy wielokryterialnej [1–9]. Metody analizy wielokryterialnej są przydatne wszędzie tam, gdzie wiele czynników decyduje o wyborze rozwiązania dopuszczalnego realizacji inwestycji budowlanych. W celu przeprowadzenia analiz i określenia znaczenia czynników niemierzalnych przeprowadza się ankiety i wywiady dostarczające informacji o znaczeniu wcześniej zdefiniowanych kryteriów. Takie badania są źródłem ogromnej ilości informacji, które wymagają przygotowania do dalszych obliczeń. Ocena przydatności uzyskanych danych i przygotowanie ich do dalszego postępowania wymaga odpowiedniego podejścia opartego na doświadczeniu. Jest wiele prostych metod opracowania danych, ale można również zastosować bardziej zaawansowane techniki.

Uzyskane dane mogą mieć różny charakter. Najlepsza, z punktu widzenia oceniającego, jest sytuacja gdy odpowiedzi są spójne i wyraźnie wskazują jak ważne jest oceniane kryterium. Jednak taka sytuacja występuje niezwykle rzadko. Odpowiedzi ekspertów są z reguły różnorodne i wynika to z różnego wykształcenia, przygotowania zawodowego, różnych doświadczeń zawodowych i pozazawodowych. Wówczas podjęcie decyzji o ważności kryterium komplikuje się. Jest wiele metod proponujących postępowanie z dużymi zbiorami danych [11–14]. W artykule przedstawiono przegląd metod przetwarzania danych oraz przykłady postępowania stanowiące fragmenty szerszej analizy wariantów przebiegu trasy inwestycji drogowej. W przedstawionym przykładzie skupiono się na ocenach pięciu kryteriów z grupy „oddziaływanie na środowisko naturalne", które są bardzo istotne przy realizacji tego typu inwestycji [17–20]. Analizowane kryteria: naruszenieobszarów chronionych, długość przebiegu tras przez obszary leśne, ilość drzew do wycięcia, przecięcie szlaków wędrówek zwierząt oraz przecięcie cieków wodnych. W artykule przedstawiono różne podejście do ustalenia wartości wymienionych kryteriów, przykładowe obliczenia a całość wieńczą wnioski.

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