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A multiple-criteria decision-making model for the selection of a hotel location

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ABSTRACT

The primary objective of this paper is to give an efficient model for the selection of an optimal location for the construction of a tourist hotel. The application of the multiple-criteria decision-making – MCDM methods is proposed because the examined problem is related to a set of alternatives that should be estimated against a set of conflicting criteria. The proposed model includes the application of the adapted step-wise weight assessment ratio analysis – SWARA for the determination of the weights of criteria and the Weighted Sum method, based on the decision-maker's preferred levels of performances – WS PLP for the final prioritization and ranking of alternative locations. The applicability of the proposed model is demonstrated through a concrete example, which includes the consideration of six Serbian mountains as the potential locations where a tourist hotel could be constructed.

1. Introduction

The key issue for the hotel industry is how to select an appropriate hotel location because a choice made has numerous effects on the hotel's future business. In the paper by Newell and Seabrook (2006), the location is denoted as one of the five categories important for making a decision on an investment in a hotel. The results obtained from the application of the AHP method in the mentioned paper show that the location is the first or the second important factor (depending on whether the hotel owners or investors are in question) for decisions on investment in a hotel, which reflects the fact that the location attributes that could be specifically identified have a great influence. Namely, decisions on the location have significant strategic implications because they involve a long-term commitment of resources. Therefore, the determination of the geographical site where a hotel is to be located is a very important task for the investor because if the selection is appropriate, it will save the costs of a relocation or reconfiguration and bring a myriad of advantages, such as: the shorter payback of the invested resources, a bigger market share, a higher tourist satisfaction (which leads to their loyalty, facilitates the operations of the hotel, etc.). All of the foregoing points out the fact that the location selection is a very important strategic decision that requires the investor's full attention and careful planning because future operation depends on this first step.

During the past three decades, researchers and practitioners have been paying greater attention to the issue of the selection of a hotel location, which has increasingly been a very important issue because the satisfied tourist/customer will be loyal in a future period. The selection of the location of a hotel implies the identifying of available location alternatives, their evaluation and the final selection of the most suitable one for the present conditions. The number of the tourists that will visit a hotel and stay in it, on the one hand, and future hotel income, on the other, are directly dependent on the location. The location does not only represent the infrastructure and utilities, but it also represents the surroundings, such as cultural heritage, national parks and other picnic areas potentially interesting to the average tourist. Chou et al. (2008) stated that the decision on "a suitable hotel location has become one of the most crucial issues for the hotel industry".

The prioritization of the locations of a hotel requires a detailed analysis of alternative locations, as well as the preferences of the target group of tourists. Yang et al. (2014) recognize the three categories of the models for the selection of a hotel location, and they are as follows: the theoretical model, the empirical model, and the operational model. Each of these models is elaborated in a certain number of sub-models in accordance with their disciplinary backgrounds. As can be inferred, different factors have an influence on the decisions connected with the choice of the location that is adequate for the construction of a hotel, i.e. their evaluation can be performed on the basis of different, often

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conflicting, criteria. Therefore, developing a model for the selection of the hotel location based on the different criteria that would provide an adequate and rational choice is very important because it will increase the chance of achieving success and a competitive advantage on the tourist market. Considering the previously mentioned, the MCDM methods would be a convenient tool for solving the problem of the hotel location selection.

There are many different MCDM approaches that can be used for the hotel location selection, but in this case the use of the WS PLP method, developed by Stanujkic and Zavadskas (2015), is proposed. The weights of the considered criteria, on which the assessment and selection of the offered alternatives is based, are determined by using an adapted SWARA method (Keršulienė et al., 2010). The applicability of the proposed model is presented through a concrete example demonstrating the selection of the appropriate mountain in Serbia suitable for the construction of a tourist hotel. In order to establish the decision-making model, the paper is arranged as follows: the second section presents the literature review; the proposed model is presented in the third section; the fourth section contains an empirical study, which clearly outlines the research problem and the application process of the proposed model; the sensitivity analysis of the proposed model is conducted in the fifth section; finally, the conclusion is given.

2. Literature review

MCDM relates to the methods that can be used for solving the real-world problems which are complicated by the fact that there are many different, usually conflicting, criteria that exert an influence on the final decision and therefore must be taken into consideration (Liou and Tzeng, 2012). Using these methods facilitates the decision-making process and the selection of the most appropriate alternative among the existing ones. The good overviews of the proposed methods, as well as their applications, can be found in the papers by Zavadskas and Turskis (2011), Zavadskas et al. (2014), Mardani et al. (2015), Govindan et al. (2015), Ilgin et al. (2015), etc. The appropriate extensions of the above-mentioned methods have been developed in order to overcome uncertainty, imprecision and vagueness; therefore, the applying of fuzzy, intuitionistic fuzzy and grey numbers has become regular practice.

MCDM methods have been used quite a lot in the past few decades; they are still being used within the new areas of application because the new methods are being developed or the old are being improved. In the area of the tourist i.e. hotel industry, the MCDM methods are used for the purpose of overcoming different kinds of problems and facilitating and prevailing various business difficulties related to decision making. The application of the MCDM methods in the field of the hotel and tourism industry is summarized in Table 1.

This paper proposes a model for prioritizing the location for the construction of a tourist hotel that relies on the WS PLP method which represents the improvement of the WS or SAW method and the adapted SWARA method used for the purpose of determining the weights of criteria. The application of the WS PLP method is proposed because it incorporates the preferences of the decision maker (*DM*) in the decision-making and selection processes and enables the *DM* to choose between the alternative that has the best performances and the one that has a better matching with the presumed conditions, expressed through preferred performance ratings or *ppr* values.

The WS or SAW method, which is the base for the WS PLP method, is broadly used in the decision-making process in many different business fields for different purposes, and is still very popular, beside the fact that new MCDM methods have been disclosed in the recent period. The popularity of this method has been confirmed in the research studies listed below. Alavi et al. (2013) applied the SAW method for the evaluation of a landfill site selection in Iran, whereas Jeong et al. (2013) used the SAW method for the selection of a site for rural buildings construction. The SAW method was also applied for the ranking of the suggested alternatives for the demarcation of the Caspian Sea (Madani et al., 2014) and the assessment of power supply technologies (Shakouri et al., 2014). Salih et al. (2015) included wireless network users' preferences in the decision-making procedure by incorporating the SAW method into the framework of the non-cooperative game theory. The combination of the SAW and other MCDM methods has proven to be very useful and applicable in clarifying many different decision-making problems (Oltean-Dumbrava et al., 2016; Wang et al., 2016).

The WS PLP method that would be used in this paper for solving the problem of the location selection is a relatively new method, whose possibilities still have not been completely tested. This MCDM method is mentioned in the paper by Keshavarz Ghorabaee et al. (2016), in which the utilization of MCDM methods in the supplier selection is considered. Esangbedo and Che (2016), who used the grey WS method for the evaluation of the business environment in West Africa, also pointed out the WS PLP method. Stanujkic et al. (2017a) used combination of the WS PLP and SWARA method for the personnel selection.

The SWARA method is a very simple method often employed for identifying the weights of criteria as well as for ranking available alternatives. Some examples of using this method are shown below. Hashemkhani Zolfani and Saparauskas (2013) used it for estimating the energy system sustainability indicator appraisal, whereas Hashemkhani Zolfani and Bahrami (2014) applied it for estimating investment in the high-technology industries in combination with COPRAS. Stanujkic et al. (2015) proposed a model suitable for the election of the packing design that involves the application of the SWARA method. Also, Karabasevic et al. (2016) proposed a framework for personnel selection under uncertainties, based on the combination of the SWARA and ARAS methods. Starting from the fact that SWARA has proved to be useful in various fields, the main assumption is that it will be adequate for defining the weights of the criteria in the case of prioritizing the mountain destinations for making an investment in the construction of a tourist hotel as well.

3. A Model for the location selection

3.1. The computational procedure for the adapted SWARA method

It is important in decision making by using MCDM methods that criteria weights should be determined. Many different procedures were introduced for that purpose, such as: the analytic hierarchy process – AHP (Saaty, 1977), the linear programming techniques for the multidimensional analysis of preferences – LINMAP (Srinivasan and Shocker, 1973), KEmeny Median Indicator Ranks Accordance – KEMIRA (Krylovas et al., 2014), PIvot Pairwise RElative Criteria Importance Assessment – PIPRECIA (Stanujkic et al., 2017b) and so on. In this paper, the SWARA method (Keršulienė et al., 2010) that has been slightly adapted for the purpose of this study is proposed and can exactly be demonstrated through the following steps:

***Step* 1**. The determination of the criteria that would be the basis for the selection process. In original SWARA, criteria should be arranged in descending order, according to their anticipated relevance, but it is not the rule in this case.

***Step* 2**. Relative importance should be determined for every single criterion, starting from the second. For the observed criterion j, relative importance is determined with respect to the previous criterion $(j-1)$. If the respondent gives greater significance to the observed criterion than the previous one, the given value is higher than 1, whereas in the opposite case, it is lower than 1.

***Step* 3.** The determination of the coefficient k_j in the original SWARA is as follows:

$$k_j = \begin{Bmatrix} 1 & j=1 \\ s_j+1 & j>1 \end{Bmatrix}, \tag{1}$$

Table 1
The application of the MCDM methods in the field of the hotel and tourism industry.

Field	Method	Author	Year
Service quality	DEMATEL	Tseng	2009
	AHP/DEA	Shirouyehzad, Lotfi, Arabzad, and Dabestani	2013
	AHP/PROMETHEE	Akincilar and Dagdeviren	2014
Assessment of the tourism destination	AHP/TOPSIS/Fuzzy set theory	Hsu, Tsai, and Wu	2009
	TOPSIS/Fuzzy Rasch model	Huang and Peng	2012
	ELECTRE	Botti and Peypoch	2013
	AHP	Zhou, Maumbe, Deng, and Selin	2015
	PROMETHEE/GAIA	Ranjan, Chatterjee, and Chakraborty	2016
Assessment of the ecotourism destination	PROMETHEE III/AHP/Fuzzy set theory	Kaya, Kaya, and Kahraman	2013
	AHP/OWA	Jeong, García-Moruno, Hernández-Blanco, and Jaraíz-Cabanillas	2014
	Fuzzy DEMATEL	Gigović, Pamučar, Lukić, and Marković	2016
Marketing strategy selection	ANP/TOPSIS	Wu, Lin, and Lee	2010
	DEMATEL/NRM/DANP/VIKOR	Liu, Tzeng, and Lee	2012
	AHP	Chen	2013
	Fuzzy AHP	Shahin, Khazaei Pool, and Poormostafa	2014
Location selection	Chouqet Integral/Fuzzy measure	Li, Law, Vu, and Rong	2013
	Fuzzy AHP	Wang, Jung, Yeo, and Chou	2014
	AHP	Emir and Saraçli	2014
	KEMIRA-M	Krylovas, Zavadskas, and Kosareva	2016

where s_j indicates the ratio of the comparative importance of the average value.In this case, however, because the respondent does not sort the criteria according to the expected significances, Eq. (2) is written as follows:

$$k_j = \begin{Bmatrix} 1 & j = 1 \\ 2 - s_j & j > 1 \end{Bmatrix}. \tag{2}$$

***Step* 4.** Provide the recalculated weight q_j as follows:

$$qj = \begin{Bmatrix} 1 & j = 1 \\ \frac{k_{j-1}}{k_j} & j > 1 \end{Bmatrix}. \tag{3}$$

***Step* 5.** The determination of the relative criteria weights by using the following equation:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}, \tag{4}$$

where w_j indicates the relative weights of the criterion j.

3.2. The computational procedure of the WS PLP method

Stanujkic and Zavadskas (2015) performed a modification of the WS method by introducing the *ppr* values that represent the preferable values of the performance ratings given by the *DM*s in the aforementioned procedure. In that way, the *DMs*' attitudes connected with the preferable values of the considered criteria which the ranking and final selection are based on are expressed more directly than in the other MCDM methods. The set of the available alternatives by applying the WS PLP method becomes a set of more acceptable alternatives, and the selection is performed among the alternatives from the second set. When the overall performance ratings of the evaluated alternatives are equal to zero, the performance ratings of these alternatives match completely with the preferable *ppr* values. In the case when overall performance ratings are greater than zero, the performance ratings of the considered alternatives exceed the *ppr* values. So, the *DM*s have a possibility of making a choice between the alternative that has a better matching with the preferred performance ratings or the other that has the best performances of all. In order to avoid the situation when an alternative has a good ranking because of a single criterion, or when a small number of criteria have a greater distance in relation to the *ppr* values, a compensation coefficient is introduced. The mentioned coefficient fine-tunes the ranking order of such alternatives by reducing their overall performance ratings.

The WS PLP method is suitable to apply in the field of the selection of the location for the construction of the hotel because the *DM*s involved in the decision-making process mainly know what characteristics the desired location should have and what expectations should be met. Although the *DMs*' expectations are incorporated in all of the MCDM methods to a greater or lesser extent, in the WS PLP method they are concretely numerically expressed through the aforementioned *ppr* values. The *DM*s outline the desired value of every criterion through *ppr* values and estimate the available alternative location against them. The procedure of the proposed method enables the *DM* to discard the alternative that is not in line with his/her requirements in the beginning. In a situation when not a single alternative location meets the preset conditions, the ranking could be immediately performed, but the *DM* would be aware of the fact that his/her requirements are not satisfied in such a case. In that way, *DMs* perform the pre-selection of the available alternative locations, generate a set of more satisfactory locations and finally make a choice from the second set. Besides, the results gained by applying the WS PLP method clearly indicate and distinct the alternative location that has a better matching with the set requirements and that which is the best of all the available ones. So, *DMs* have a possibility to decide whether they will rather select the location that better fits in with their specifications or that which is the best-ranked of all the alternatives. Moreover, the *DM* could detect if an alternative location has a good ranking position because of the good parameters of one criterion or only a few criteria which minimize the possibility of selecting such a location that does not meet the largest number of the preconditions.

The steps that enable the application of the WS PLP method are as follows:

***Step* 1.** Form a decision matrix that consists of a set of the representative criteria that describe the set of alternatives and ascertain the criteria weights.

***Step* 2.** Define the *ppr* values for each criterion. The virtual alternative $A_0 = \{x_{01}, x_{02}, \ldots, x_{0n}\}$ is introduced in this step, inclusive of the *ppr* values, according to the *DM*. In the case when the *DM* does not determine the *ppr* value of any criterion, the same is defined by using the following Eq.:

$$x_{0j} = \begin{cases} \max_i x_{ij} & |j \in \Omega_{\max} \\ \min_i x_{ij} & |j \in \Omega_{\min} \end{cases}, \tag{5}$$

where x_{ij} denotes the performance rating of the alternative i regarding the criterion j, x_{0j} denotes the optimal preference rating of the criterion j; $\Omega_{\max}$ and $\Omega_{\min}$ are the set of the maximization and minimization criteria, respectively.

***Step* 3.** Create a normalized decision matrix. A normalized decision matrix is created by using the normalization procedure proposed by Stanujkic et al. (2013) and it is determined as follows:

$$r_{ij} = \frac{x_{ij} - x_j^*}{x_j^+ - x_j^-}; \quad j \in \Omega_{\max}, \tag{6}$$

and

$$r_{ij} = \frac{x_j^* - x_{ij}}{x_j^+ - x_j^-}; \quad j \in \Omega_{\min} \tag{7}$$

where r_{ij} is the normalized performance rating of the alternative i in relation to the criterion j, x_j^* denotes the *ppr* value of the criterion j, and x_j^+ and x_j^- represent the largest and the smallest performance ratings of the criterion j, respectively.

***Step* 4.** Compute the overall performance rating for each alternative. For the purpose of doing this calculation, the following equation is used:

$$S_i = \sum_{j=1}^{n} w_j \cdot r_{ij}, \tag{8}$$

where S_i denotes the overall performance rating of the alternative i, w_j is the weight of the criterion j, and $S \in [0, 1]$.The calculation should be continued through the following steps if there are two or more alternatives whose overall performance ratings are higher than 0 ($S_i > 0$). Otherwise, the ranking is performed in this step in ascending order and the best-ranked alternative is the one whose S_i value is the highest.

***Step* 5.** Determine the compensation coefficient c_i ($c_i > 0$) that should be calculated for all the alternatives in which $S_i > 0$, as follows:

$$c_i = \lambda d_i^{\max} + (1 - \lambda)\,\bar{S}_i^+, \tag{9}$$

where:

$$d_i^{\max} = \max_i d_i = \max_i r_{ij} w_j, \tag{10}$$

$$\bar{S}_i^+ = \frac{S_i^+}{n_i^+}, \tag{11}$$

where $d_i^{\max}$ is the maximum weighted normalized distance of the alternative i regarding the *ppr* values of all the criteria, for $r_{ij} > 0$, $\bar{S}_i^+$ indicates the average performance ratings obtained on the basis of the criteria, for $r_{ij} > 0$, n_i^+ is the number of the criteria of the alternative i, for $r_{ij} > 0$, λ denotes the coefficient that could have a value between 0 and 1, but it is usually set at 0.5.

***Step* 6.** Calculate the adjusted performance rating for all the alternatives in which $S_i > 0$ by using Eq. (12):

$$S'_i = \sum_{j=1}^{n} w_j r_{ij} - \gamma c_i, \tag{12}$$

where S'_i represents the adjusted overall performance rating of the alternative i, and γ represents the coefficient ($\gamma = [0, 1]$).

***Step* 7.** Rank the considered alternatives in ascending order. That with the highest S'_i is the most suitable option for the present conditions.

3.3. The proposed model

The prioritization of the locations for the construction of the tourist hotel relies on group decision making. There are fifteen *DM*s (academic experts and tourism managers) involved in the decision-making process and they have an impact on the final choice in each separate case. The model for prioritizing locations for the construction of the tourist hotel based on the WS PLP method, the adapted SWARA method and group decision making can briefly be presented through the following steps:

***Step* 1.** First, it is necessary to determine a set of evaluating criteria against the available alternatives and to form a decision matrix.

***Step* 2.** Second, the criteria weights should be determined by applying the adapted SWARA method. In this step, the *DM*s express their opinions about the importance of the criteria by assigning numerical values to the variable s_j. The weights of the criteria will be determined separately for each *DM*.

***Step* 3.** Third, the S_i value should be calculated for each alternative and whether to go further into the procedure or not should be determined. If $S_i > 0$, then the WS PLP method could be applied.

***Step* 4.** Fourth, the WS PLP method should be used for prioritizing the locations for the construction of the hotel. The *DMs*' preferences are included in this procedure, so, the results will be more accurate and reliable. Each *DM* engaged in the decision-making process gives his/her own *ppr* values and in that manner, a more reliable final ranking is achieved.

***Step* 5.** Fifth, the final ranking of the alternatives is conducted and a decision compliant with the *DMs*' preferences is made. Rank the alternatives according to each *DM* separately and use the domination method and the WA operators in order to accomplish the overall ranking results. The achievement of the overall ranking results by applying the WA operators are obtained by using the following equation:

$$S''_i = \frac{1}{n}\sum_{j=1}^{n} S'_i, \tag{13}$$

where S''_i denotes the overall performance rating of alternative i according to all fifteen *DM*s. Ranking is performed in ascending order and optimal choice has the highest S''_i value.

4. The application of the proposed model

Serbia has a potential for the expansion of mountain tourism. Some mountain destinations are relatively well known, whereas others are still uncovered natural wealth. In order for us to demonstrate the applicability of the proposed model, we have selected six locations at which a four-star hotel should be constructed, and they are: Kopaonik, Golija (Barren Mountain), Besna Kobila (Angry Mare), Tara, Stara planina (Old Mountain) and Kučajske planine (The Mountains of Kučaj). Among the above-mentioned mountains, the most famous and popular is Kopaonik mountain, which is known as an exclusive ski resort in Serbia. The other destinations are more or less unknown to the domestic, as well as foreign, tourists. The beauty of these destinations, however, reflects through their untouched nature and beautiful sights, and the cultural heritage located in these areas.

The determination of the list of the criteria against which the assessment and selection of the most suitable alternative location, i.e. a mountain, would be performed is very significant for the further procedure. The main dimensions influencing investors' decisions on the hotel location, stressed in the paper by Aksoy and Ozbuk (2017), are as follows: costs, the hotel characteristics, and a firm strategy and capacity. According to Juan and Lin (2013), the selection of the resort location should be based on the following criteria: capacity aspects, demand circumstances, a firm strategy, the structure and competition, associated and promoting industries, government and an opportunity.

Table 2
The evaluation criteria.
Source: Chou et al. (2008).

	Criteria	The explanation for the criteria
C_1	The infrastructure	The communal and traffic infrastructures adequate for tourism development
C_2	Access	The distance from freeways, airports, the downtown area and scenic spots
C_3	The surrounding environment	Proximity to the main competitors, public facilities and public security
C_4	Investment	An anticipated amount of investments
C_5	Rest resources	The characteristics of natural resources and nearby facilities
C_6	Human resources	Quality and sufficient human resources

Each of these criteria is further elaborated in a certain number of subcriteria. In their paper, Chou et al. (2008) give a good overview of the perspectives and factors influencing the hotel location selection. The main perspectives presented in the mentioned paper are: geographical conditions, the traffic infrastructure, the hotel attributes and operation management. Every one of these aspects includes the two factors (the total of eight) that are further parsed into a certain number of criteria. For the purpose of this paper, the factors proposed by Chou et al. (2008), whose number is slightly modified, are adopted as the evaluation criteria accounted for in Table 2.

Because some criteria are of the linguistic nature, the *DM*s estimated them on the scale from 1 to 10, where 1 stands for the worst mark and 10 for the best, separately for every alternative. Also, when the criteria such as investment (€/m^2) are concerned, the data were taken from the Development Master Plans for the mentioned mountains (Horwath, 2007a,2007b,2007c,2009a,2009b; Scientific-Research Center, 2007).

As already said, the fifteen academic experts and tourism managers from renowned Serbian tourist agencies (marked as *DM* in the text) were involved in the decision-making process and every one of them determined his/her own weights of the criteria. The weights of the criteria were determined by applying Eqs. (1)–(4), but due to the length of the paper, the procedure for determining the weights of the criteria is omitted and only the final results are shown in Table 3.

For the purpose of an illustration in Tables 4–6, the initial decision matrix only for the first three *DM*s is presented, together with the determined weights and the *ppr* values.

For each alternative and *DM*, the overall performance ratings S_i were calculated by using Eq. (8), and whether to continue with the procedure or not was determined. Table 7 shows the obtained results.

The alternatives whose $S_i < 0$ are excluded from the further decision-making process.

The previous results show that the application of the WS PLP method has proved to be acceptable because there are the alternatives whose S_i values are greater than 0. For example, for DM_1 the alternatives that would be included in the further procedure are: A_2, A_3 and A_4. The alternatives A_1, A_5 and A_6 would not be further examined because their S_i values are negative. In a similar way, which alternatives would be included in the further procedure is defined for every *DM*.

The S'_i value was obtained by applying Eqs (9)-(12), respectively, for $\gamma = 0$, $\gamma = 0.5$, $\gamma = 1$ and $\lambda = 0.5$, and the results for each *DM* are presented in Tables 8–10.

In the case when $\gamma = 0$, the coefficient c_i is completely disregarded, and the ranking is performed according to the greatest possible values of S'_i (which coincides with the value S_i because $\gamma = 0$). The alternative A_4 – *Tara* – most frequently ranks the first, and is followed by the alternatives A_1 – *Kopaonik* and A_5 – *Stara planina*.

Table 4
The initial decision matrix – DM_1.

		C_1	C_2	C_3	C_4	C_5	C_6
	Optimization	max	max	max	min	max	max
	w_j	0.19	0.19	0.13	0.19	0.12	0.18
	ppr	*3*	*5*	*4*	*950*	*5*	*4*
A_1	Kopaonik	6	5	2	920	3	2
A_2	Golija	5	3	5	920	9	5
A_3	Besna Kobila	3	3	3	910	9	5
A_4	Tara	4	5	6	925	5	6
A_5	Stara planina	3	3	7	1730	9	6
A_6	Kučajske planine	1	1	4	875	7	4

Table 5
The initial decision matrix – DM_2.

		C_1	C_2	C_3	C_4	C_5	C_6
	Optimization	max	max	max	min	max	max
	w_j	0.11	0.11	0.13	0.27	0.22	0.17
	ppr	*4*	*5*	*6*	*1000*	*6*	*5*
A_1	Kopaonik	5	5	5	920	3	4
A_2	Golija	2	4	4	920	8	4
A_3	Besna Kobila	2	5	4	910	8	7
A_4	Tara	3	5	7	925	5	6
A_5	Stara planina	4	5	9	1730	9	6
A_6	Kučajske planine	4	5	6	875	7	5

Table 6
The initial decision matrix – DM_3.

		C_1	C_2	C_3	C_4	C_5	C_6
	Optimization	max	max	max	min	max	max
	w_j	0.12	0.20	0.13	0.21	0.16	0.18
	ppr	*2*	*3*	*3*	*1100*	*4*	*3*
A_1	Kopaonik	3	4	4	920	3	2
A_2	Golija	2	3	4	920	5	3
A_3	Besna Kobila	1	2	4	910	5	2
A_4	Tara	3	3	3	925	5	5
A_5	Stara planina	2	2	3	1730	5	5
A_6	Kučajske planine	2	3	3	875	2	4

Table 3
The relative weights of the criteria for all *DM*s.

	DM_1	DM_2	DM_3	DM_4	DM_5	DM_6	DM_7	DM_8	DM_9	DM_{10}	DM_{11}	DM_{12}	DM_{13}	DM_{14}	DM_{15}
C_1	0.19	0.11	0.12	0.13	0.18	0.14	0.11	0.11	0.15	0.20	0.12	0.20	0.13	0.13	0.12
C_2	0.19	0.11	0.20	0.15	0.15	0.12	0.14	0.11	0.15	0.18	0.10	0.15	0.12	0.14	0.11
C_3	0.13	0.13	0.13	0.15	0.18	0.12	0.14	0.10	0.12	0.18	0.13	0.14	0.17	0.20	0.11
C_4	0.19	0.27	0.21	0.24	0.18	0.23	0.12	0.15	0.21	0.18	0.18	0.17	0.19	0.19	0.22
C_5	0.12	0.22	0.16	0.19	0.18	0.20	0.21	0.29	0.21	0.14	0.26	0.17	0.19	0.19	0.22
C_6	0.18	0.17	0.18	0.14	0.13	0.20	0.29	0.24	0.17	0.12	0.21	0.16	0.19	0.15	0.22

Table 7
The overall performance ratings S_i for all *DMs*.

	DM_1	DM_2	DM_3	DM_4	DM_5	DM_6	DM_7	DM_8	DM_9	DM_{10}	DM_{11}	DM_{12}	DM_{13}	DM_{14}	DM_{15}
A_1	−0.06	−0.13	0.22	0.22	0.29	−0.08	0.14	0.17	0.66	0.26	0.57	0.44	0.15	0.48	0.50
A_2	0.14	−0.19	0.22	−0.05	−0.17	0.00	−0.26	0.01	−0.17	−0.04	0.33	0.24	0.02	0.21	0.24
A_3	0.01	0.09	0.01	−0.22	−0.21	−0.17	−0.26	−0.02	−0.05	−0.16	0.33	0.04	−0.10	0.21	0.07
A_4	0.18	0.03	0.28	0.23	0.33	0.26	0.36	0.36	0.31	0.35	0.82	0.63	0.52	0.60	0.67
A_5	−0.02	0.02	−0.08	−0.25	0.12	0.21	0.15	0.19	0.04	0.18	0.72	0.39	0.12	0.40	0.40
A_6	−0.21	0.08	0.01	0.11	−0.25	0.13	0.10	0.11	0.07	0.19	0.44	0.42	0.34	0.17	0.52

Table 8
The overall performance ratings S'_i for all *DMs* when $\gamma = 0$.

		A_1	A_2	A_3	A_4	A_5	A_6
DM_1	S'_i	–	0.1389	0.0119	0.1838	–	–
	Rank	–	2	3	1	–	–
DM_2	S'_i	–	–	0.0914	0.0341	0.0201	0.0756
	Rank	–	–	1	3	4	2
DM_3	S'_i	0.2177	0.2242	0.0052	0.2775	–	0.0073
	Rank	3	2	5	1	–	4
DM_4	S'_i	0.2193	–	–	0.2312	–	0.1072
	Rank	2	–	–	1	–	3
DM_5	S'_i	0.2862	–	–	0.3326	0.1190	–
	Rank	2	–	–	1	3	–
DM_6	S'_i	–	0.0011	–	0.2627	0.2140	0.130
	Rank	–	4		1	2	3
DM_7	S'_i	0.1414	–	–	0.3622	0.1458	0.1035
	Rank	3	–	–	1	2	4
DM_8	S'_i	0.1675	0.0147	–	0.3619	0.1864	0.1119
	Rank	3	5	–	1	2	4
DM_9	S'_i	0.6560	–	–	0.3059	0.0389	0.0710
	Rank	1	–	–	2	4	3
DM_{10}	S'_i	0.2592	–	–	0.3512	0.1820	0.1917
	Rank	2	–	–	1	4	3
DM_{11}	S'_i	0.5688	0.3267	0.3288	0.8238	0.7185	0.4358
	Rank	3	6	5	1	2	4
DM_{12}	S'_i	0.4430	0.2357	0.0377	0.6329	0.3930	0.4244
	Rank	2	5	6	1	4	3
DM_{13}	S'_i	0.1544	0.0217	–	0.5170	0.1202	0.3440
	Rank	3	5	–	1	4	2
DM_{14}	S'_i	0.4794	0.2086	0.2108	0.6019	0.3968	0.1696
	Rank	2	5	4	1	3	6
DM_{15}	S'_i	0.4996	0.2359	0.0736	0.6742	0.4013	0.5167
	Rank	3	5	6	1	4	2

Table 9
The overall performance ratings S'_i for all *DMs* when $\gamma = 0.5$.

		A_1	A_2	A_3	A_4	A_5	A_6
DM_1	S'_i	–	0.1066	−0.0199	0.1503	–	–
	Rank	–	2	3	1	–	–
DM_2	S'_i	–	–	0.0452	0.0111	−0.0280	0.0564
	Rank	–	–	2	3	4	1
DM_3	S'_i	0.1655	0.1740	−0.0452	0.2301	–	−0.0221
	Rank	3	2	5	1	–	4
DM_4	S'_i	0.1837	–	–	0.1925	–	0.0324
	Rank	2	–	–	1	–	3
DM_5	S'_i	0.2477	–	–	0.2970	0.0636	–
	Rank	2	–	–	1	3	–
DM_6	S'_i	–	−0.1481	–	0.1920	0.0587	−0.0005
	Rank	–	4	–	1	2	3
DM_7	S'_i	0.0323	–	–	0.2578	0.0708	0.0613
	Rank	4	–	–	1	2	3
DM_8	S'_i	0.1246	−0.0609	–	0.3030	0.0923	0.0178
	Rank	2	5	–	1	3	4
DM_9	S'_i	0.5770	–	–	0.2209	−0.0498	0.0142
	Rank	1	–	–	2	4	3
DM_{10}	S'_i	0.2086	–	–	0.2849	0.1101	0.1165
	Rank	2	–	–	1	4	3
DM_{11}	S'_i	0.4899	0.2352	0.2372	0.7390	0.6104	0.3514
	Rank	3	6	5	1	2	4
DM_{12}	S'_i	0.3779	0.1649	−0.0257	0.5548	0.3003	0.3501
	Rank	2	5	6	1	4	3
DM_{13}	S'_i	0.1168	−0.0274	–	0.4524	0.0647	0.2767
	Rank	3	5	–	1	4	2
DM_{14}	S'_i	0.4273	0.1143	0.1162	0.5305	0.3155	0.1382
	Rank	2	6	5	1	3	4
DM_{15}	S'_i	0.4135	0.1518	0.0217	0.5855	0.2960	0.4257
	Rank	3	5	6	1	4	2

When $\gamma = 0.5$ and the coefficient c_i is partly included, the ranking order does not change significantly, and the alternative A_4 – *Tara* confirms its first position. The ranking positions of the rest of the alternatives are more or less changed.

In this case, the coefficient c_i is fully appreciated and the S'_i performance ratings for the alternatives that have a greater distance from the *ppr* values are reduced, which fine-tunes the ranking order. Now, the alternative A_6 directly follows the first–ranked alternative A_4, while the alternatives A_1 and A_5 come after them.

According to all of the fifteen *DMs*, the overall ranking results obtained by applying Eq. (13) are shown in Table 11.

The overall results show the final ranking order of the considered alternatives, i.e. the locations for the construction of the tourist hotel. According to them, the best alternative is the alternative A_4 – *Tara*, which has a good matching with the preconditions expressed through the *ppr* values, and occasionally even exceeds them. The application of the domination method also confirms the results connected with the first position obtained by using the WA operators. The alternative A_1 – *Kopaonik* is positioned the second, regardless of the varying of the c_i coefficient. When the priority of the overall rating performances is higher, then the alternative A_5 – *Stara planina* ranks the third. By giving greater significance to the coefficient c_i and to the alternatives that have a better matching with the required performances, the alternative A_5 – *Stara planina* has the same rank in the case when $\gamma = 0.5$, but falls to the fourth position when $\gamma = 1$. The alternative A_6 – *Kučajske planine* takes the fourth place when $\gamma = 0$ and $\gamma = 0.5$, and the third when $\gamma = 1$. The alternative A_3 – *Besna Kobila* ranks as the worst choice, which points out the fact that this alternative does not have a good matching with the given *ppr* values, nor does it exceed them.

The main advantage of the proposed method reflects through the c_i coefficient, which enables the *DM* to make a difference between the alternative that has a good matching with the preset *ppr* values and that which exceeds the given parameters. In that way, the risk of the selection of the alternative that has a good ranking because one criterion or only a few criteria has/have a high performance rating while the rest could be unsatisfactory for the *DM* is avoided. So, the *DM* quite consciously chooses whether he/she wants to give the advantage to the alternative with high overall performance ratings or to the one that better matches with his/her requirements. The possibility of a wrong choice is minimized because the difference between these two possibilities is obvious and the *DM* knowingly takes the risk if he/she selects the alternative that has one performance rating or a few performance ratings which are extremely good, while the other ones are quite bad. Additionally, by pre-selecting the criteria, the *DM* initially eliminates the locations that do not meet the conditions expressed through the *ppr* values.

Table 10
The overall performance ratings S'_i for all DMs when $\gamma = 1$.

		A_1	A_2	A_3	A_4	A_5	A_6
DM_1	S'_i	–	0.0743	−0.0516	0.1168	–	–
	Rank	–	2	3	1	–	–
DM_2	S'_i	–	–	−0.0011	−0.0119	−0.0762	0.0373
	Rank	–	–	2	3	4	1
DM_3	S'_i	0.1132	0.1238	−0.0956	0.1828	–	−0.0516
	Rank	3	2	5	1	–	4
DM_4	S'_i	0.1480	–	–	0.1539	–	−0.0424
	Rank	2	–	–	1	–	3
DM_5	S'_i	0.2092	–	–	0.2614	0.0082	–
	Rank	2	–	–	1	3	–
DM_6	S'_i	–	−0.2974	–	0.1213	−0.0966	−0.1316
	Rank	–	4	–	1	2	3
DM_7	S'_i	−0.0768	–	–	0.1535	−0.0042	0.0191
	Rank	4	–	–	1	3	2
DM_8	S'_i	0.0818	−0.1365	–	0.2442	−0.0018	−0.0478
	Rank	2	5	–	1	3	4
DM_9	S'_i	0.4980	–	–	0.1358	−0.1385	−0.0425
	Rank	1	–	–	2	4	3
DM_{10}	S'_i	0.1580	–	–	0.2187	0.0382	0.0414
	Rank	2	–	–	1	4	3
DM_{11}	S'_i	0.4110	0.1438	0.1456	0.6543	0.5022	0.2670
	Rank	3	6	5	1	2	4
DM_{12}	S'_i	0.3127	0.0941	−0.0890	0.4766	0.2076	0.2758
	Rank	2	5	6	1	4	3
DM_{13}	S'_i	0.0792	−0.0765	–	0.3878	0.0091	0.2093
	Rank	3	5	–	1	4	2
DM_{14}	S'_i	0.3753	0.0200	0.0217	0.4591	0.2342	0.1068
	Rank	2	6	5	1	3	4
DM_{15}	S'_i	0.3273	0.0677	−0.0303	0.4969	0.1907	0.3347
	Rank	3	5	6	1	4	2

Table 11
The overall ranking results obtained on the basis of the different values of γ.

	γ = 0		γ = 0.5		γ = 1	
	S''_i	Rank	S''_i	Rank	S''_i	Rank
A_1	0.2728	2	0.2243	2	0.1758	2
A_2	0.0938	5	0.0474	5	0.0009	5
A_3	0.0506	6	0.0220	6	−0.0067	6
A_4	0.3969	1	0.3335	1	0.2701	1
A_5	0.1957	3	0.1270	3	0.0582	4
A_6	0.1793	4	0.1212	4	0.0656	3

Table 12
The overall ranking results based on the recalculated initial decision matrix.

	γ = 0		γ = 0.5		γ = 1	
	S'_i	Rank	S'_i	Rank	S'_i	Rank
A_1	0.2855	2	0.2485	2	0.2115	2
A_2	0.0474	5	−0.0032	5	−0.0539	5
A_3	–	–	–	–	–	–
A_4	0.4794	1	0.4276	1	0.3757	1
A_5	0.2448	3	0.1843	3	0.1237	3
A_6	0.1308	4	0.0975	4	0.0642	4

5. The sensitivity analysis

The stability of the proposed model is verified by using the sensitivity analysis which is conducted through three phases. In the first phase, the geometric mean of the criteria weights, the *ppr* values and the alternative location input data given by all the fifteen *DMs* are calculated by applying the following equation:

$$GM_j = \left(\prod_{k=1}^{K} w_j^k\right)^{1/K}, \tag{14}$$

where GM_j represents the geometric mean and K is the number of the *DMs*.

After the calculation of the geometric mean of the weights, their total sum is not equal to 1, so their recalculation is performed by using the following equation:

$$w_j = \frac{GM_j}{\sum_{l=1}^{n} GM_l}. \tag{15}$$

In the previously explained way, the new initial decision matrix that entails the geometric mean of all the input data is obtained and the WS PLP method is applied then. The gained results are presented in Table 12.

By comparing these newly-obtained results with those previously obtained (Table 11), a conclusion could be drawn that the alternative A_4 – *Tara* keeps its first place. In the case when the computational procedure is based on the geometric mean of all of the input data, the alternative A_3 – *Besna Kobila* is disregarded during the operation and is not involved in the set of the "appropriate" alternatives that meet the requirements of the set. This result confirms the previous estimation of the alternative A_3, ranked the sixth and being the least suitable location for the construction of the tourist hotel.

In the second phase of the sensitivity analysis, the criteria weights are varied with the goal of determining how their variation will affect the ranking order of the alternatives (Fig. 1).

In the first three sets, the weight of the criterion C_1 – *The infrastructure* is increased by 50%, whereas the weights of the criteria C_4 – *Investment*, C_5 – *Rest resources* and C_6 – *Human resources* that previously had the greatest significances are decreased by 40%, respectively. In the second three sets, the weight of the criterion C_2 – *Access* is raised by 50%, and the significance of the criteria C_4, C_5 and C_6 are again reduced by 40%, respectively. Then, the significance of the criterion C_3 – *Surrounding environment* is increased by 50%, whereas the importance of the criteria C_4, C_5 and C_6 is again decreased by 40%m respectively, in

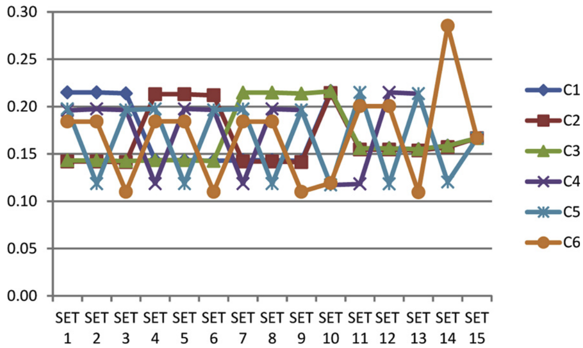

Fig. 1. The varying of the criteria weights.

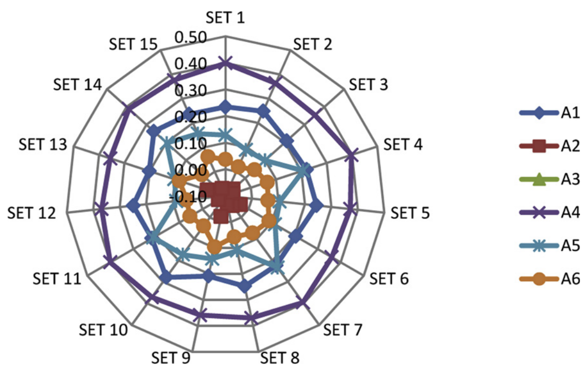

Fig. 2. The results of the sensitivity analysis.

the sets 7, 8 and 9. In Set 10, the significance of the criteria C_1, C_2 and C_3 is raised by the 40%, the weights of the criteria C_4 and C_5 are reduced by 45%, and the weight of the criterion C_6 by 40%. In the sets 11, 12, 13 and 14, we declined the significance of the criteria C_4, C_5 and C_6 without changing the weights of the rest of the criteria. In the 15th set, all the criteria have the same importance. The goal of this kind of weights varying is to determine whether the ranking order of the alternatives will change if the most significant criteria become the least significant. The obtained results of the conducted analysis are presented in Fig. 2.

The changing of the criteria weights does not significantly affect the total scores of the considered alternatives. The performance ratings of the alternative A_3 – *Besna Kobila* are not satisfactory in all the fifteen sets, and this alternative location is not included in the selection process. For that reason, the alternative A_3 is only mentioned in Fig. 2, but its scores are not obvious because it was eliminated in the previous steps. The rest of the alternatives also provided the mostly stable results. The alternative whose scores are the most sensitive to criteria weights change is the alternative A_5 – *Stara planina*, but this has no serious impact on its final ranking. In Fig. 3, the final ranking order of

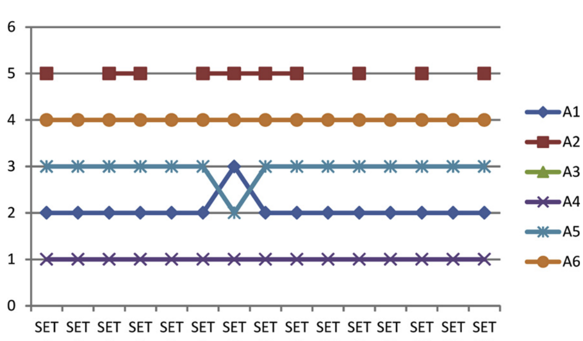

Fig. 3. The ranking of the locations in the sensitivity analysis.

Table 13
The sensitivity analysis based on the comparison with the results of the WS PLP, TOPSIS and VIKOR methods.

	WS PLP	Rank	TOPSIS	Rank	VIKOR	Rank
A_1	0.2115	2	0.1874	2	0.6833	3
A_2	−0.0539	5	0.1717	4	0.8731	5
A_3	–	–	0.1725	3	0.9512	6
A_4	0.3757	1	0.1941	1	0.0000	1
A_5	0.1237	3	0.1401	6	0.7226	4
A_6	0.0642	4	0.1713	5	0.6530	2

the alternatives in all of the fifteen sets is presented.

As Fig. 3 shows, the ranking order of the alternatives is mostly the same in all of the considered cases. Only in Set 7, the alternatives A_5 and A_1 mutually changed places, but it is a unique instance. Again, we emphasize the fact that the alternative A_3 was included as one of the alternatives for the appraisal, but was eliminated in the pre-selection of the alternatives because it did not meet the set requirements. In order to point out its presence, that alternative is presented in Fig. 3. Based on the results obtained in the second phase of the sensitivity analysis, it could be concluded that the proposed model is stable and resistant to criteria weights change.

The third and final phase of this analysis consists of the comparison of the results obtained by applying the WS PLP method together with the results of the well-known and proven MCDM methods, such as TOPSIS and VIKOR. The obtained results are presented in Table 13.

The results of the applied methods shown in Table 13 indicate that the alternative A_4 – *Tara* ranks the first in all of the three cases. The results connected with the rest of the reconsidered alternatives are mainly equalized, which confirms the previous conclusion that the proposed model is reliable and adequate to apply in the cases of the selection of the location for the construction of the hotel, because it does not depend on the changing conditions of the decision-making environment.

6. Conclusion

The selection of the appropriate location for the construction of a new tourist hotel is one of the crucial tasks for the *DM* because a successful investment depends greatly on the decision on the hotel location. As Yang et al. (2014) stated in their paper, an ideal location contributes to larger accommodation demand, higher revenue per available room, higher customer satisfaction, better performance and a lower failure rate. Different and very often conflicting factors have an influence on the decision on finding the ideal location. The stated implies that the MCDM methods are completely suitable to apply in the field of the selection of the hotel location, which is confirmed in the paper by Chou et al. (2008), Kundakçı et al. (2015) and Aksoy and Ozbuk (2017).

In this paper, the use of the adapted SWARA method for the determination of the criteria weights and the WS PLP method for the evaluation and selection of the ideal alternative location, i.e. the mountain, is proposed. The adapted SWARA method is proposed for defining the weights of the criteria because it is applicable, easy to use and has a procedure that is simpler than that of the original SWARA method. There are two reasons for proposing the WS PLP method for the selection of the hotel location, and they are: (1) the ability to directly express the *DM*'s desired performance ratings of the criteria by introducing *ppr* values; (2) a possibility of a selection between the alternatives that have the highest overall performance ratings and the alternatives that better fit into the *DM*'s requirements. The applicability of the proposed model is tested by using a real case study dedicated to the selection of the optimal Serbian mountain for the construction of a tourist hotel. Additionally, the conducted sensitivity analysis has confirmed that the proposed model is stable and resistant to changes in criteria weights and also that the results are reliable and accurate in comparison with the other proven MCDM methods, such as TOPSIS and VIKOR.

There are different sets of the criteria proposed for the evaluation of the alternative hotel location, which could reflect the investor's or tourist perspective (Newell and Seabrook, 2006; Kundakçı et al., 2015; Aksoy and Ozbuk, 2017). In this paper, we have observed the already mentioned decision-making problem from the investor's point of view. The evaluation process is based on the criteria retrieved from the paper by Chou et al. (2008), yet slightly modified. In the mentioned paper, the main perspectives, factors and a greater number of the criteria important for the evaluation and selection of the location for the construction of a tourist hotel are presented. In order to demonstrate the applicability of the proposed model without a complex numerical procedure, a set of the six criteria against which the evaluation of the six alternative mountains has been performed has been used.

Due to the fact that a location selection is extremely important because it directly affects the future operations of a hotel, its attractiveness and income, it requires a careful planning and analysis. In that sense, the *DM* could apply the proposed model to the available data in order to define the alternative that is the most suitable for the present conditions and, in that way, reduce the risk of making unsatisfactory choices. From the scientific point of view, the key novelty of the proposed model reflects in the application of the adapted SWARA method, which simplifies the process of defining the criteria weights, and the WS PLP method, which is a relatively new MCDM method still not widely applied in the field of the location selection, or in the selection of the location for the construction of a hotel.

One of the limitations of this paper is a small number of the criteria which the selection process is based on. A greater number of criteria would improve the reliability of the decisions made. The starting point in defining the list of the criteria could be the aforementioned papers by Chou et al. (2008), Newell and Seabrook (2008), Kundakçı et al. (2015), Aksoy and Ozbuk (2017), etc. Also, a very important limitation is reflected through the use of crisp numbers in the proposed model. It is very difficult to express real-world problems as crisp numbers because it is impossible to have them separated from uncertainty and vagueness. Turskis et al. (2015), Çebi and Otay (2015) and Dey et al. (2016) are some of the authors whose incorporated the fuzzy logic into the decision-making process connected to the location selection for different purposes. The proposed model based on the adapted SWARA and WS PLP methods could be further elaborated by introducing grey system theory (Deng, 1982), intuitionistic fuzzy sets (Atanassov, 1986) or neutrosophic sets (Smarandache, 2005), which would appreciate and incorporate the uncertainty associated with the volatile business environment.

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