MULTI-CRITERIA APPROVAL FOR EVALUATING LANDSCAPE MANAGEMENT STRATEGIES (CASE STUDY: FRUŠKA GORA NATIONAL PARK)

ABSTRACT: This paper deals with the problem of multi-criteria evaluation of four management strategies for Fruška Gora National Park. The criteria set was defined in accordance with the IUCN guidelines for management of national parks. Four strategies were evaluated by testing preference intensities for each alternative with respect to each criterion. Alternatives with preference above the approval threshold were approved, and a multi-criteria approval matrix was generated. According to the matrix, the most suitable management strategy was identified. It implies an intense protection of natural resources and landscape diversity in the national park by applying bio-engineering measures. This illustrative example proved that multi-criteria approval can be considered as a good decision support tool when there is no need for a deeper insight into cardinal values of criteria weights and alternatives, or if the decision maker has to select few from many of alternatives to reduce the decision problem. For a more precise analysis, it is recommended to combine multi-criteria approval with other decision support tools, and future studies might deal with this problem in order to define an alternative framework for decision making in landscape management.

KEYWORDS: decision making, management strategy, multi-criteria approval, Fruška Gora National Park

INTRODUCTION

National parks are highly valuable from many aspects, especially because they contribute to sustainable regional development, biodiversity preservation, natural disaster prevention, regional welfare effects, environmental education and training, etc. [Mose and Weixlbaumer 2007]. Therefore, the management of national parks should be focused on different objectives such as: support of
environmental processes, protection of natural biodiversity and its underlying ecological structures, promotion of tourism, education and recreation, etc. [IUCN, 2008]. Management strategies are supposed to maintain or upgrade the main functions of national parks [Palomo et al., 2013]:

– provisioning (water, food, raw material provision, renewable energy, etc.),
– regulating (habitat for species, climate and water regulation, air purification, erosion control, etc.) and
– cultural (scientific knowledge, natural and rural tourism, spiritual and aesthetic values, etc.).

Evaluation of different strategies for national parks management can be done by applying multi-criteria methods and tools [e.g. the Analytic hierarchy process – AHP, Saaty, 1980; PROMETHEE, Brans et al., 1986; ELECTRE, Roy, 1968; Compromise Programming – CP Zeleny, 1973, etc.] and/or voting techniques belonging to the social choice theory [Kangas et al., 2006].

This research demonstrates the application of multi-criteria approval for evaluating several landscape management strategies for Fruška Gora National Park, Serbia. Even though only one expert performed decision making, similar procedure is applicable in a group decision making context [Laukkanen et al., 2005]. Contemporary studies state that inclusion of different stakeholder groups in managing national parks has not become mandatory, but it is highly recommended. It is worthy to mention that in the previous research, reported in [Lakićević 2013], the same management strategies were assessed and evaluated in a group context by authorized representatives of different stakeholder groups. The results obtained in this research are compared with earlier ones and the differences are discussed.

Nowadays, it is also quite common to combine different methods and techniques in making environmental decisions [Kangas and Kangas 2003; Lakićević et al., 2014]. Apart from the already known methods described in [Laukkanen et al., 2005], future research agenda could include linking multi-criteria approval with other decision support tools in order to provide an alternative and upgraded framework for decision-making in landscape planning tasks.

**MATERIAL AND METHOD**

Fruška Gora is proclaimed a national park in 1960 and is well known for its remarkable cultural and natural values. The total actively protected area occupies 25,393 ha and recent studies identified several problems in the area, such as spread of invasive species along with the suppression of oak trees [Bobinac 2003; Vasić et al., 2012], intensification of erosion processes [Dragićević et al., 2013], etc. Experts suggest that properly defined landscape management strategies could preserve existing park’s qualities and ensure the major problems in the park to diminish in the near future [Vlada AP Vojvodine, 2011].

In this paper we consider four management strategies (alternatives) for the national park, aiming at determination of the most suitable one. The strategies were defined in [Lakićević 2013], taking into account the preferences of different
stakeholder groups. In short (for details consult Lakićević 2013), management strategies are as follows:

(a₁) Maintain the current policy without significant alternations;
(a₂) Develop eco-tourism and network of tourist and recreation facilities in well-preserved natural areas;
(a₃) Provide an intense protection of natural resources and landscape diversity by applying bio-engineering measures;
(a₄) Develop sustainable organic agriculture in order to provide stable incomes to the local residents.

For the purpose of evaluation of these management strategies, the criteria set is defined in accordance with the recommendations stated by the International Union for Conservation of Nature – IUCN [1994, 2008]. The original set [IUCN, 1994] is altered to a small extent and eight criteria are merged into six and then listed by decreasing importance:

(C₁) Maintenance of environmental services (the most important);
(C₂) Preservation of biodiversity;
(C₃) Tourism, recreation and education;
(C₄) Protection of specific natural/cultural features;
(C₅) Wilderness protection;
(C₆) Sustainable use of resources from natural ecosystems (the least important).

Multi-criteria approval

Multi-criteria approval [Fraser and Hauge 1998] begins by determining the set of alternatives under consideration: \( A = \{a₁, a₂, ..., a_i, ..., a_m\} \). The next step is to identify the set of criteria: \( C = \{c₁, c₂, ..., c_j, ..., c_n\} \) for comparing the set of alternatives. A decision maker ranks the criteria by the importance, from the most important to the least important, and then evaluates which of the alternatives are above and which are below the average for each criterion being considered. In cases when the utility for a criterion can be treated as linear transformation of the criterion measures a precise average for the criterion can be calculated as:

\[
\bar{c}_j = \frac{\sum_{i=1}^{m} c_j(a_i)}{m}
\]

and \( a_i \in \begin{cases} P_j \text{ if } c_j(a_i) > \bar{c}_j \\ P'_j \text{ if } c_j(a_i) \leq \bar{c}_j \end{cases} \).

If \( a_i \in P_j \) alternative \( i \) is approved for criterion \( j \) and if \( a_i \in P'_j \) alternative \( i \) is not approved for this criterion. In addition, the process of pronouncing the alternatives as approved or disapproved for a certain criterion can also be a result of classifying the alternatives into different categories, such as excellent,
average, undesirable, etc. [Laukkanen et al., 2002]. Based on this classification it is possible to define the average value (in this case – category) for each criterion, and therefore to determine their approval/disapproval threshold, as input data for deriving final decision.

In order to get the final results, it is necessary to form a matrix, where columns are criteria ordered by importance, and rows present alternatives. Matrix cells are filled in accordance with the approval/disapproval of an alternative for a certain criterion (‘+’ denotes approval and ‘–’ disapproval). In the end, the data provided in matrix are supposed to be analyzed, and one of the outcomes shown in Figure 1 may happen.

Figure 1. Multi-criteria approval classifications [Fraser and Hauge 1998].

A brief explanation of possible outcomes is provided in the following text. 

Unanimous – only one alternative is approved upon all criteria, and it is declared a winner.

Majority – only one alternative is approved for the majority of the most important criteria and it is the winner.

Ordinarily dominant – one alternative is superior to remaining alternatives based on ordinal ranking of criteria and information regarding criteria approval.

Deadlocked – at least two alternatives are approved and disapproved on exactly the same criteria. In this case there is no single winner.

Indeterminate – one alternative cannot be labeled as superior to the others based on ordinal criteria importance and it is not possible to declare the winner. More information is necessary in order to get the final decision.

RESULTS AND DISCUSSION

The multi-criteria approval evaluation of four management strategies with respect to six relevant criteria was done by one decision maker, a landscape architect. For the analysis that follows, ranking of criteria was not relevant and thus it was not performed.
Evaluation of alternatives was supported by testing preference intensities for each alternative with the respect to each criterion. The preference intensities are marked as follows: undesirable (ud), not good (ng), below average (ba), average (av), good (gd), very good (vg) and excellent (ex), as suggested by [Laukkanen et al., 2002]. The evaluation results are presented in Fig. 2.

![Figure 2. Evaluation of alternatives with respect to criteria set](image)

Based on the results of evaluation provided in Figure 2 it was possible to generate the multi-criteria approval matrix (Figure 3) and analyze the final decision.

![Figure 3. Multi-criteria approval matrix](image)

Fig. 3 shows that alternative $a_3$ can be labeled as the ordinally dominant winner. This management strategy predicts conduction of bio-engineering measures aiming to ensure high protection of natural resources and values in the national park.
It is worthy to mention that the final decision in the previous research [Lakićević 2013] differs, as it recognizes alternative $a_4$ as the most suitable management strategy. In the precedent study the decision was made in a group context by applying AHP, the technique of cumulative voting and consensus convergence model (CCM). The decision makers in that research were representatives of six stakeholder groups: local authorities, academic experts, members of non-governmental organizations (NGOs), tourists, local residents and business persons (i.e. people who financially benefit from Fruška Gora National Park). Their group decision derived by applying above listed methods declared as a winner the management strategy which advocates development of sustainable organic agriculture.

In short, different results are identified in cases of individual and group decision making when evaluating same management strategies for Fruška Gora National Park. The reason for that can be regarded as a consequence of applying different decision support methods. In addition, strategy $a_4$ aims to provide stable incomes for the local residents and this can be the other important reason why this strategy is preferred over nature protection strategy ($a_3$), when representatives of different stakeholder groups were included in the decision making process.

However, multi-criteria approval can be a good starting point in decision making process, as it can be used for providing a quick acquaintance with the problem as well as for discarding the irrelevant alternatives. Multi-criteria approval requires defining the rank of the criteria and testing the alternatives’ performance for each criterion. This can be a good base for performing AHP evaluations in pair-wise manner or the number of alternatives which are supposed to be considered as a final solution can be reduced (those would be the alternatives disapproved for the majority of the most important criteria). Reducing the number of alternatives makes the application of AHP easier and ensures better consistency of evaluation [Bozóki et al., 2013].

CONCLUSION

There are different techniques and approaches supporting the process of individual and group decision making in landscape management studies [Srđević et al., 2013]. Multi-criteria approval and its upgraded versions are recognized as good support tools for the decision making processes when one or more decision makers have to just mutually compare the criteria and the alternatives regardless of the deeper insight into the real cardinal values of the decision matrix such as, for example, criteria weights and/or alternative real numerical ratings across criteria. The consequence could be the difference in the final results if the decision making approaches for individual/group contexts are different. The proof that this may happen is described in the present study; namely, the most suitable management plan for Fruška Gora National Park selected by method described here is not the same as the one identified as the
best in [Lakićević 2013]. The difference in results is also partly a consequence of different stakeholders involved in these two researches.

To summarize, for a good quality decision making process it is essential to apply appropriate methodology and to include relevant decision makers. Selection of the methods to be applied depends on the decision makers’ background, responsibility, personal preferences, etc. The decision making process can be trusted to one person, but in that case s/he should act and decide respecting the needs of all stakeholders that will be affected by the final decision. In the group decision making context, combing different methods has a significant potential as it, for instance, encourages participation of different stakeholders [Lakićević et al., 2014] and reduces the disadvantages of the methods when they are applied solely [Kangas and Kangas 2003]. In that regard, future studies might deal with the problem of combining multi-criteria approval with other decision support methods in making environmental decisions. One possible solution could be to start the decision-making process with application of multi-criteria approval and to continue it using AHP. The purpose of the first step would be to analyze the problem at a glance and to possibly reduce the number of alternatives, by discarding the least relevant ones. The next step would imply the application of AHP, in order to obtain more precise and comprehensive results than application of multi-criteria approval could provide itself.

ACKNOWLEDGMENT

The authors acknowledge grants received from the Ministry of Education, Science and Technological Development of the Republic of Serbia under contract no. 174003: Theory and application of analytic hierarchy process (AHP) in multi-criteria decision making under conditions of risk and uncertainty (individual and group context).

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ВИШЕКРИТЕРИЈУМСКО ОДОБРЕЊЕ У ВРЕДНОВАЊУ СТРАТЕГИЈА УПРАВЉАЊА ПРЕДЕЛИМА (СТУДИЈА СЛУЧАЈА: НАЦИОНАЛНИ ПАРК ФРУШКА ГОРА)

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РЕЗИМЕ: Рад се бави вишекритеријумским вредновањем четири стратегије управљања Националним парком „Фрушка гора“. Скуп критеријума за вредновање је дефинисан у складу са IUCN смерницама за управљање националним парковима, а критеријуми су рангирани према значају. Четири стратегије су вредноване помоћу тестирања интензитета преференци за сваку алтернативу у односу на сваки критеријум. Альтернативе са интензитетом преференци изнад одговарајућег прага су оцењене као одобрене за дати критеријум и формирана је матрица вишекритеријумског одобрења. На основу резултата у матрици идентификована је најпогоднија стратегија управљања која подразумева интензивну заштиту природних ресурса и предеоне разноврсности у националном парку. Овај илустративни пример доказује да вишекритеријумско одобрење може да се сматра као добар алат за подршку одлучивању уколико није неопходно детаљно анализирати кардиналне вредности критеријума и тежине алтернатива или када доносилац одлука треба да изабере неколико од већег броја алтернатива у циљу поједностављења проблема одлучивања. За прецизнију анализу препоручено је да се комбинује примена вишекритеријумског одобрења и других алата за подршку одлучивању (нпр. Аналитичког хијерархијског процеса). Наредна истраживања могла би да се баве овим проблемом, у циљу дефинисања новог приступа за доношење одлука у управљању пределима.

КЉУЧНЕ РЕЧИ: одлучивање, стратегија управљања, вишекритеријумско одобрење, Национални парк „Фрушка гора“