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THE USE OF AHP-PROMETHEE METHOD IN ENVIRONMENTAL MANAGEMENT- NATIONAL PARK DJERDAP

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Abstract

An approach of using outranking methods, with a particular emphasis on a sustainable use of natural resources and its protections, is considered in this manuscript. The research is conducted on the basis of National Park Djerdap, located in Serbia, with the particular with particular emphasis on sustainable model of forest exploitation. The integrated usage of AHP and PROMETHEE methods could be identified as contribution of this manuscript, where the AHP method is used for determining the significance of the evaluation criteria and the PROMETHEE method is used for the final ranking of the alternatives. The final research results are presented based on the usage of the PROMETHEE GAIA.

***Keywords*:** *National park, PROMETHEE, Djerdap, Forestry.*

1. INTRODUCTION

Multiple Criteria Decision Making (MCDM) refers to the evaluation of alternatives from a set of available alternatives, i.e. selecting one and/or ranking all alternatives based on a set of, often conflicting, criteria [1] [2]. Greco *et al*. [3] also defined MCDM as the study of methods and procedures by which concerns about multiple conflicting criteria can be formally incorporated into the management planning process.

The MCDM can also be stated as one of the most important and the fastest growing subfield of management science. As a result of its rapid development and its usage for solving a number of problems a number of different MCDM methods have been proposed. To simplify the classification of MCDA methods, they are often divided into two broad groups: multi-attribute and multi-objective decision-making methods [4] [5]. There are two primary outranking methods, ELECTRE [6] and PROMETHEE [7], both developed and extensively used in Europe. Widely used MCDM methods include, among others: Simple Additive Weighting (SAW) method [8], Linear Programming Technique for Multidimensional Analysis of Preference (LINMAP) method [9], Technique for Ordering Preference by Similarity to Ideal Solution (TOPSIS) method [10], Analytic Hierarchy Process (AHP) method [11], ELimination and Choice Expressing REality (ELECTRE) method [12], TODIM (an acronym in Portuguese of Interactive and Multicriteria Decision Making) method [13][14], Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE) method [15], Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) method [16], VIKOR (acronym in Serbian of multiple criteria optimization and compromise solution) method [17], and so on.

The concise overview of these methods, their characteristics and applicability are presented in Hwang and Yoon (1981) [18].

Besides the above mentioned, there are also a number of newly-proposed MCDM methods, such as: MULTIMOORA [19], KEMIRA [20], Step-Wise Weight Assessment Ratio Analysis (SWARA) technique [21], FARE [22] and so on. A comprehensive overview of these MCDM methods, as well as their usage, was considered by Kahraman *et al.* (2015) [23].

Outranking is an ideal method in many environmental problems as it is able to realistically capture the complexity of environmental issues, allows for group participation, can accommodate multiple decision makers, criteria, and alternatives in the process, and permits modifications to the process at any stage [24]. According to many authors, environmental management is one of the most important actual problems. Finding acceptable economic and social development must be defined in terms of sustainability in accordance with sustainable impact to the environment. That is very complex and very important problem, whose solution requires our attention. In addition, there is no universal solution to this problem. In the field of sustainability and environmental management, a number of decision problems can be identified and for each of them an adequate, compromise, solution must be found.

Ministerial Conference on the Protection of Forests in Europe (MCPFE) defined sustainable forest management as: "The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems" [25].

The base of forest management is planning. Kangas (2015) [25] defined the aim of forest planning like "providing support for forestry decision-making so that such a mix of inputs to and outputs from the forests is found that best fulfills the goals set for the management of the forest area under planning". The main phases in a strategic forest planning process are: (i) forest data acquisition and assessing the present state of the forests, (ii) clarifying the criteria and preferences of the decision-maker(s) regarding the use of forests and, in participatory planning, clarifying the criteria and preferences of other interested parties, (iii) generating alternative treatment schedules for forest stands within the planning area and predicting their consequences, (iv) producing efficient production programs for the forest area, and (v) choosing the best production program from among those deemed to be efficient with respect to the criteria and preferences as clarified in phase (ii) [26]. Forests should produce reasonable incomes while at the same time promoting conservation and recreational considerations [26].

In the Table 1, an overview of the use of PROMETHEE methods is presented.

Table 1. An overview of the use of PROMETHEE methods

Author(s)	Year	Specific area
Anand and Kodali [27]	2008	Manufacturing and Assembly
Araz and Ozkarahan [28]	2005	Business and financial management
Ayoko *et al.* [29]	2007	Hydrology and water management
Carmody *et al.* [30]	2007	Chemistry
Dagdeviren [31]	2008	Manufacturing and Assembly
Dulmin and Mininno [32]	2003	Logistics and Transportation
Hajkowicz and Collins [33]	2007	Hydrology and water management
Madlener and Stagl [34]	2005	Energy Management
Simon *et al.* [35]	2007	Hydrology and water management
Zhou *et al.* [36]	2006	Energy Management

The PROMETHEE methods are based on the use of pair wise comparisons and outranking relationships, as well as the use of the positive and negative preference flows, also named credibility degrees, of each alternative. The positive preference flow indicates how an alternative is outranking all the other alternatives and the negative preference flow indicates how an alternative is outranked by all the other alternatives [37]. The degree of preference for one alternative over the other are expressed on interval [0, 1], with „0“denoting indifference and „1“denoting strict preference [24].
In 1989 the Geometrical Analysis for Interactive Assistance (GAIA) was added as a descriptive complement to the PROMETHEE rankings, and thus enable a graphical representation of the multicriteria problem enables the decision maker to better understand the available choices and the necessary compromises he or she will have to make to achieve a best decision. GAIA can also be used to see the impact of the criteria weights on the PROMETHEE rankings [38].
The remaining part of the paper is organized as following: In Section 2, a case study about environmental management in NP Djerdap is considered. In Section 3, a review of research objectives is presented. In Section 4, the results of AHP and PROMETHEE computations are discussed. In Section 5, PROMETHEE ranking is conducted and in the Section 6, conclusions are presented.
performance and focused on the most profitable customers with the progression of time.

2. NATIONAL PARK DJERDAP

National Park Djerdap was founded in 1974. [42]. Name of the NP Djerdap comes from the most beautiful gorge on the Danube which is called Iron Gate. Area of NP Djerdap covers territory of 63 608.45 ha and it is located in the Southeastern part of Europe [39].

The Djerdap NP follows some 100 km of the river Danube, from Golubac town to Karatas by Kladovo, covering a narrow strip of forested hills, about 2–8 km wide, in the altitude range from 50 to 800 meters [40]. Djerdap consists of 4 gorges and 3 valleys that are distributed in the following order: Djerdap gorge, Golubac gorge, Ljupkovska valley, Gospodjin vir gorge, Donjomilanovacka gorge, valley Veliki and Mali kazan, Orasavska valley and Sipska gorge [41].

NP Djerdap is a public company that manages the use of forests and land within national park boundaries as well as its fishing area, which includes the right bank of the Danube to the Romanian border and tributaries within the park [42].

Some parts of the NP Djerdap are protected as unique natural, cultural, historical and archeological phenomena in Europe. Three zones of protection are defined. The first zone of protection includes 18 units which represent the most valuable and well preserved part of the national park. The total surface is 58,46 km^2 and it represent the vegetation of the Djerdap gorge. The second zone of protection includes 14 units on the total surface of 130 km^2 and it represents beauties of the tributary of the Danube valley. The third zone represents the rest surface of the national park, around 449 km^2 [39]. In national park some activities are allowed which do not threaten the authenticity of nature and survival of threatened species, natural ecosystems and landscapes.

According to the Plan of managing the NP Djerdap, from the total forest land area of the national park, 452.4 km^2 represent the forest land area, from which 382.2 km^2 is state-owned (84.5%) and 70.2 km^2 is private-owned land (15.5%). 97.4% of the total forest land area is forest covered.

In the NP Djerdap timber production for commercial purposes is allowed on 12 150 ha land area. 37 000 ha of the forest area represents the property of the Republic of Serbia. NP

Djerdap has three protection zones, within them 29.86% refer to the first and second protected zone where managing forests for timber production is not allowed. National Parks in Serbia are the public companies and they are funded by using natural resources such as timber production, fishing and hunting. National parks are not funded or sub-funded by the Republic of Serbia.

The management plan of NP Djerdap from 2012 represent the vision of further development, protection and management of the national park. It is based on environmental protection and sustainable development principles [39]. The main aim of the national park is the preservation, protection and promotion of the sites with special natural value and rarity, and the appropriate use for scientific research, education and recreation, public presentation, in accordance with ecological potentials of the region. Also, the need to protect cultural and historical heritage is emphasized as one of the most important resource of the national park [43].

3. RESEARCH OBJECTIVES

This research project deals with applying outranking methods in natural resources management. It includes an international review of applications of outranking in natural resources management and environmental planning, and an illustrative example of the use of outranking methods (using PROMETHEE) in natural resources management.

Although it is a question of an illustrative example, it is always recommendable to apply real-life material in the example. Aim is that conclusions regarding the usability of the applied method can be made on grounds of the example – at least from methodological and technical viewpoints. When using real-life material, the example can also provide with applicable or at least interesting information regarding the management of the area under consideration. The very nature of the material used also matters when assessing the quality of the research project.

Having NP Djerdap as an example area is very interesting, as the natural conditions are very diverse in the park and it has multiple functions and modes of use, including also forest management and timber harvests within a limited zone of the park.

The plan is that in the illustrative example the zone where forest management for timber production is allowed is under special consideration. The idea is that the size of that zone with harvests allowed can be taken as a strategic choice - it may be enlarged or decreased depending on the aims and objectives for the park. For the outranking calculations, alternative management strategies can be constructed simply by changing the area of the zone where wood harvests are allowed; six alternatives, one as the current one, one with 10 % smaller “wood production zone”, one with 20% smaller zone, one with 10% larger zone, one with 20% larger zone, and one with 30% larger zone. Then, multiple objectives for the park and its management are presented: such as biological diversity, nature tourism, recreation of local inhabitants and for people living nearby, income and employment opportunities provided by wood harvests, maintaining habitats of game animals, cultural heritage. Further, priorities of alternatives with different timber production zones with respect to the objectives/criteria must be assessed for multi-criteria outranking calculations separately with respect to each criterion. The study project may provide interesting information for the management of the National Park.

4. AHP AND PROMETHEE COMPUTATION

In this paper an integrated AHP- PROMETHEE approach is used for the selection of the most suitable „wood production zone“ in the NP Djerdap. In this approach AHP method is used to determine the weight of criteria and then the PROMETHEE method is used for final ranking. Finally, PROMETHEE GAIA is used for analyzing the results. AHP method will be used to determine the weights of given criteria and then PROMETHEE method will be used for final ranking. The weights of evaluation criteria are determinated on the basis of opinions by three experts.

For this research, the following criteria are used:

- Maintaining habitats of game animals (*M*)
- Nature tourism (*N*)
- Biological diversity (*B*)
- Cultural heritage (*C*)
- Income and employment opportunities provided by wood harvests (*I*)
- Recreation of local inhabitants and for people living nearby (*R*)

In the table 2 the average weights of criteria from all decision experts are shown. The resulting weights obtained on the basis of experts involved in evaluation could be found as follows:

$$w_j = \frac{1}{K}\sum_{k=1}^{k} w_j^k \tag{1}$$

where w_j denotes weight of criterion j, w_j^k denotes weight of criteria j obtained of expert k, and K denotes number of experts involved in the evaluation.

Table 2. Average weights of criteria from all decision experts

Weight / Criteria	E_1	E_2	E_3	Sum	w_j
Maintaining habitats of game animals	0.197	0.133	0.136	0.466	0.155
Nature tourism	0.128	0.079	0.164	0.372	0.124
Biological diversity	0.378	0.318	0.258	0.954	0.318
Cultural heritage	0.182	0.297	0.329	0.807	0.269
Income and employment opportunities provided by wood harvests	0.071	0.114	0.060	0.246	0.082
Recreation of local inhabitants and for people living nearby	0.043	0.058	0.054	0.156	0.052
				Sum	1

The results in Table 2 present the order of the criteria based on their value for management of NP Djerdap. The most important criterion according to the three experts is biological diversity (w_3=0.318). The rest of criteria are presented respectively by decreasing importance for management of NP Djerdap: cultural heritage (w_4=0.269), maintaining habitats of game animals (w_1=0.155), nature tourism (w_2=0.124), income and employment opportunities provided by wood harvests (w_5=0.082) and recreation of local inhabitants and for people living nearby (w_6=0.052).
For this paper Likert seven steps scale is used for evaluating alternatives and criteria and the scale is shown in the Table 3.

Table 3 **.**Seven steps Likert scale used for evaluating strategies

Qualitative value	Numerical value
Very low (VL)	1
Low (L)	2
Medium low (ML)	3
Medium (M)	4
Medium high (MH)	5
High (H)	6
Very high (VH)	7

Table 4 and Table 5 display positive $\Phi^+$and negative Φ^-scores, respectively. Alternatives are ranked according to PROMETHEE II complete ranking.

Table 4. Preference flow for each criterion

Criteria / Alternatives		*M*	*N*	*B*	*C*	*I*	*R*
*A*1 zone	Current	0.2000	0.2000	0.4000	0.2000	0.0000	0.0000
*A*2 zone	10% smaller	0.6000	0.6000	0.4000	0.2000	-0.4000	0.0000
*A*3 zone	20% smaller	0.8000	0.8000	1.0000	0.2000	-1.0000	0.4000
*A*4 zone	10% bigger	-0.2000	-0.4000	-0.6000	0.0000	0.4000	0.0000
*A*5 zone	20% bigger	-0.6000	-0.6000	-0.6000	0.0000	0.4000	-0.2000
*A*6 zone	30% bigger	-0.8000	-0.6000	-0.6000	-0.6000	-0.6000	-0.2000

Table 5. Multicriteria preference flow

Preferences / Alternatives	$\Phi^+(a)$	$\Phi^-(a)$	$\Phi(a)$	Rank
*A*1 Current zone	0.3726	0.1358	0.2368	3
*A*2 10% smaller zone	0.4284	0.1128	0.3156	2
*A*3 20% smaller zone	0.6158	0.0820	0.5338	1
*A*4 10% bigger zone	0.0638	0.3024	-0.2386	4
*A*5 20% bigger zone	0.0328	0.3680	-0.3358	5
*A*6 30% bigger zone	0.0492	0.5610	-0.5118	6

On grounds of the results of calculations presented in Table 5 it can be concluded that alternative number 3, i.e. the one with 20% smaller „wood production zone“, is the best ranked alternative based on the chosen criteria. The alternative with 10% smaller „wood production zone“ has the rank 2, followed by current zone. Increasing the „wood production zone“ is not suitable solution for observed criteria. The higher the percentage of „wood production zone“ the less acceptable an alternative.

5. PROMETHEE RANKING

In this section the obtained result as well as the presentation opportunities provided by PROMETHEE-GAIA are commented. The GAIA program provides a geometrical presentation of results obtained by PROMETHEE methodology. It is a useful tool for better understanding the problem under consideration.

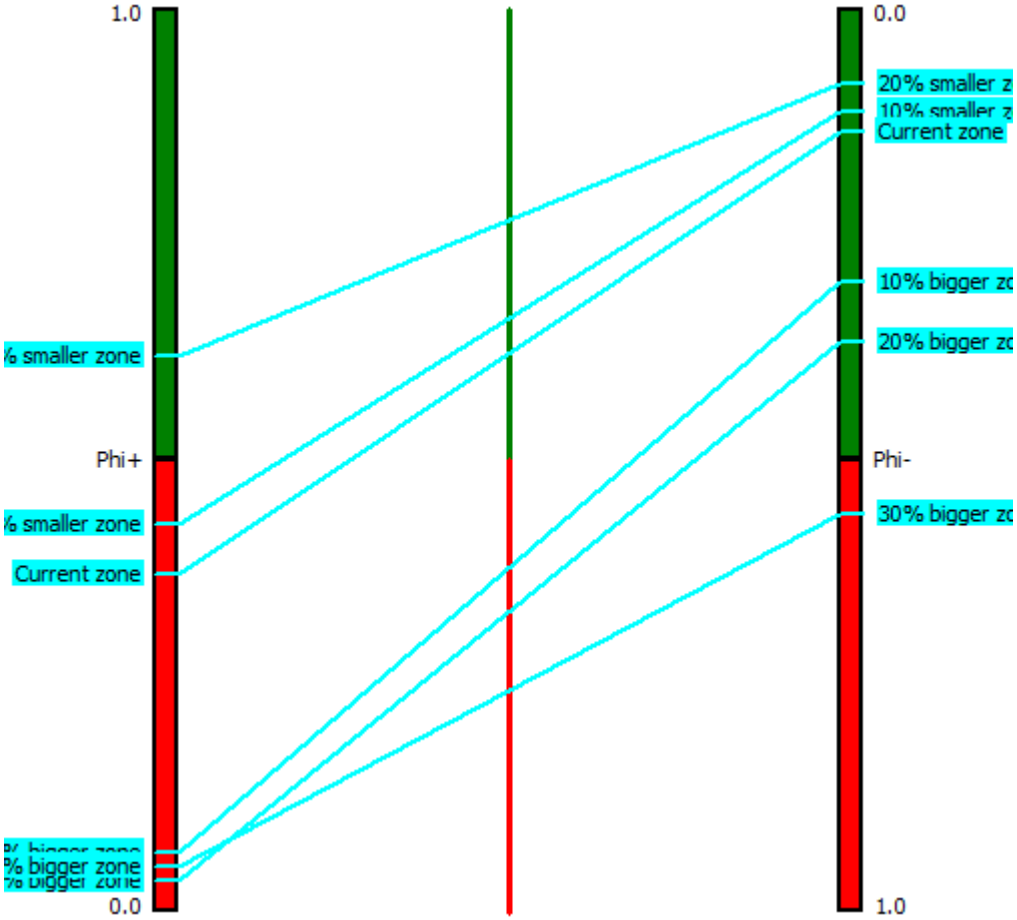

Figure 1. PROMETHEE I Partial Ranking

On the PROMETHEE I Partial Ranking (Figure 1), the leftmost bar shows the ranking of the actions according to Φ^+: 20% smaller zone is on top, followed by 10% smaller zone, Current zone, 10% bigger zone, 30% bigger zone and 20% bigger zone. The rightmost bar shows the ranking of the actions according to Φ^-: 20% smaller zone is still on top, but it is followed by 10% smaller zone, Current zone, 10% bigger zone, 20% bigger zone and 30% bigger zone.

Based on this picture it can be concluded that:

- 20 % smaller zone is preffered to all other actions in the PROMETHEE I ranking.
- 10 % smaller zone is on the top of current zone and these actions are pretty close to each other.
- The GAIA Visual analysis enable two-dimensional (U,V) analysis, where U denotes the first principal component and V denotes the second principal component. The results obtained on the considered case study are shown on Figure 2.
- The alternative 20% smaller zone is the best for criteria B, R and N. The 10% smaller zone and the Current zone are the best for criteria N, M and C. Finally, 10% bigger and 20% bigger zone are the best for criterion I.

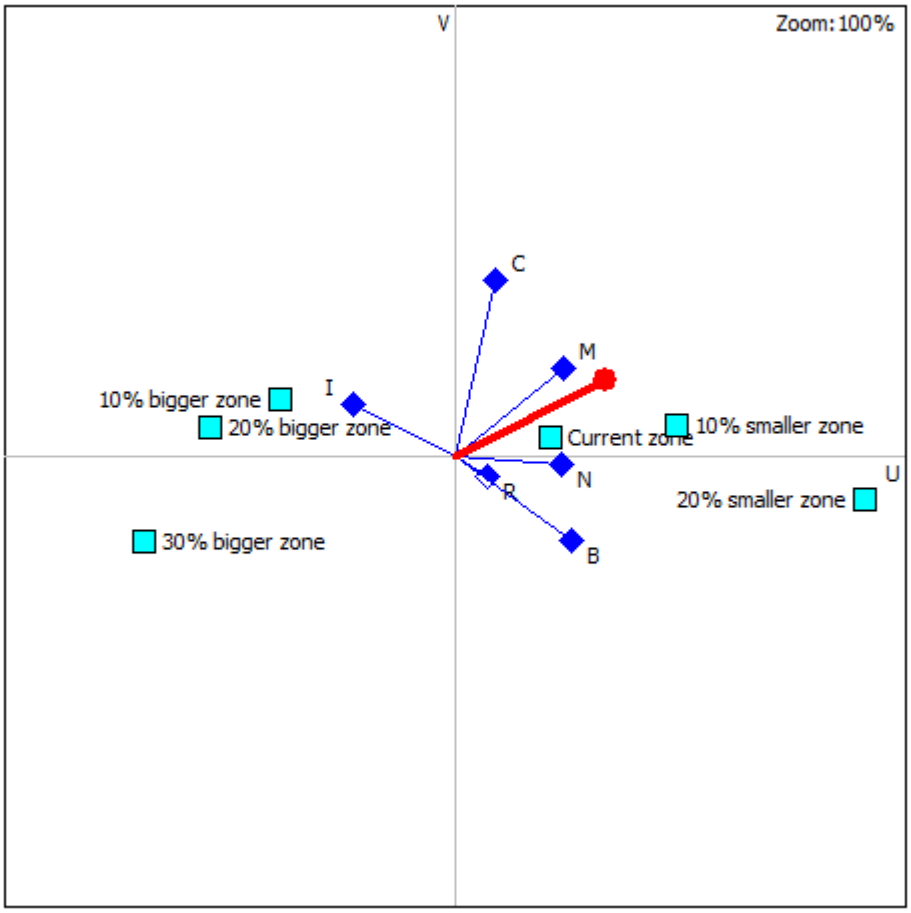

Figure 2. GAIA Visual Analysis

6. CONCLUSION

Our illustrative example shows that outranking methods may be are very useful in environmental management. In this study, PROMETHEE method was used as the most appropriate for ranking alternatives since it is flexibly and simple for users. The used methodology for assessing current and five other possible „wood production zones“ in the NP Djerdap showed interesting data for the management of the NP.

As it was stated in the project, management of National Park is turned toward nature conservation and sustainable development. The results showed that among the considered management alternatives the most suitable solution for preserving natural and cultural values of NP would be to reduce the size of the „wood production zone“ by 20% (alternative 3). Currently, the zone where timber production is allowed represents 71% of the total forest land, only 29% of the forest land is protected by the law. On the other hand, timber production is important for existence of the National Park because NP Djerdap is public company and it is responsible for its own management.

The best alternative for this special case is chosen according to defined criteria but there is always possibility to include more criteria for assessing alternatives. Criteria were defined so that them all were to be maximized. The criteria included maintaining habitats of game animals, nature tourism, biological diversity, cultural heritage, income and employment opportunities provided by wood harvests and recreation of local inhabitants and for people living nearby. As most important criterion according to three experts is biological diversity. The rest of the criteria in the order of decreasing importance for management of

NP Djerdap were: cultural heritage, maintaining habitats of game animals, nature tourism, income and employment opportunities provided by wood harvests and recreation of local inhabitants and for people living nearby.

According to GAIA Visual Analysis the best option for criteria biological diversity, recreation of local inhabitants and for people living nearby and nature tourism is *A*3 (20% smaller "wood production zone". Current and 10% smaller "wood production zones" are the best for nature tourism, maintaining habitats of game animals and cultural heritage. Criterion income and employment opportunities provided by wood harvests is the only one that suits to the potentially increased "wood production zone" for 10% and 20%.

The challenge for management is to balance between these requests because some of them are opposite. If management would like to increase income and employment opportunities provided by wood harvests, it would disturb achieving other criteria. After all, to preserve and conserve natural state of the National Park was found to be the primary goal.

Further development of this project can include more criteria for assessing alternatives. Introducing other criteria for the Case Study more precise model can be created for ranking alternatives. Other criteria can include protection of the environment like carbon sequestration or other relevant criteria. Determination of the weights for each criterion can include opinion of more employees in high positions in NP Djerdap and also employees on lower positions so general opinion is based on different working structure. Criteria weights which are used in this Case study are based on the opinion of three experts, but for more accurate determination of weights more experts can be included in the decision-making process. Process of implementation of AHP method is conducted through several iterations. Results of the Case Study based on the defined criteria and alternatives are satisfactory for management of NP Djerdap. Applying this outranking method in real-life management planning at NP Djerdap acquires more research time. Research is conducted during student mobility so there were some difficulties in filling the questionnaires, direct contact with employees in NP Djerdap couldn't be accomplished. Managers of NP Djerdap are interested in more detailed research based on various criteria and alternatives. This idea could be achieved in cooperation with NP Djerdap, University of Eastern Finland and Technical Faculty in Bor.

PRIMENA AHP- PROMETEJ METODA U UPRAVLJANJU ZAŠTITOM ŽIVOTNE SREDINE – NACIONALNI PARK DJERDAP

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Izvod

Jedan pristup upotrebe outranking metoda, sa posebnim naglaskom na održivo korišćenje prirodnih resursa, kao i njihovu zaštitu, je razmatrana u ovom radu. Predstavljeno istraživanje je bazirano na potencijalima Nacionalnog parka Đerdap, lociranog u Srbiji, sa posebnim naglaskom na pronalaženje modela za održivu eksploataciju šumskog potencijala nacionalnog parka. Integrisana primena AHP i PROMETHEE metoda se mogu navesti kao jedan od doprinosa ovog rada, pri čemu je AHP metoda upotrebljena za

određivanje značaja kriterijuma, a PROMETHEE metoda je korišćena za finalno rangiranje alternative. Konačni rezultati ostvareni tokom istraživanja prikazani su korišćenjem PROMETHEE GAIA.

Ključne reči: *Nacionalni park, PROMETEJ, Đerdap, Šumarstvo.*

LITERATURA / REFERENCES

[1] Kou, G., Lu, Y., Peng, Y., & Shi, Y. Evaluation of classification algorithms using MCDM and rank correlation. International Journal of Information Technology & Decision Making, 11(01), (2012) 197-225.
[2] Hwang, C. L., & Yoon, K. Multiple Attribute Decision Making - Methods and Applications. (1981) Springer, New York.
[3] Guitouni A., & Martel J.M. Tentative guidelines to help choosing an appropriate MCDM method. European Journal of Operational Research 109, (1998) 501-521.
[4] Methods, (2016). (Available at: http://www.promethee-gaia.net/methods.html, last time accessed 19.10.2016.)
[5] Hajkowicz, S., & Collins, K. A review of multiple criteria analysis for water resource planning and management. Water resources management, 21(9), (2007) 1553-1566.
[6] Roy, B. The Outranking Approach and the Foundation of ELECTRE Methods. Theory and Decision 31(1), (1991) 49-73.
[7] Brans, J. P., & Vincke, P. A preference ranking organization method : The PROMETHEE method for MCDM. Management Science 31(6), (1985) 647-656.
[8] Madlener, R., & Stagl, S. Sustainability-guided promotion of renewable electricity generation. Ecological Economics, 53(2), (2005) 147-167.
[9] Zakon o zastiti prirode (2009), Sluzbeni glasnik Republike Srbije. Br. 36/09 i 88/2010. (in Serbian, available at http://www.paragraf.rs/propisi/zakon_o_zastiti_prirode.html)
[10] JP Nacionalni park Djerdap, (2012). Plan upravljanja podrucjem Nacionalnog parka Djerdap (2011-2020): Donji Milanovac. (In Serbian, available at: http://www.npdjerdap.org/wpcontent/uploads/2014/12/ppu_npdj_2011_2012.pdf, last time accessed 29.10.2016.)
[11] Sabovljevic M. Contribution to the bryophyte flora of the Djerdap National Park (E Serbia). Phytologia Balcanica 12 (1): 51–54, (2006) Sofia, 51.
[12] Saaty, T.L. Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. (1980) McGraw-Hill, New York.
[13] Gomes, L. F. A. M., & Lima, M. M. P. P. TODIM: basics and application to multicriteria ranking of projects with environmental impacts. Foundations of Computing and Decision Sciences 16(4), (1992b) 113-127.
[14] Greco, S., Ehrgott, M., & Figueira, J. R. Trends in multiple criteria decision analysis - International Series in Operations Research & Management Science, (2010). 142. Springer-Verlag New York.
[15] Gomes, L. F. A. M., & Lima, M. M. P. P. From modeling individual preferences to multicriteria ranking of discrete alternatives: A look at Prospect Theory and the

additive difference model. Foundations of Computing and Decision Sciences 17(3), (1992a) 171-184.
[16] Brans J. P., & Mareschal B. A new family in outranking methods in multicriteria analyses. Operational Research 84, (1984) 477-490.
[17] Panic, N., & Lovren, V.O. Ekoturizam kao integralni deo upravljanja nacionalnim parkom Djerdap, (2014). Beograd: Zavod za zastitu prirode Srbije.
[18] Brauers, W. K. M., & Zavadskas, E. K. Project management by MULTIMOORA as an instrument for transition economies. Technological and Economic Development of Economy (1), (2010) 5-24.
[19] Carmody, O., Frost, R., Xi, Y., & Kokot, S. Adsorption of hydrocarbons on organo-clays—implications for oil spill remediation. Journal of Colloid and Interface Science, 305(1), (2007) 17-24.
[20] MacCrimmon, K. R. Decision Marking Among Multiple-Attribute Alternatives: a Survey and Consolidated Approach. RAND memorandum, (1968) RM-4823-ARPA.
[21] JP Nacionalni park Djerdap, (2016). (In Serbian, available at: http://www.npdjerdap.org/, last time accessed 30.10.2016)
[22] Kahraman, C., Onar, S. C., & Oztaysi, B. Fuzzy multicriteria decision-making: a literature review. International Journal of Computational Intelligence Systems 8(4), (2015) 637-666.
[23] Kangas J., & Kangas A. Multiple criteria decision support in forest management—the approach, methods applied, and experiences gained. Forest Ecology and Management, 207, (2005) 133-143.
[24] http://srbija.superodmor.rs/prirodne-znamenitosti/nacionalni-parkovi/34/nacionalni-park-djerdap (Last time accessed 5.12.2016.)
[25] Kersuliene, V., Zavadskas, E. K., & Turskis, Z. Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA). Journal of Business Economics and Management 11(2), (2010) 243-258.
[26] Kangas, A., Kurttila, M., Hujala, T., Eyvindson, K., & Kangas, J. Uncertainty in Multi-criteria Decision-Making. Decision Support for Forest Management (pp. 81-124). Springer International Publishing (2015).
[27] Araz, C., & Ozkarahan, I. A multicriteria sorting procedure for financial classification problems: The case of business failure risk assessment. In International Conference on Intelligent Data Engineering and Automated Learning (pp. 563-570). Springer Berlin Heidelberg (2005).
[28] Ayoko, G. A., Singh, K., Balerea, S., & Kokot, S. Exploratory multivariate modeling and prediction of the physico-chemical properties of surface water and groundwater. Journal of Hydrology, 336(1), (2007) 115-124.
[29] Bana e Costa, C. A. B., & Vansnick, J. C. MACBETH - an interactive path towards the construction of cardinal value functions. International transactions in operational Research 1(4), (1994) 489-500.
[30] Dagdeviren, M. Decision making in equipment selection: an integrated approach with AHP and PROMETHEE. Journal of intelligent manufacturing, 19(4), (2008) 397-406.
[31] Dulmin, R., & Mininno, V. Supplier selection using a multi-criteria decision aid method. Journal of Purchasing and Supply Management, 9(4), (2003) 177-187.
[32] Ginevicius, R. A new determining method for the criteria weights in multicriteria evaluation. International Journal of Information Technology & Decision Making 10(06), (2011) 1067-1095.

[33] Hermans M. C., Erickson D. J. Multicriteria decision analysis: overview and implications for environmental decision making. Economics of Environmental Resources 7, (2007) 213-228.
[34] Malczewski J., GIS and multicriteria decision analysis (1999). New York, Wiley.
[35] Roy B., Methodologie Multicriterie d'Aide a la Decision (1985). Paris: Economica.
[36] Srinivasan, V., & Shocker, A. D. Linear programming techniques for multidimensional analysis of preferences. Psychometrika 38(3), (1973) 337-369.
[37] Zhou, P., Ang, B. W., & Poh, K. L. Decision analysis in energy and environmental modeling: An update. Energy, 31(14), (2006) 2604-2622.
[38] Opricovic, S. Multicriteria Optimization of Civil Engineering Systems. Faculty of Civil Engineering, Belgrade (1998). (In Serbian)
[39] Kolios, A., Mytilinou, V., Lozano-Minguez, E., &Salonitis, K. A Comparative Study of Multiple-Criteria Decision-Making Methods under Stochastic Inputs. Energies, 9(7), (2016) 566.
[40] Simon, U., Bruggemann, R., Behrendt, H., Shulenberger, E., & Pudenz, S. METEOR: a step-by-step procedure to explore effects of indicator aggregation in multi criteria decision aiding–application to water management in Berlin, Germany. Acta hydrochimica et hydrobiologica, 34(1-2), (2006) 126-136.
[41] Hwang, C. L., & Yoon, K. Multiple attribute decision making: methods and applications a state-of-the-art survey (Vol. 186). Springer Science & Business Media (2012).
[42] Krylovas, A., Zavadskas, E. K., Kosareva, N., & Dadelo, S. New KEMIRA method for determining criteria priority and weights in solving MCDM problem. International Journal of Information Technology & Decision Making 13(06), (2014) 1119-1133.