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SELECTING THE LOCATION OF A NAUTICAL TOURISM PORT BY APPLYING PROMETHEE AND GAIA METHODS CASE STUDY – CROATIAN NORTHERN ADRIATIC

ABSTRACT

In this paper, the author presents the multi-criteria analysis methods, PROMETHEE I and II and GAIA, used for selecting the location of a nautical tourism port. In an example of the selected location of a nautical tourism port in the Northern Adriatic, the author has used an analytic and graphical evaluation for solving such a problem. Particular attention has been paid to the use of GAIA method, which is suitable for visualisation of the problem characteristics through geometrical interpretation and presentation of the results of a multi-criteria analysis. By application of the described methods, it is possible to establish the most acceptable location considering the principles of sustainable development. The paper emphasises the importance of applying multi-criteria analysis and multi-criteria use of selected methods, which contain criteria and sub-criteria for selecting the optimal location of a nautical tourism port. In the paper the results of the research "Criteria for selecting the location of a nautical tourism port" conducted during 2006/2007 have been used.

KEY WORDS

nautical tourism port, selecting the location, multi-criteria analysis

1. INTRODUCTION

The development of nautical tourism in Croatia is connected to the construction of new nautical ports and to modernisation and reorganisation of the existing ones. The studies relating to the needs and possibilities of further development of nautical tourism ports indicate the following:

- increased demand for berths, i.e. their insufficiency,
- damages caused by vessels that cannot be berthed in nautical tourism ports are great in terms of revenue and ecology.

In relation to some Mediterranean countries, the capacity of Croatian aquatorium could accept a significant increase in the number of vessels, which will not cause the saturation (congestion) of sea and coastal area.

Systematic research aimed at defining criteria and sub-criteria of optimising the selection of the location and facilities of nautical tourism port by applying some of multi-criteria analyses has not been conducted so far. There are some partial researches and a number of papers relating to nautical tourism in view of the complexity of development of a nautical tourism port and the economic effects achieved in nautical tourism.

There were only a few studies in which the factors relevant for selection of the location and facilities of a nautical tourism port were analysed. In 1997, the Croatian authors Knezić, S. and Mladineo N. made a study entitled "A model of evaluation of maritime domain", in which the authors applied modern techniques and methods of multi-criteria analysis, which makes the study particularly important in studying and evaluating the maritime domain.

In cooperation with various experts, the Hydrographic Institute of the Republic of Croatia (Split, 2006) has designed a Study on the development of nautical tourism. The Study was the basis for further activities on the preparation and designing the strategic development document of long-term preservation of available resource basis of nautical tourism, planning its development, organisation and management as a complex system.

The subject of the paper is the application of the model of optimisation of selecting the location of a nautical tourism port by applying the methods PROMETHEE I and II and the method GAIA using as example the Northern Adriatic. The objective of the paper is to indicate the importance of methods of multi-criteria analysis in optimising the selection of the location for a nautical tourism port. The set subject and objective of the paper lead to the following hypothesis:

By applying an optimisation model of multi-criteria analysis for selecting a nautical tourism port it is possible to determine the most acceptable location for developing a nautical tourism port in the Northern Adriatic.

During the optimisation the methodology of multi-criteria analysis and the methods PROMETHEE I and II and GAIA will be used.

2. MULTI-CRITERIA ANALYSIS – METHODOLOGICAL APPROACH

There are several methods that can be used in problem solving, e.g. linear programming, AHP, ELECTREE, PROMETHEE, GAIA and others, and the author's experiences vary. The methods of linear programming allow for solving the problem at the operational level since it starts from minimum limitations of the system and with one or more aims (criteria that has to assume a certain value). The PROMETHEE method is supported by an adequate programme support and is user-friendly [9].

2.1 Presentation of the Promethee method

Since, in general, there are no best solutions when dealing with multi-criteria problems, the problem is reduced to determining a set of good alternatives, systems, locations, projects, etc. One of the most significant methods is the PROMETHEE method, designed by J. P. Brans and P. Vincke [2]. It is characterised by the following three segments [2]:

- **Coverage of the criteria** – Conceiving the preferences of the decision-maker is designed in such a manner that each criterion is observed through six possible volumes (function of preference) based on the intensity of the preference. Some of them allow intransitivity of indifference, while the others provide smooth transfer from indifference to strict preference. The researches showed that six types of preference functions include most of the cases that are present in practice, and for which the decision-maker has to define not more than two parameters. It is a simple task in view of the fact that each parameter has its real economic value.
- **Estimated relation of a higher rank** – The use of criteria formed in this way allow the construction of estimated relation of a higher rank. Such a relation is less sensitive to minor changes of parameters and its interpretation is simple.
- **The use of a relation of a higher rank** – This relates to considering a specific use of estimated relation of a higher rank, especially in the case when actions have to be ranked from the worst to the best ones. If necessary, the PROMETHEE I method allows partial ranking of actions and complete ranking may be achieved by means of the PROMETHEE II method.

2.2 Presentation of GAIA method (Geometrical Analysis for Interactive Aid)

When the PROMETHEE method is used for solving a problem of multi-criteria analysis, there are two basic results: partial and complete ranking of alternatives, which is mean ranking of all alternatives [3]. However, in view of the fact that there are alternatives that cannot be correlated (i.e. cannot make a strict distinction between a better and a worse alternative), and the possibility that when ranking the alternatives into a complete rank the differences of the complete flow among some alternatives may be very little (which means that there is a certain unreliability of complete ranking, for instance, the rank would change if a weight was slightly changed), there is need for additional geometrical information about the behaviour of alternatives according to specific criteria. Such information allows for the decision-maker to have a better understanding of the relations of alternatives and criteria, facilitates predictions for "what if" situations and allows a comprehensible and effective presentation of the results obtained through the PROMETHEE method.

The GAIA programme (Geometrical Analysis for Interactive Aid) gives geometrical presentation of the results obtained through the PROMETHEE method and it naturally continues the programme PROMCALC (Mareschal B., Brans J.P., 1988). A multi-dimensional problem is reduced to a two-dimensional one so that a plain presentation is possible. By its nature, the dimension of a multi-criteria analysis is determined by a number of criteria (each criterion determines one vector in such area) and it is clear that, if a geometrical presentation is desired, the problem has to be reduced to a two-dimensional presentation [7]. When decreasing the number of dimensions there is necessarily a certain loss of information about the problem. In order to have a lesser loss, the plane in which the geometrical presentation is given is determined by two highest characteristic values of the co-variation matrix. There, the programme provides data on the percentage of information presented. Except when the structure of the problem is exceptionally adverse, the geometrical presentation gives a sufficiently high percentage of information needed for considering the problem. Nowadays, other presentations are used for a geometrical arrangement, e.g. tensor, etc. Tensors are generalisations of a vector; hence, for instance, 2^{nd} class tensor has 9 components. In a two-dimensional GAIA plane, activities and criteria are observable, which allows for a direct interpretation of a multi-criteria problem.

It is also possible to relate the GAIA method to the PROMETHEE II method. PROMETHEE II requires that each criterion is associated with a specific weight wj and a complete order is made in set A. Weights may also be presented in the (u, v) plane by means of decision axis that is oriented towards the best ranked activities [1]. In this way, by interactive changing of the weights, it is possible to observe the consequences to the rank obtained through the PROMETHEE II method.

By using the GAIA software package it is possible to obtain numerical results and diagrams that help the decision-maker to observe the problem more realistically and to obtain a more comprehensive view of the relations among criteria and activities. The described manner of selecting the plane for a geometrical presentation of multi-criteria problem results in the minimal loss of information (in terms of the method of minimal squares), which means that (with necessary certain losses occurring in decreasing the number of problem dimensions) interrelations of criteria are also kept, as well as the significance of each criterion in relation to other criteria. In that presentation, the conflicted criteria will have fundamentally different direction (a minor co-variance among the criteria causes also a minor value of the scalar product of the vectors that present them), while synchronised vectors are presented by vectors of close direction. The importance of criteria for making a decision is geometrically presented by the length of the vector, so that the dominating criteria have corresponding vectors of higher absolute value. By adding vectors that present criteria, a summary vector is obtained, whose direction and value illustrate the resultant effect of the criteria. If the summary vector is of low absolute value it indicates that the criteria are conflicted.

3. CRITERIA OF THE LOCATION OF A NAUTICAL TOURISM PORT

The analysis of a particular location includes macro analysis and micro analysis, the analysis of local factors, the analysis of the needs at the selected location and finally, the selection of the location. When selecting a location a distinction is made between the selection of a broader and a closer area. First, the broader area for a nautical tourism port is determined, which is evaluated according to economic and geographical criteria. Then the selection of the specific location follows, which is most often influenced by the elements like physical plan of the area, maritime conditions, position of the water area, proximity of industrial water, potable water and sewage network, vicinity of existing and potential settlements and possibility of employing local personnel, proximity of energy sources, etc. Individual criteria that affect the selection of the location of a nautical tourism port are the shape of the space for constructing the objects of a nautical tourism port, fillings and existing sea walls, air temperatures and deviations, humidity, number of sunny days, frequency of fog, quantity of precipitations, speed and directions of wind, traditional orientation of the area, necessary personnel, proximity of the location to infrastructure and traffic, possibility of spare parts supply, organisation of services, etc. In order to avoid mistakes when selecting a location, it is necessary to contrast advantages and weaknesses of a particular location.

3.1 Evaluating criteria of the location of a nautical tourism port

In addition to the researches of the factors for selecting the nautical tourism port during 2006/2007, an overall research of criteria for selecting the most optimal location of a nautical tourism port has been performed [8]. The research has been carried out for the project "Criteria for the selection of the location of a nautical tourism port" taking into account the stated theoretical premises and past researches of the criteria for the selection of the location of a nautical tourism port. The study included a number of Croatian and European experts in various fields related to the subject. The questions related to specific problems of nautical tourism ports and the concept was that the experts in their answers and suggestions will give relevant evaluations. The goal of the research was to determine the criteria and sub-criteria for the selection of the location of a nautical tourism port, to evaluate and rank the defined criteria and sub-criteria, to rank the proposed groups of criteria and to propose other criteria or sub-criteria according to their expertise and experience.

The analysis of the obtained data determined the number of experts who ranked a particular criterion to a particular position, for instance, criterion B - location and nature was ranked as the most important by 11 experts, while not a single expert ranked it to the positions 5 and 6 as the least important (*Table 1*). The equation for calculating the weights of the criteria on the basis of their correlated ranking is [5]:

$$w_j = \frac{\sum_{k=1}^{n} R_{jk}}{\sum_{j=1}^{m}\left(\sum_{k=1}^{n} R_{jk}\right)}; \; R_{jk} \in \{m - i : i \in (1, \ldots, m)\} \qquad (1)$$

where R_{jk} is the rank of j criterion according to the ranking of k^{th} expert and has the value:

$R_{jk} = m - 1$ for the most important criterion

$\vdots$

$R_{jk} = 0$ for the least important criterion

n – total number of experts,

m – total number of criteria,

w_j – weight calculated for j^{th} criterion.

Table 1 - Ranking the criteria weights

Criterion/rank	1	2	3	4	5	6	Weight - w_j
A. Institutional-political	0	0	1	1	4	13	0.030201
B. Location and nature	11	4	1	3	0	0	0.268456
C. Technical and technological	1	2	3	11	2	2	0.154362
D. Economic	2	4	7	2	4	1	0.184564
E. Social and cultural	0	2	5	0	8	4	0.104027
F. Ecological	6	8	4	1	1	0	0.258389

After having made the ranking of criteria by application of the mentioned formula, weights have been obtained, *Table 1*.

Selecting the location of a nautical tourism port is presented in this paper by using the PROMETHEE method. Since not all criteria have the same weight, a weight index of preference is introduced, obtained by calculating the criteria weight on the basis of their interacted ranking obtained by equation 1 (Graphic 1).

The function of the preference $P_j(a,b)$ in the general model is of type III, since it allows the decision-maker a progressive preference of "a" over "b", at the progressive growth of difference between the functions of criteria f(a) and f(b). The intensity of the preference is linearly increased until the difference equals a particular parameter "p" that can be determined in particular cases, and after that value the preference is strict. The criteria weights W_j are specific for each criterion $j = 1,\ldots,6$, (*Table 1*), hence, multi-criteria index of preference for $\forall a,b \in \mathbf{A}$ is defined as [1]:

$$\prod(a,b) = \frac{\sum_{j=1}^{6} W_j P_j(a,b)}{\sum_{j=1}^{6} W_j}, \qquad (2)$$

where $\mathbf{A}$ is a set of possible actions (alternatives) i.e. locations of a nautical tourism port.

The directed graph, whose action knots are from A are such that $\forall a,b \in \mathbf{A}$, branch (ab) has the value $\Pi(a,b)$, is called estimated graph of higher rank, and it can be more easily calculated using the Decision Lab 2000 software. For a particular problem it is necessary to enter particular evaluations for a particular nautical port.

4. NUMERICAL PROCESSING OF A PROBLEM BY APPLYING THE METHODS OF MULTI-CRITERIA ANALYSIS

The problem of location is a problem of selecting the most convenient or optimal place for performing an activity. An optimal selection of the location of a nautical tourism port requires a systematic analysis of physical, and technical and technological criteria, economic-political and ecological criteria, which become crucial determinants for the location of a nautical tourism port in a particular area [4].

Using the selected procedures of multi-criteria analysis and the seriously examined input data, the selection among ten (10) generated variants (locations) was done, by evaluating six (6) different groups of criteria and twenty-eight (28) dimensional sub-criteria in accordance to the defined plan of the examination. Criteria and sub-criteria are the following [8]:

A. Institutional and political (physical plan of the micro-location, regional system of taxes and surtax, views and development policy of the region);
B. Natural and physical (geomorphologic and oceanographic properties, hydrographic properties of the location, microclimate properties);
C. Ecological (ecological value of the micro-location, susceptibility to human activities, estimated adverse impacts to the environment, monitoring of the water area of the micro-location, amount of investments into environmental protection (5-30%);
D. Technical and technological (physical and geographical properties of the micro-location, accommodation capacity, categorisation and minimal standards, development of traffic and other infrastructure, vicinity of the city cores, safety and navigational conditions;
E. Economic (offer of nautical tourism in the region, offers in the surrounding area, the amount of the concession fee, cost of investment, development of information and communication system in the area, available labour, development possibilities);
F. Social and cultural (direct and indirect benefits, level of urbanisation and recognition of the micro-location, improvement of life quality of the local community, social and cultural aspects of the region).

4.1 Numerical processing of the problem by applying the Promethee method

Selecting the location of a nautical tourism port is based on selecting the location that satisfies particular parameters. It is difficult for a decision-maker to recognise all parameters and understand the data about them. The consequence is an unstructured problem, which is the reason for selecting V-shape for all types of criteria, since it is the most adequate one for the problem. The criteria and sub-criteria evaluated in this way, with their maximum and minimum determined, allow for the presentation of the conducted procedure of multi-criteria analysis. The input in the programme contains data that relate to the weight and to the type of the criterion, the pertaining parameters, and the description of actions, or, in this particular example, to variant solutions. To have a visual control, the values of input parameters are automatically shown in different colours: minimum values – red and maximum values – green. It is known that the Decision Lab allows reading of the results on the screen and the production of the report in HTML format. Data processed by the PROMETHEE I method show calculated Φ (Phi) values, i.e. input (-) and output (+) flows, or the ratios of dominations of certain pairs of actions, and also the achieved rank on the basis of the calculation of the net value using the PROMETHEE II method.

Table 2 shows positive, negative and net flows on the basis of which the ranking was made through the PROMETHEE I method, and *Figure 2* shows the obtained partial rank and the relation among the locations.

Table 2 - Presentation of the positive (output), negative (input) and net flows, and the achieved level of successfulness

Mark of the location (L)	Φ_+	Φ_-	Φ	Ranking
L 7	0.2733	0.1099	0.1634	1
L 8	0.2291	0.1382	0.0908	2
L 1	0.2383	0.1551	0.0832	3
L 2	0.2396	0.2048	0.0349	4
L 10	0.2105	0.1841	0.0264	5
L 3	0.1639	0.1875	-0.0235	6
L 5	0.1374	0.1980	-0.0606	7
L 6	0.2033	0.2663	-0.0630	8
L 4	0.1200	0.2031	-0.0831	9
L 9	0.1301	0.2985	-0.1685	10

Partial ranking of the locations indicate the partial order, according to which location 7 has a net flow of 0.16% and occupies the first place, ahead of locations 8 and 1 that are in the third position. The next is location 2 that also has a positive net flow, followed by location 10. Other locations have a negative net flow, and the last position is occupied by location 9 that at present is not to be considered. *Figure 1* presents the results of the processed data using the PROMETHEE I method and the obtained partial order of the examined locations.

In *Figure 2*, it can be noticed that location L7 is ranked first and that it dominates over location L8, to be followed by locations L1, L2 and L10 that cannot be correlated. Locations L1 and L2 have the same values

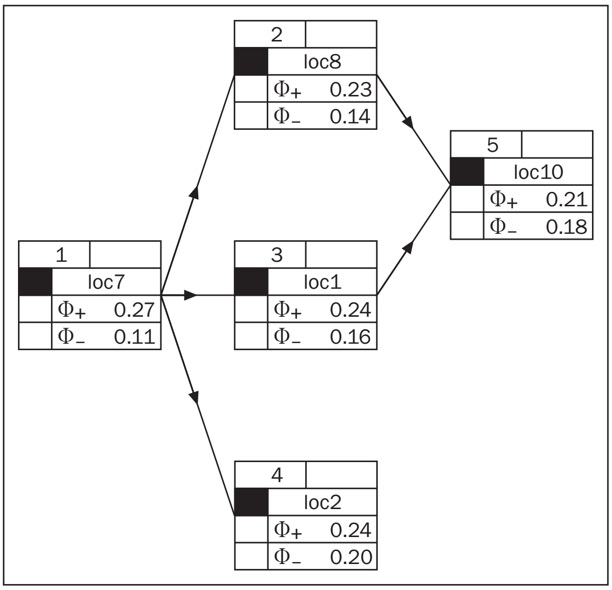

Figure 1 - Results obtained through the PROMETHEE I method (partial order)

only for the positive course, while location L2 is situated at the end of the partial rank. Locations L1 and L8 dominate over L10 and jointly dominate over the remaining five locations. These facts are important for a decision-maker, since the fact that locations cannot be contrasted indicates their essential diversity and requires a more detailed analysis aimed at determining those parameters which cannot be correlated. For instance, alternatives which have extreme values of criteria cannot usually be compared. By using the PROMETHEE II method it is possible to obtain the complete placing (integral rank) but part of information is lost because even those locations that cannot be easily compared are correlated (which is indicated by the PROMETHEE I method).

The results obtained through the PROMETHEE II method are presented in *Figure 3* and the complete order is shown while certain information is lost. It may be observed that location L7 is optimal for the selection, followed by L8, L1 etc. The last location is L9, preceded by location L4.

It is logical to observe identical net flows of locations L2 and L10, locations L5 and L6, and very close net flows of locations L1 (0.08) and L8 (0.09). In partial ranking it is clearly indicated that L1, L2 and L10 are reciprocally incomparable; now L1 is with its net flow in front of L8. Locations having the same net flow can substitute their places changing in such a way the illustrated rank. Similarly to the partial ranking, the results of processing by PROMETHEE II method indicate that location L7 is the best choice.

Graphical display of numerical values of net flows in *Figure 3* is shown in the form of histogram to facilitate observing the differences in net flows values. It may be concluded that the first five locations are very suitable for the selection and the construction of a

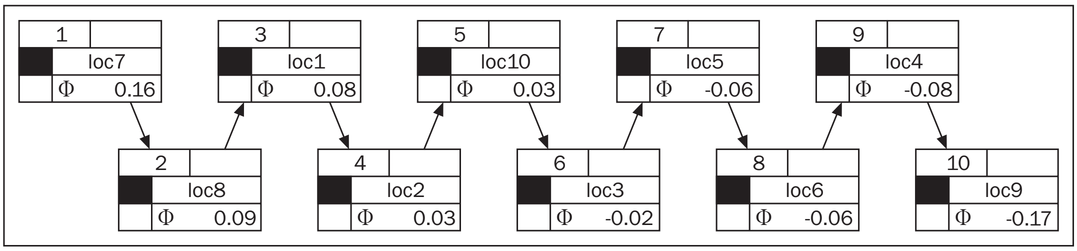

Figure 2 - Results of data processing through the PROMETHEE II method (complete ranking)

nautical tourism port, and that the selection depends on the decision-maker and the set objectives. The objective of this research was to research the factors of the locations and contents of nautical tourism port on a theoretic and operative level in order to establish criteria and sub-criteria and by use of the method of multi-criteria analysis choose the most suitable location for construction of a nautical tourism port in the Northern Adriatic.

In *Figure 3* it can be seen that 5 locations have positive net flows, while other locations have negative net flows, and it can be concluded that the investor should give priority to developing locations L7, L8, L1, L2 and L10, accompanied by a detailed study of their characteristics. The lower part of the Figure shows the attributed weights of individual criteria and sub-criteria in the form of horizontal bars. The programme support "Decision Lab 2000" allows the decision-maker to modify the value of the criteria and sub-criteria weights (bottom part of the Figure), and the result of the modification will immediately be updated in the upper part of the diagram showing net flows. In this way it is possible to analyse immediately the effects of criteria and sub-criteria weights to the rank, and it is possible to determine alternative scenarios for analysing data using other weights of criteria and sub-criteria.

Since the programme support can also provide the analysis of the stability of criteria and sub-criteria weights, the presentation of the stability analysis has been given. These data can be the basis for further analysis from the point of modifications of weight coefficients. However, it should be noted that the defined criteria and their parameters have a decisive influence on determining the ranking of locations of a nautical port.

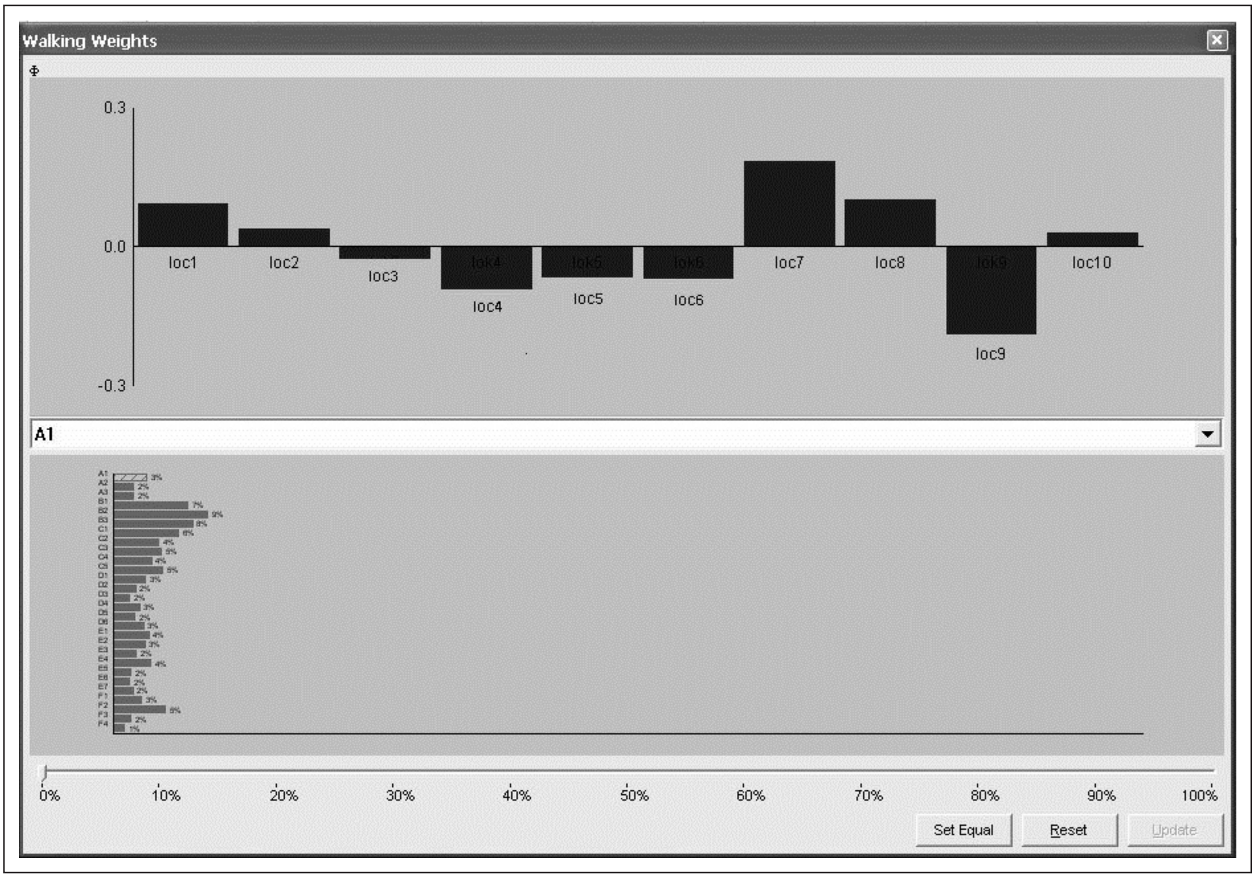

Figure 3 - Graphical display of numeric values of net flows and attributed weights of criteria and sub-criteria

Stability Intervals

Stability Level: 10 first actions AutoLevel

	Weight	Interval		% Weight	% Interval	
		Min	Max		Min	Max
A1	0.0343	0.0000	0.1132	3.34%	0.00%	10.24%
A2	0.0210	0.0035	0.0288	2.04%	0.34%	2.79%
A3	0.0207	0.0000	0.0803	2.01%	0.00%	7.38%
B1	0.0750	0.0662	0.1122	7.30%	6.50%	10.54%
B2	0.0953	0.0767	0.0975	9.28%	7.60%	9.47%
B3	0.0797	0.0753	0.0967	7.76%	7.36%	9.26%
C1	0.0663	0.0509	0.0867	6.45%	5.03%	8.27%
C2	0.0457	0.0351	0.0604	4.45%	3.45%	5.80%
C3	0.0490	0.0255	0.0543	4.77%	2.54%	5.25%
C4	0.0387	0.0321	0.0706	3.77%	3.15%	6.67%
C5	0.0503	0.0328	0.1247	4.90%	3.25%	11.32%
D1	0.0330	0.0290	0.0417	3.21%	2.83%	4.02%
D2	0.0230	0.0203	0.0361	2.24%	1.98%	3.47%
D3	0.0170	0.0000	0.0243	1.65%	0.00%	2.35%
D4	0.0270	0.0128	0.0474	2.63%	1.26%	4.52%
D5	0.0227	0.0000	0.0741	2.21%	0.00%	6.87%
D6	0.0307	0.0197	0.0484	2.99%	1.94%	4.64%
E1	0.0363	0.0240	0.0450	3.53%	2.36%	4.34%
E2	0.0323	0.0166	0.1009	3.14%	1.64%	9.21%
E3	0.0240	0.0000	0.0328	2.34%	0.00%	3.16%
E4	0.0383	0.0212	0.0488	3.73%	2.10%	4.70%
E5	0.0187	0.0045	0.0318	1.82%	0.44%	3.06%
E6	0.0167	0.0000	0.0292	1.63%	0.00%	2.81%
E7	0.0203	0.0165	0.0286	1.98%	1.61%	2.76%
F1	0.0290	0.0199	0.0431	2.82%	1.95%	4.14%
F2	0.0525	0.0411	0.0876	5.11%	4.05%	8.24%
F3	0.0180	0.0056	0.0258	1.75%	0.55%	2.50%
F4	0.0118	0.0030	0.0544	1.15%	0.30%	5.08%

Figure 4 - Results of analysis of weights stability of criteria and sub-criteria

In *Figure 4*, it can be seen that only sub-criteria A1, A3, B1, B2, B3, C1, C5, E2 and F2 have a relatively high stability towards the upper limit. Other sub-criteria are very unstable at the lower limit, i.e. minor changes of their weights would affect the change of the rank obtained in the previous analysis. The sub-criteria A1, A3, D3, D5, E3 and E6 have higher stability towards the lower limit. These results are also a warning for the decision-maker to reconsider the weights of the criteria in terms of their significance for the final decision.

To obtain a detailed insight into the problem, a part of the GAIA programme support will be used, which will allow for a comprehensive understanding of the behaviour of the criteria and sub-criteria of the entire problem of location selection by means of geometrical presentation of multi-criteria analysis, based on the same input data used for the numeric data processing through the PROMETHEE method.

4.2 Selecting optimal location of a nautical tourism port in the Croatian part of the Northern Adriatic

The GAIA programme support has been used for the geometrical presentation of the behaviour of criteria and sub-criteria, where the position of criteria and sub-criteria are shown in "u, v" plane (two-dimensional space).

Figure 5 shows the criteria and sub-criteria in a two-dimensional space, i.e. in (u, v) plane, and their dispersion and grouping of similar criteria with regard to numerical values can be observed. Sub-criteria C3 and A3, and C4, C5, D5, D6, E2 make homogenous groups, while the third group consists of sub-criteria D3, E5, E6, and F2. This is understandable as for the decision-makers these groups of preference sub-criteria are almost the same, and therefore they have been illustrated in (u, v) level by vectors having almost the same direction.

Several other, less homogenous groups can be observed. The majority of criteria are remarkably dispersed, but their orientation towards the right of the (u, v) plane can be observed. The position of sub-criteria E1, E3, D1, D2, A3 and C3 on the left part of the plane point to the confliction in some aspects of the problem and to the validation of use of the method of multi-criteria analysis in the decision-making process of selecting the optimal location.

Figure 6 shows potential locations in (u, v) plane and the axis of the decision. The diagram shows the

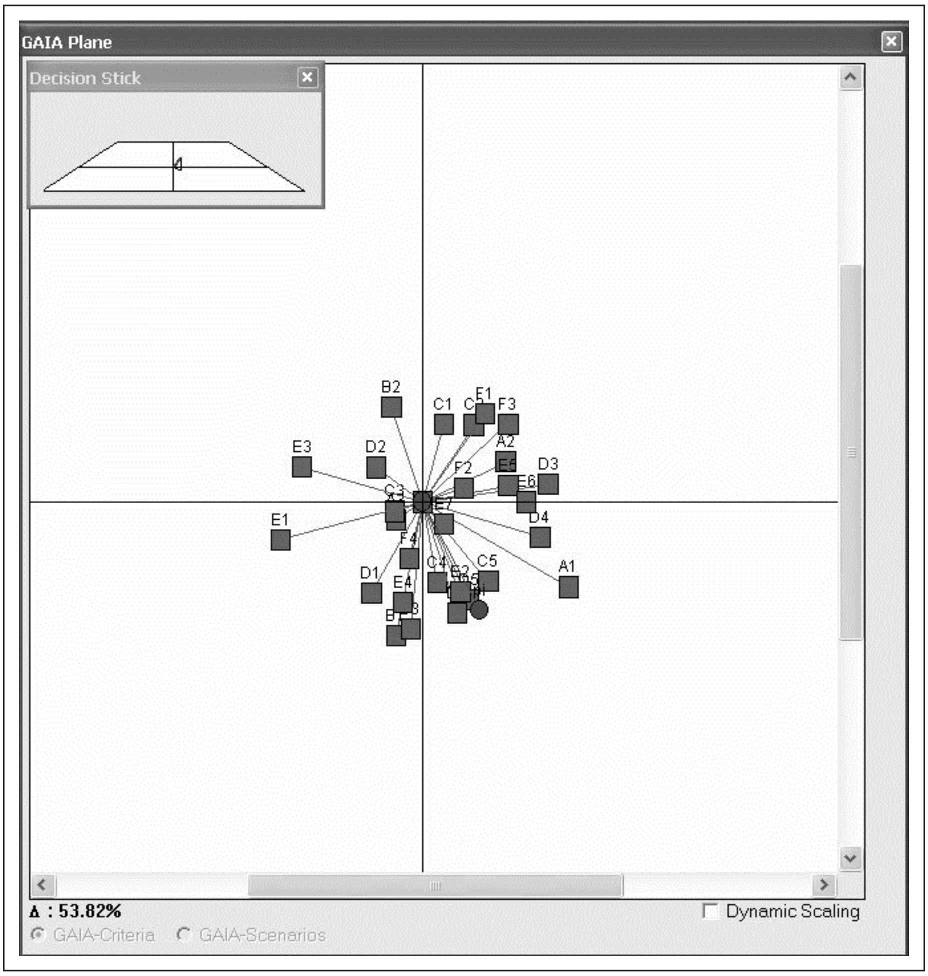

Figure 5 - Presentation of the position of criteria and sub-criteria in the "u, v" plane

grouping of locations L7 and L8 on the right part of the plane, and locations L3 and L4 on the left part of the plane, which indicates their similarity. This will explain, considering the moderate aspect of the decision axis, the domination of locations L7 and L8 over other locations. The distinctive detachment of locations L6 and L5, L9 and L10, and L2 and L1 on the left part of the plane can also be observed.

If properly conducted, the process of multi-criteria analysis requires cooperation of all interested parties and practically involves in the decision-making process all participants to whom the problem relates, which, on the other hand, facilitates the realisation of the obtained priorities and eliminates doubts about subjective decision-making [6]. The importance of the construction of a nautical tourism port and the use of natural resources of the Croatian coast has been particularly emphasised in the recent researches and parallel with them, the number of interested parties for an efficient management of the seaside area. By observing the process of selecting the optimal solution, the problems relating to potential jeopardising of the common interests will be, at least partially, eliminated. On the other hand, knowing the procedure of selecting the optimal solution will create a trusting atmosphere and strengthen the opinion that the evaluation of the interest is clearly and transparently determined, since a large number of the interested parties will be able to control the majority of the criteria necessary for making decisions. The transparency of available data necessary for the analysis is very important because it allows for the inspection of properly evaluated parameters.

A multi-criteria analysis subsequently requires questions, such as for instance, whether all relevant criteria have been considered, whether they have been properly evaluated, especially those parameters that are the product of experts' opinion. The Decision Lab 2000 programme support has therefore, a number of options for post-analyses and simulation estimation "what if" (e.g. "Walking Weights") aimed at utmost elimination of subjectivity that is always present in modelling behaviour in the decision-making process.

5. RESULT OF RESEARCH

The main criteria for balanced exploitation and development of the sea and coastal area, along

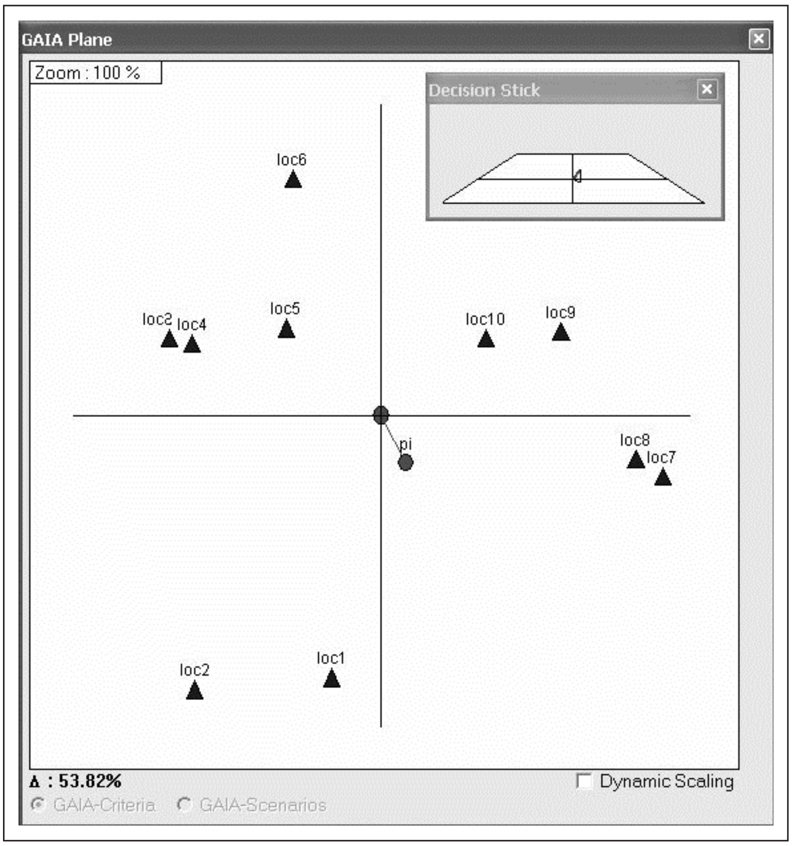

Figure 6 - Presentation of the position of potential locations of nautical ports in "u, v" plane

with the protection of natural features of the environment, and the selection of potential locations have been determined on the basis of sustainable development principles. It has been determined that the selected locations for nautical tourism ports are adequate. Simultaneously, individual and cumulative negative effects of nautical tourism ports to the environment have been taken into account, which relate to the construction solutions of piers and berths (solid, floating), characteristics of the basin in which the port would be located (depth, elevation, rate of water exchange) and the natural quality of the sea water. A possibility of fish farms or fishery near the nautical tourism port was also analysed, as well as other recreational activities.

The obtained results indicate that the selection of the location of a nautical tourism port is compatible with physical characteristics of the area. The selected locations, especially location L7, allow for:

- adequate exchange of water in the basin;
- configuration of the basin has advantages in relation to the depth (greater volume of water decreases negative effects like stale stagnant water, and increases the receiving capacity), gradient, basins do not require dredging, and stability of the coast.

The selection of facilities, that is, of services in a nautical tourism port is the result of the conducted analysis in which the demand and offer of nautical services were studied. A decision-maker, owner or investor, has to study the results of the market research before making a final decision about the selection of the facilities of a nautical tourism port. The analysis of the environment by a multi-criteria analysis will provide answers and orient the decision-maker towards the selection of the facilities of a nautical tourism port.

As it was already pointed out, the offer of the services of a nautical tourism port has to be suited to the boaters' expectations. The offer of the environment is an important factor in selecting the location of a nautical tourism port, because a good quality offer contributes to efficient business operations and to the development of the surrounding area. Therefore, selecting location L7, its adequate technological capacity (350 sea berths and 100 dry berths) and a possibility of offering high quality services, development of various facilities, both in the nautical port and in the nearby surroundings, is an optimal decision.

Locations L1, L8 and L2 have their significance and may be selected, since the selection of these locations, especially of L1 and L2 has socio-economic effects to the development of the surroundings and to the living conditions of the local inhabitants. The question about investing in locations L1 and L2 relates mostly to insufficient offer and infrastructure, while the location L8 has lower technological capacity (200 sea berths and 30 dry berths). By selecting these locations, the decision-maker will support the development of the area, provide employment for local inhabitants, and stimulate the development and the growth of complementary activities such as shipbuilding, repairing shipyards, servicing vessels, engines, sails, equipment and tools. The selection of locations L1 and L2 is the option of optimal selection of the location, with potential construction of smaller nautical ports of about 150 sea berths and 50 dry berths, and, as previously said, on condition of developing quality facilities in the nautical port and in its surroundings. The importance and the role of the local government are great, as it can stimulate and allow the development of nautical activities in a less developed area.

6. CONCLUSION

Multi-criteria analysis allows the decision-maker to attribute weight values to each criterion, taking into consideration the criteria for selecting the location of a nautical tourism port and clearly defined development objectives. Weight coefficients are different and depend on the level of decision-making. The results of the research indicate that locations have been adequately analysed, and that weight coefficients attributed in accordance to cartographic displays, physical plans, estimations, studies and experts' opinions are relevant. Further researches of micro-location for a nautical tourism port require a complex analysis of technological capacities and the production of several studies: maritime, traffic, economic justification and environmental effects.

The methods applied in this research are suitable for optimisation of selecting the location of a nautical port since they allow the selection of the preference types for every criterion (PROMETHEE). The PROMETHEE method allows for a model (numeric) processing of the problem and for presenting numeric and graphical results of ranking alternatives or locations. By presenting the behaviour of the criteria and sub-criteria using the GAIA method, the position of the criteria and sub-criteria and of potential location in "u, v" plane will be obtained.

Summarizing the exposed report, it is clear that by using the multi-criteria analysis method, the reached results can be used in the process-making of selecting the best location and contents of a nautical tourism port. According to the reached knowledge, it is possible to further improve the research for evaluating and managing the maritime domain and nautical ports.

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SAŽETAK

IZBOR LOKACIJE LUKE NAUTIČKOG TURIZMA PRIMJENOM METODA PROMETHEE I GAIA CASE STUDY – HRVATSKI DIO SJEVERNOG JADRANA

U radu se izlažu metode višekriterijske analize u funkciji izbora lokacije luke nautičkog turizma i to na način da se na primjeru izbora lokacije luke nautičkog turizma na Sjevernom Jadranu daje analitički i slikovni prikaz rješavanja postavljenog problema. U radu su korištene metode PROMETHEE I i II i metoda GAIA. Posebno se ukazuje na uporabu metode GAIA za vizualizaciju karakteristika problema geometrijskom interpretacijom te prezentiranjem rezultata višekriterijske analize. Primjenom opisanih metoda moguće je utvrditi najprihvatljiviju lokaciju uvažavajući načela održivog razvoja.

Naglašava se značaj primjene višekriterijske analize i korištenje višekriterijskog modela za odabrane metode koji sadrži kriterije i podkriterije za izbor optimalne lokacije luke nautičkog turizma. U radu su korišteni rezultati istraživanja „Kriteriji za odabir lokacije luke nautičkog turizma", koje je provedeno tijekom 2006/2007 godine.

KLJUČNE RIJEČI

luka nautičkog turizma, izbor lokacije, višekriterijska analiza.

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