USING GIS AND ANALYTIC HIERARCHY PROCESS IN DETERMINING THE SUITABILITY OF LAND FOR CONSTRUCTION OF WASTE FACILITIES IN FEDERATION OF BOSNIA AND HERZEGOVINA

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In the Federation of Bosnia and Hercegovina there no adequate area and system for processing hazardous waste , such as eg . Medical or the electronic. The construction of such facilities requires extensive planning with special emphasis on the protection of nature and environment. We also need to explore in detail the terrain and location of future space for waste facilities. The method of selecting the optimum location is interdisciplinary and requires a greater number of experts and criteria. As support of the decision-making process were selected AHP - analytical hierarchical process and the basis for decision-making are taken raster maps obtained in GIS tools. Combining these two tools will get a map with the optimal areas for construction of depots , which will facilitate their decisions planners in future plans.

Keywords: *AHP, GIS, waste, BIH, Federation of Bosnia and Herzgovina, raster, vector*

UVOD
INTRODUCTION

The situation with waste disposal in the Federation of Bosnia and Herzegovina is extremely critical. There are a number of pre-war official landfills, as well as a multitude of illegal dumps that its capacity began to exceed the mid-nineties. There will be many expansions of existing landfills, but little has been realized. In addition, there are very few landfills that sort and store waste by types or categories. Especially there is no special storage facilities for treatment of hazardous waste, such as medical or electronic.

For such installations need to take into account primarily on environmental factors, and the protection of nature and environment. So, in deciding where such locations to choose it is necessary to have information on the type and capacity of the area, population, hydrology, etc. These data represent the spatial information that is displayed using GIS. GIS a powerful tool for handling spatial data, which offers great opportunities for their display and analysis, but it is observed that the use of GIS and just is not enough to cover the complexity of the problem of determining the suitability of locations for any purpose and to contribute to timely decisions on how and where to use location.

The complexity of the problem and the various factors (social, environmental and economic) in assessing the suitability of the land for the last time is solved by combining GIS and some of multicriteria tools for individual and group application. Recently it was shown that the combination of GIS and multi-criteria methods and tools such as AHP naoptimalnije solution in decision making. Already there are specific methods and disciplines that combine these two tools, such as SDSS - spatial decison support system.

METODOLOGIJA
METHODOLOGY

Analitički hijerarhijski proces (AHP)
Analytic hierarchy process

Analytical Hierarchy Process (AHP) was developed at the Wharton Business School of the University of Penslivanije scientist Thomas Saaty. This method has been used for numerous high pole to analyze problems in decision-making in recent years. Analytical Hierarchy Process allows creators decision to set priorities and make choices on the basis of their objectivity, knowledge and experience with the intention that in accordance with our intuition make the best decision. (Džeba, 1996). By the way, this method discards redundant (illogical) decision, ie, points to them. This approach reduces the decision-making errors and gives us the measure (unit) and errors ie, index or coefficient of reliability decision (coincidence decision in comparing elements of the hierarchy).

Rejecting needless, this method allows precise determination of priorities in deciding between the verbal elements of the hierarchy even when concepts (characters, words) are not sufficiently defined. This feature opens up a whole new world opportunities - which means that we can use words (terms) as "quantitative factors compared elements of hierarchy and perform scale relations priorities hierarchy elements that can be combined with quantitative factors. Analytical Hierarchy Process is also numeric module, which with its quantitative aspect of problem solving can be too "precise" ie. give more "weight" to an element of the hierarchy than it really that element in hierarchy scale has. In regard to the AHP-in ie. the process of comparing pairs "toughest" element or the strongest priority is not crucial that is certain ie. directly elected, they are derived from a set of decisions, either verbally, either in numbers.

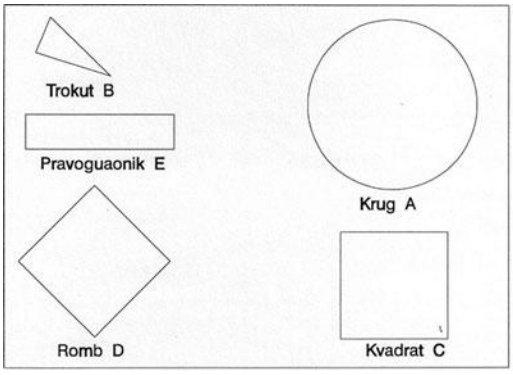

Fig. 1. Geometrical figures used in proving the validity of AHP study.

How do we know that this method of execution priority is really correct? First, based on the famous mathematical basis which shows that the sum of all the elements of a system or process the same unit. Secondly, the validity of the study was tested in reality and verified with international scientific associations. Suppose we need to allocate basic elements of nature necessary for human life and that we want to carry out the relative human needs: clean air, clean water, sound no noise, industrial waste, medical waste and acid rain (Džeba, 1996). By analogy this method, we assume that our understanding of the relative needs (for elements of our environment) coincide with areas of five facilities that are found in Figure 1. Also on that analogy, we can see these objects and to estimate their relative area (size) in number but this same analogy shows us how words can be used in setting priorities as qualitative factors. Using the words of comparison: the same, moderate, strong, very strong and extreme in a series of comparing pairs, individuals and even groups of people can judge (decide) the relative size of the given

5 elements and determine which element has the greatest "weight" on the list of priorities. The results are strikingly accurate and identical in all donosliaca decision.

Glavni koraci u provedbi AHP
Main steps using AHP

The implementation of the analytic hierarchy process requires several key steps (phases). The following conclusions based on Wind's and Saaty's descriptions there are four main steps in solving the problem of AHP.

These are:
1. Decomposition the hierarchy
2. Identify priority elements of the hierarchy by using a comparison pairs
3. Synthesis of results
4. Judgment - determining the reliability index

The first step in the analytical hierarchical process decomposition problem / decision in the hierarchy of judgment - which means precise objectives, criteria and alternatives. Every element of the hierarchy or level in the hierarchy can be described in advance, and as such is suitable for comparison of component in all levels of the hierarchy (Saaty, 1980). For example, criteria can be decompose in the sub-criterion and thus be lowered by one level in the hierarchy. The next hierarchical structure problem from top to bottom, ie, toward more specific to certain components of the problem, we can notice the increasing involvement of decision makers. Objectives Level 0 has the highest position in the hierarchy and from it all starts. Level 1 reflects the level of 0, ie. decomposing the main criteria. This level could be decompose into sub-criteria as sub-levels of the main criteria. The lowest levels sualternative ie. real objects. The second step is to determine the priority between pairs of elements of the hierarchy at every level of the hierarchy. The decision maker has the ability to determine the "importance", "preference" or "likelihood" of each element of the hierarchy, with giving precedence to higher levels in the hierarchy. First, we should determine the "importance" of elements at the lowest level of the hierarchy that is. be comparing alternatives in pairs to determine the significance between them. It is necessary to strictly respect the higher level of the hierarchy ie. criteria or sub-criteria (Džeba, 1996). The next step is the "preference" higher level ie. comparison criteria or sub-criteria. During this process should pay attention to objective criteria, ie. when comparisons criterion when comparing sub-criteria. For each set of comparisons of pairs were performed mathematical calculations in the form of numbers (index) for each element of the hierarchy, among them there are lines whose lengths represent the size of that number, and in the end is a very important factor consistency or reliability coefficient. This ratio shows us that it is our decision (judgment) within the set of comparisons pairs of elements of the hierarchy were consistent, logical.

Synthesis of results - This step represents a summarize of the results obtained a decision from the previous steps and calculates the sum of the priorities of each of the alternatives in relation to the entire hierarchy ie. with respect to the highest level of the hierarchy-goal. The sum of priorities of alternative represents to the degree that each of the alternatives fit any of the criteria or sub-criteria. Or rather a synthesis of "local" priorities

results in a "global" or the overall priorities for alternative courses of actions. The alternative with the largest sum is most preferred real object.
Judgment - determination of the coefficient of reliability for each set of comparing pairs exist reliability coefficient. Generally this ratio should not exceed 0.10. A higher coefficient of this number tells us that the model of decision-making is inconsistent and that the decision-maker must re-examine its own. Decision compared pairs and are of such a re-enter the AHP model. Only after obtaining the number of under 0:10, we can say that the model is a good decision.

AHP i GIS
AHP and GIS

Combining AHP methods and GIS tools gets a new dimension to rational decision-making in order to evaluate the land. The combination of these two elements we got a SDSS - spatial decision support system, one of the latest methods in decision making when evaluating land or location (Malczewski, 2006).
The steps in the implementation of the following:
1. Defining the problem
2. Define criteria for evaluating land
3. Collected and preparation of data (digital maps, raster maps, DEM)
4. Converting obtained maps in formats set criteria
5. Reclass of created/given map
6. Making matrix of decision obtained reclassified maps
7. Getting the results of decision making and consistency coefficients
8. Making and display the resulting new map with details of land value with the specified criteria.
These steps will apply in the case of determining the best location for the landfill of hazardous waste in the Federation BiH.

DISKUSIJA
DISCUSSION

An example was made in the GIS software ArcMap and corresponding AHP module.

1. In our example, the problem is to determine the location of land for the depot of hazardous waste in the Federation. FBiH is geographically very different, the north is mostly mountainous and the south on the Adriatic Sea, a central part of the FBiH is mostly mountainous and hilly.

2. For landfill of hazardous waste, we took the following geophysical criteria:

- Altitude (elevation)
- The slope of the land (slope)
- Distances from river
- Distance from bigger settlements
- Near roads

3. Digital maps are collected from the Internet, most of the servers The European Environment Agency (EEA) and were DEM formats (digatal elevation model).

4. After converting maps by criteria, such as altitude, slope and distances from the river, the distance from the village, and the proximity of roads in ArcMap software had the following maps:

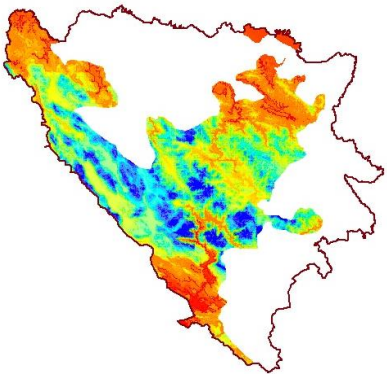

Fig. 2. Digital Terrain Model of FBiH

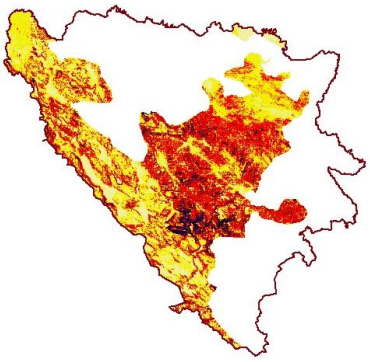

Fig. 3. Slope

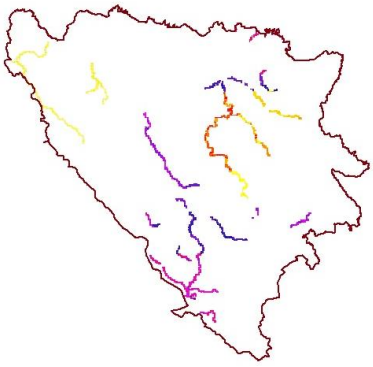

Fig. 4. Rivers of FBiH

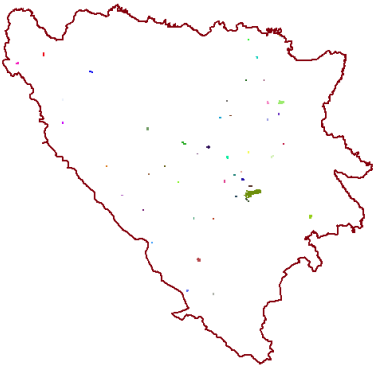

Fig. 5. Larger settlements in FBiH

Fig. 6. The main roads in the FBiH

Reclassification of created map

Treatment of the above shown maps with *reclass* function in ArcMap ie. reclassification maps, we received the following:

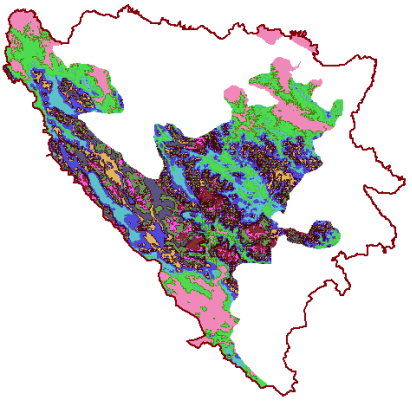

Fig. 7. Reclassified map FBiH

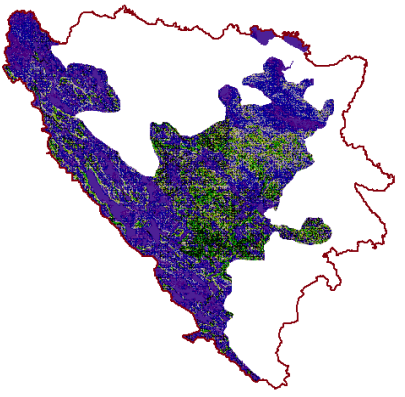

Fig. 8. Reclassified slope

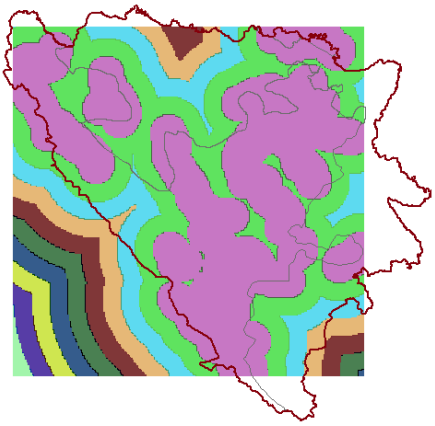

Fig. 9. Reclassified distance from the river

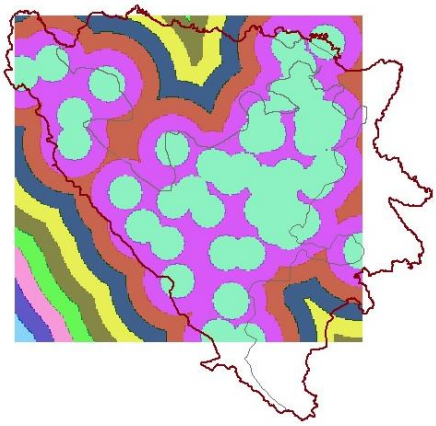

Fig. 10. Reclassified distance from settlements

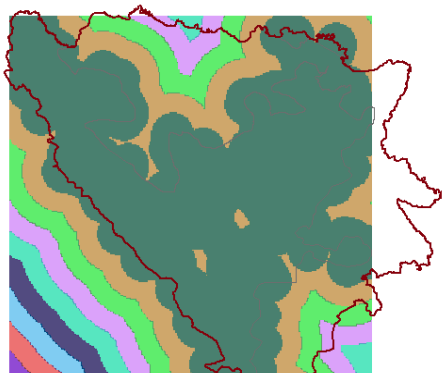

Fig. 11. Reclassified proximity to main roads in the FBiH

After reclassification, the optimal approach to the formation of maps for each criterion so that each cell in the grid on the map to give criteria to be classified in the appropriate class, which it is given the matching result.

7. Making decision matrix obtained reclassified maps. For criteria C1, .., CM, forming a matrix of decision-making, as in Table 1. Elements of matrices are the result of comparison criteria in pairs using Saaty 's Scale. The AHP-in to determine the weight of the criteria used methods eigenvalues (eigenvector Method), that determines the right main vector of eigenvalues of matrix A by solving linear systems: $Aw = Xw$, $w^Tw=1$ where w is the required vector weight criteria, and X is the largest net value (eigenvalue) of A (Jandrić, Srđević, 2000). Optimum map with the specified criteria to obtain:

$^{r}ix,iy = z\ ^{w}v\text{^}.y \qquad ^{ix} = {}^{1}\ ..^{,\ nx};\ ^{i}y = \wedge\ ^{n}y$ where rix, iy value of the cell ix, iy on the final map benefits, wj weight coefficient of criteria j, vj; lxiy record date cell for criterion j, and nx and ny are the number of cells in the grid in the x and y direction. Image review process would look like: After thus prepared maps ready for processing in AHP Module as part of ArcMap software, we execute the decision with the specified criteria. Therefore, it is our most important criterion distance from the river (rcl_vode), then, distance from the larger settlements (rcl_grad), close to the main roads (rcl_magist) then slope (reclass_slope) and elevation (reclass_fbih). Matrix decision-making, ie AHP module can see Figure 13.

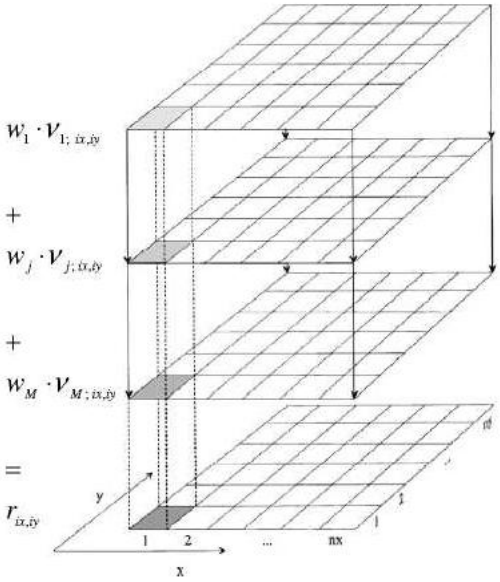

Fig. 12. The principle of combination weights raster criteria

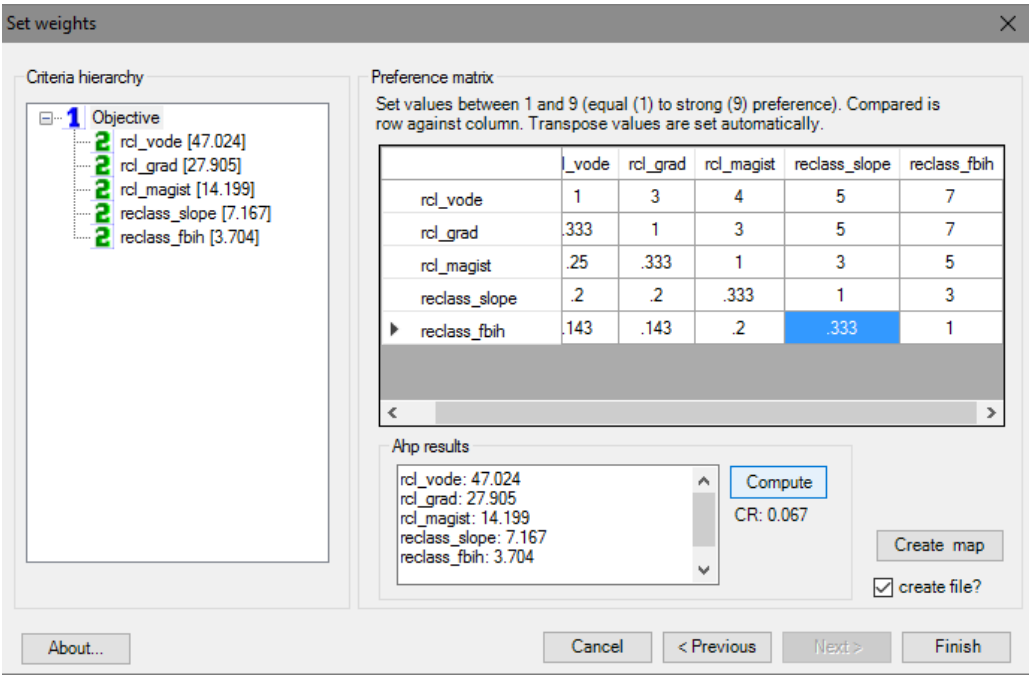

Fig. 13: Determination of the weight coefficients in AHP module.

REZULTATI
RESULTS

As can be seen in Figure 13, the criterion rcl_vode (distance from the river) by a Sattiy's scale isimportant criterion from rcl_grad for 3 points and for 4 points of the rcl_magist and reclass_slope for 5 points and 7 points from reclass_fbih. Etc. for all pairs of comparison criteria as shown in Figure 13. Coefficient of consistency we have 0,067, which means that our decision was logical. Finally, we have a new map that shows the most suitable sites for the construction of a depot for waste in the FBiH.

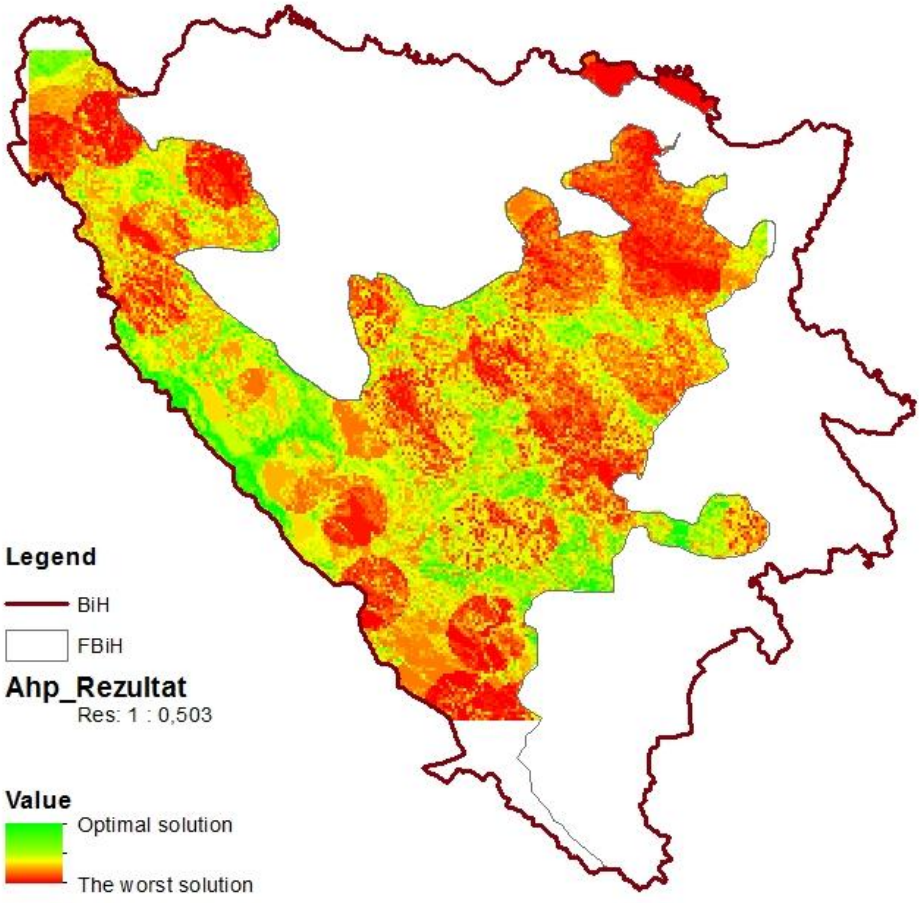

Fig. 14. The final map obtained AHP process

Figure 14 is a map that shows us the best places to build the landfill of hazardous waste. The green color means the best places to build, while the red the worst. Yellow is the medium solution.

ZAKLJUČAK
CONCLUSION

In order to select the best location to build waste depots in FBiH, we used a combination of two tools, multi-criteria model AHP and ArcMap software, and links between the Visual Basic module extAHP20 (Marinoni, 2006). The problem to decide was find optimal location. Preparation of data in the form of maps and database, we get a basis for the selection criteria in decision-making. After prioritization of the criteria is more important we get the final visual map, which can be present to people who give the final decision on the construction of the depot. In the final map to see that the green areas most suitable for the location, while the red most unfavorable.In this way we could bring other decisions, given the change in criteria.
As the introduction of new criteria, so changing priorities between criteria.

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