Selecting the optimal opensource GIS software for local authorities by combining the ISO 9126 standard and AHP approach

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Abstract – This paper presents an example of the combined application of multicriteria analysis and ISO 9126 standards in the selection of the optimal open source GIS software for use in GIS is the local government. Due to the large number of open source GIS solutions, the question of choosing the best open source GIS software in depending on the objectives, is becoming increasingly topical. In particular, the case is in the development of local government GIS, where the quality obtained depends quality of decisions made, and thus the direction of community development. The paper highlights this basic AHP methodology and observed opensource GIS software, and explained the criteria defined software quality standard ISO9126. For example, GIS software of choice the best solution for local government is shown in AHP evaluation process and the observed ranking software. Taking into account the current market trends in opensource, the software monitored, identified those who would in the future should play a significant role.

I. INTRODUCTION

Collection and processing of spatial information is a significant segment of the decision-making process, particularly in the management of resources limited by the local community. Applying information technology in this process of decision-makers were given powerful tools that enable gathering and processing large amounts of spatial data quality and create for a short time. Information systems that enable the processing of spatial data and presentation of an adequate form of treatment called geographic information system (GIS for short). These are five-component information systems make up following components: procedures, people, data, hardware and software. This paper presents one way of selecting the most optimal opensource GIS software used in decision-making in local government.

The first part, that is, the first three chapters present basic information on the AHP method, the open source GIS software that will be evaluated and criteria that can use the parking during the specified quality appraisal software. The second part describes the processes and tools use AHP methods in choosing the most optimal opensource GIS software. Finally, they presented the research results and conclusions.

II. AHP METHOD

Optimal choice of open source GIS software for use in local administration was carried out using multicriteria analysis methods, Analytic Hierarchy Process - AHP. The conceptual and mathematical setting AHP Thomas Saaty gave [1]. This method is a useful and simple method designed to provide assistance to decision makers in solving complex decision problems involving a number of criteria and decision makers [2].

This is a multicriteria technique based on the decomposition of complex problems in the hierarchy. The goal at the top of the hierarchy, while the criteria, subcriteria and alternatives at lower levels. As an illustration, Fig. 1. given is a hierarchy consisting of the goal, the four criteria and three alternatives. The hierarchy may not be complete, for example, element at some level need not be a criterion for all elements in the sub-levels, so that the hierarchy can be divided into sub- hierarchy which is the only common element in the hierarchy.

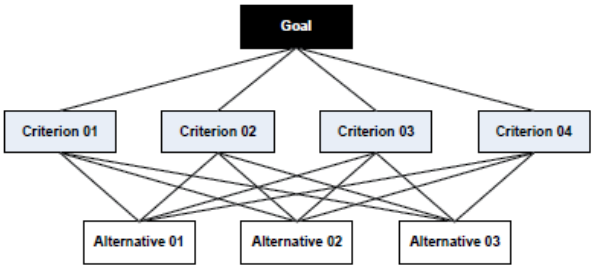

Figure 1. Example of a hierarchy of criteria/objectives [3]

As mentioned establish hierarchical structure, structure of the elements and each other in pairs compared, with the expressed preferences of decision makers with the relevant scale (Saaty's scale relative importance). It has 5 levels and 4 interstage verbally described the intensity and the corresponding numerical values for them in the range 1-9. From estimates of the relative importance of elements appropriate level of the hierarchical structure of the problem using appropriate mathematical model to calculate the local priorities (weights) of criteria, sub-criteria and alternatives, which are then synthesized in the

overall priorities of alternatives. Finally, sensitivity analysis is conducted and deduced.

III. OPENSOURCE GIS SOFTWARE

Open source software is a type of "free" software to be accessed, used or modified by their user groups and developers. There are several organizations that can provide free software license templates, such as General Public License (GPL) and Berkeley Software Distribution (BSD).

The subject of this paper is the optimal choice of opensource GIS software for the GIS community. This problem is particularly significant since we are available to a number of opensource GIS software that are in various stages of development. Analyzing the most usable software listed in the region of Western Balkans as a case assessment were selected following software [5]:

- GRASS GIS (Geographic Resource Analysis Support System) is one of the first open source GIS software. It offers comprehensive GIS analysis functions for both vector and raster datasets. The original user interface of GRASS was in command line only. Quantum GIS GRASS can embed all functions via a graphic user interface (GUI) for easier public use. Multiple data input formats are available, including MySQL, DBF, Post GIS, and SQLite.
- Quantum GIS (QGIS) is a free software desktop Geographic Information Systems (GIS) application that provides data viewing, editing, and analysis capabilities. Quantum GIS (QGIS) provides a very nice integration with Python, a scripting language to automate or customize GIS functions. The software provides useful tools in GIS spatial analysis, geoprocessing, geometry, and data management tasks. Two unique features of QGIS include the linkage (expendable) to GRASS functionalities and the support of DWG file formats.
- KOSMO is one of the most popular open source desktop GIS (Java-based), providing a nice Graphic User Interface (GUI), GIS data editing tools, and spatial analysis functions [6]. KOSMO has improved cartographic and spatial analysis functions from OpenJUMP, providing a friendly and comprehensive GIS package for desktop computers. One major advantage of the capability KOSMO is for users to edit / modify vertices (a very detailed level of segment nodes) in vector-based layers.
- gvSIG was developed by the European GIS community offering multiple language user interfaces. gvSIG has nice vector data editing functions. gvSIG is well known for its flexible GIS data input format. You can use various GIS data formats (both vector and raster) and online resources (such as WMS, WFS and WCS). Some professionals believe that GIS gvSIG is becoming close to replacing ESRI ArcMap software.
- uDig is also a popular Java-based desktop GIS software. uDig offers strong capabilities to integrate Web mapping technologies, such as WMS, WFS, remote ArcSDE, WCS, GeoRSS and KML. The uDig website includes great tutorials and walkthrough documents for first-time users. uDig is built upon IBM's Eclipse platform with a "clean" user interface. uDig GIS provides several good functions, including the Styled Layer Descriptor (SLD) support, Web Catalog Server support, and thematic mapping with advanced symbology.

IV. CRITERIA FOR SELECTION SOFTWARE

To use the appropriate software is essential for obtaining high quality information as a pre-requisite for making decisions effective. This is especially important when making decisions important to the future development of the local community. To ensure proper quality it is necessary to properly execute the specification and evaluation software.

Evaluating software characteristics above stated, in relation to its objectives, was performed based on defined criteria ISO 9126 standard for software quality assessment. This is now one of the most influential standards in software engineering. Its hierarchical structure of criteria and sub-criteria makes it very suitable for the application of the AHP methodology. This standard defines six criteria and 27 sub-criteria to assess the quality of software [7]:

- Functionality - This attribute is defined as the degree to which functions the software satisfies stated or implied needs and can be broken down into five sub-characteristics as follows: suitability, accuracy, interoperability, compliance and security.
- Reliability - This attribute is defined as the capability of software that could maintain its level of performance under stated conditions for a stated period of time. It can be decomposed into three sub-characteristics as follows: maturity, fault tolerance and recoverability.
- Usability - This attribute is defined as the degree to which the software is available for use and can be broken down into three sub-characteristics as follows: understandability, learnability and operability.
- Efficiency - This attribute is defined as the degree to which the software makes optimal use of system resources. It can be decomposed into two sub-characteristics as follows: efficiency of this behavior and efficiency of resource behavior.
- Maintainability - This attribute is defined as the ease with which repair may be made to the software and can be broken down into four sub-characteristics as follows: analyzability, changeability, stability and testability.
- Portability - This attribute is defined as the ability of software that can be transferred from one

environment to another. It can be decomposed into four sub-characteristics as follows: adaptability, installability, conformance and replaceability.

V. EVALUATION OF SOFTWARES

A. *Process of evaluation*

On the basis of the completed surveys and interviews with several municipalities on the territory of Bosnia and Herzegovina, which geographically used information system in their daily work and decision making processes came to the conclusion that the application of GIS software commercial in small municipalities is unsustainable because of the large allocations for its maintenance in relative to their small budgets. The application of open source GIS software is the solution to this problem. However, the problem of implementation of the above software to answer the question "What is open source software that meets the specific requirements of local government?", As the offer of this software is really great.

This paper presents the application of AHP methodology in selecting the best opensource GIS software application at the local level. As for the evaluation criteria were used criteria defined software quality standard ISO 9126. It examined five opensource GIS software that have been identified based on interviews with experts who can base the development of open source modules for use in local communities: GRASS, QGIS, KOSMO, uDig and gvSIG.

To create a model applicable to AHP Expert Choice software, which fully supports the structure hierarchical structure of AHP methodology. The program allows structuring hierarchical model problem in several ways, and also comparing the couples in several ways. A special value of the program give different possibilities for the sensitivity analysis based on the visualization result of the input data changes.

The first step in this process was the definition of the goal. In this study, it was: "The choice of optimal opensource GIS software for use in local government", which is the aim of the research. The second step is to define an alternative. In this study it was five previously selected open source software's GIS (GRASS, QGIS, KOSMA, uDig and gvSIG). The third step is to enter the criteria against which assessment will be done. In this study, it was the six criteria of software quality: functionality, reliability, usability, efficiency, maintainability and portability. Fig. 2. showing workplace Expert Choice 2000, defined the elements of AHP model.

Since the establishment of a hierarchical structure of decision problems is made of elements in mutual comparison levels. Comparison is done in pairs, and compares the node with the higher level nodes of the next lower level. In our study we compared the criteria with a set objective, criteria and alternatives. When it is compared to every member of the lower level with all members of the first higher level. In comparison criteria in relation to the objective of evaluate the importance of that. weight the criteria to achieve this goal. In comparison

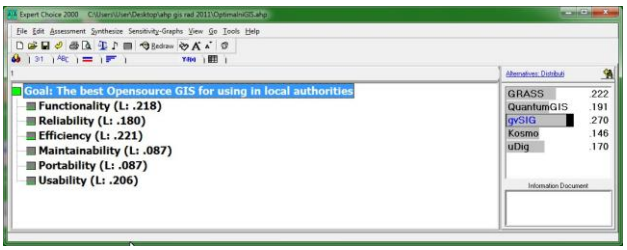

Figure 2. Windows of Expert Choice 2000 software with structured hierarchy AHP

alternative to the criteria evaluates the extent to which the benefits of one alternative to another alternative in comparison to the criterion. For the evaluation used a balanced Saaty scale (Tab. 1.) [8], since a large number of papers showed that the scale increases the reliability of the overall consistency of assessment and evaluation process reduces the waste hierarchy and calculating weight values.

During the evaluation were taken into account the

TABLE I. BALANCED SCALE

Definition	Balanced scale
Equal importance	1
Weak dominance	1.5
Strong dominance	2.33
Demonstrated dominance	4
Absolute dominance	9

comparative analysis of these available software, GIS expert opinion, and accumulated experience and expert knowledge of application technology in the local information Administrative community. Fig. 3. table shows the Expert Choice 2000 environment in which they entered ratings that compare the priority criteria in relation to its objectives. We note for example. functionality to the criteria and have the same usability significance in relation to the goal and put the score 1 (Equal importance), while the functionality significantly more important criteria in relation to the objective criteria than portability and therefore the score is placed 2.33 (Strong dominance).

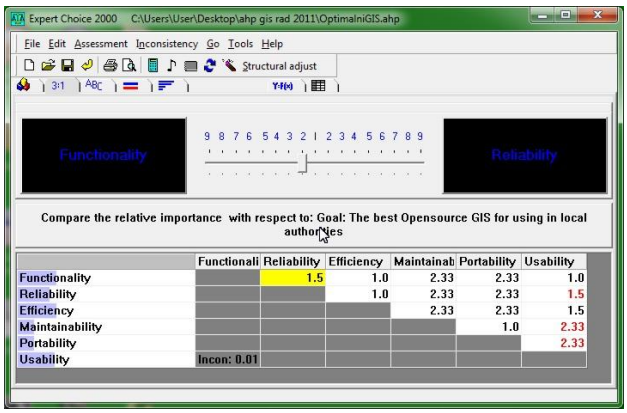

Figure 3. Windows of software Expert Choice 2000 - table with marks

Analogous to evaluate the criteria was performed according to assessment of alternatives, i.e. software in relation to criteria (or sub criteria). Fig. 4. table shows the Expert Choice 2000 environment in which they entered the grades compare alternative features (opensource GIS software) in relation to one of the criteria (e.g., functionality). We note for example. GRASS software that has significantly greater functionality than the software and the data QGIS score 2.33 (Strong dominance). The same software compared to software evaluation is gvSIG 1.0 (equal importance), which means that these two software-the same level of functionality.

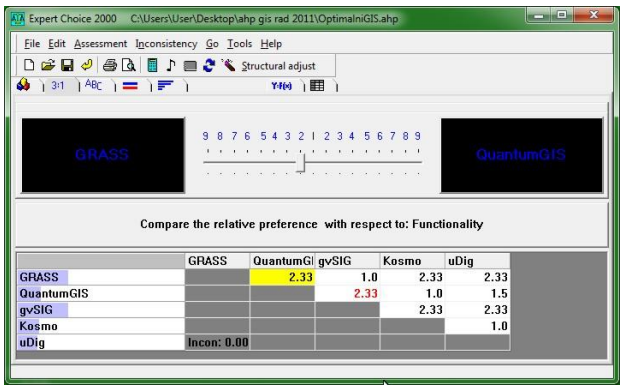

Figure 4. Windows of software Expert Choice 2000 - table with marks

During the assessment it is important to take into account the consistency of the appraisal process. This parameter is very important because any assessment of where a person is an important factor has a significant degree of subjectivity. Expert Choice 2000 software automatically calculates the degree of consistency when you type rating. If the result was sufficiently accurate and there is no need for correction in the reopening of comparisons and calculations necessary to the said level is less than 0.10. In Fig. 3. we can see that the degree consistency is 0.01 which is within tolerable limits.

B. The results of evalauation

Final results of AHP methods are weights of alternatives in relation to the goal, which is the sum of the first the greatest weight ratio is the best alternative, and the smallest - the worst. In Tab. 2. are given by weight coefficients obtained in this study:

TABLE II. RANKING OF ALTERNATIVES

Alternatives	Weight coefficients
gvSIG	0.270
GRASS GIS	0.222
QuantumGIS	0.191
uDig	0.170
KOSMO	0.146

Based on the values obtained by weight coefficients can be concluded that the open source gvSIG GIS software has the highest weight ratio and is most optimal for use in the development of geographic information systems of local governments. Fig. 5. shows a chart on which are displayed ranked software that was subject research and impact on the defined set of criteria aimed research.

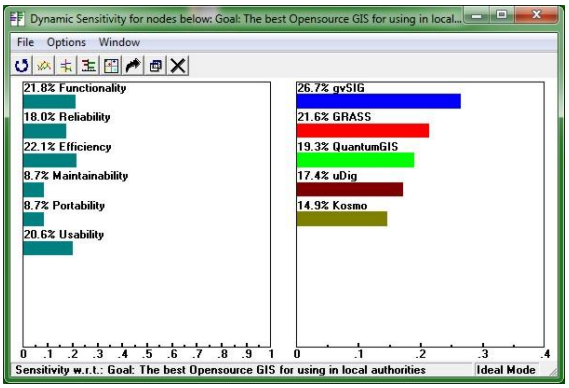

Figure 5 Windows of software Expert Choice 2000 - Dynamic graph

In addition to ranking the alternatives used Expert Choice 2000 software offers a graphical display that allows a sensitivity analysis. For example, what the alternative was the order if certain criteria given greater importance in relation to the goal. The Expert Choice 2000 following charts are available:

- Performance - to compare the characteristics of alternatives (in our example software) with criteria (Fig. 7.).
- Dynamic - allows you to see how to dynamically change priorities alternatives if we change just by dragging the weight of individual criteria
- Gradient - allows you to see how the priorities of alternatives are sensitive to changes of certain criteria (Fig. 6.).
- Head to head - provides an overview of the advantages of one alternative over the other criteria.
- 2D – two-dimension comparison to the value of the two criteria in relation to alternatives.

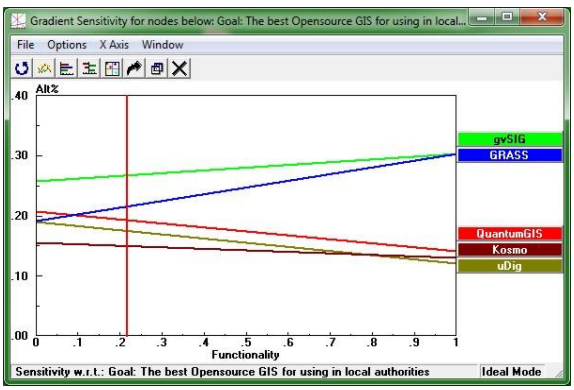

Figure 6. Windows of software Expert Choice 2000 - graph Gradine

In Fig. 6. chart type "gradient" which shows the relationship between functionality and performance criteria that is an alternative. the software. From the diagram it can be seen that the two software GRASS and gvSIG have the best in terms performance functionality software.

This analysis significant especially when the difference between the weights of individual small or alternative simulation of the planned future state where it will get some criteria more important than now. An example of this trend of development of the QGIS software in new versions of a more integrated function of GRASS software. In this way, the software in the future to significantly increase its functionality. In that case, the functionality of the software QIS and gvSIG were the same, and the software then the two had almost the same weight ratio. Fig. 7. shows the ranking of alternatives in these conditions and the impact of increased usability criteria. On the chart shows that in these conditions there were two open source GIS software that meet the optimal conditions for the use of GIS in local government.

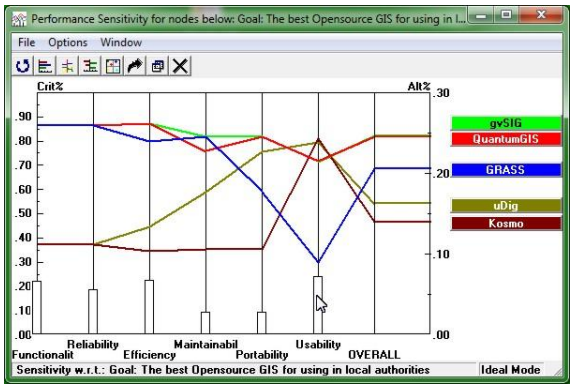

Figure 7. Windows of software Expert Choice 2000 - Performance graph

VI. CONLUSION

Solving the problem of optimal choice of GIS software for use in GIS applications in local government applying appropriate mathematical methods. Since optimal solutions to these problems generally do not exist, this paper applied the multicriteria analysis (AHP method) based on the criteria of ISO 9016 standards.

The presented results of a can't be generalized, but regarded as a representation of a single methodology to solve this problem specifically.

Finally, it can be concluded that the combination of a hierarchical structure of criteria and AHP methodology has proven very successful in the selection of the optimal analyze software. Displayed methodology can be successfully applied to a wide range of problems encountered during the development of GIS.

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