



<sup>1</sup>. Dejan JANKOVIC, <sup>2</sup>. Radmila MILIDRAGOVIC

## INTEGRATION OPENSOURCE GIS SOFTWARE FOR IMPROVING DECISION-MAKING IN LOCAL COMMUNITY

<sup>1</sup>. THE CITY OF TREBINJE, BOSNIA AND HERZEGOVINA  
<sup>2</sup>. “NEIMARSTVO” AD, BOSNIA AND HERZEGOVINA

**ABSTRACT:** The paper presents an example of integration of various functionalities opensource GIS software to improve decision-making in local governments. It shows the synergistic possibilities of integrating various opensource GIS software to support decision-making (DSS). Special attention is paid to geoprocessing capability. Further, it is analyzed the significance of building spatial data infrastructure at the local level as basis of DSS. The research was done on the example of choosing the best options for the reconstruction of public lighting. The results of this study contribute for promote the growing trend of integration the compatibility of various GIS open source software solutions.  
**KEYWORDS:** GIS, geoprocessing, opensource software, local government, DSS, SDI

### INTRODUCTION

Collection and processing of spatial information is a fundamental process of decision making. If we do not have high-quality and forehand information, and we do not have the necessary tools for their high quality and fast processing treatment, we will get the results that neither forehand nor appropriate to make prompt and quality decisions. About this would be paid attentions in decision-making in local governments. Decisions have made at this level significantly affect the development or stagnation of local communities, such as rational or irrational use its limited resources.

With applying of GIS information technology in decision-making processes, decision-makers were given powerful tools that enable the collection and processing of large amounts of spatial data and creating quality information in a very short time. The Geographic Information Systems (GIS) are complex five-component information systems that comprising the following components: procedures, people, data, hardware and software. This paper describes the integration of several open source GIS software for various purposes in the process of decision-making in local government.

The first part of papers namely the first three chapters present basic information about opensource GIS software and spatial data infrastructure. The second part describes underlying problem and research methodology. At the end of the study presents the results and conclusions.

### OPENSOURCE GIS SOFTWARE

Open source software (OSS) is computer software with its source code made available and licensed with an open source license in which the copyright holder provides the rights to study, change and distribute the software to anyone and for any purpose. Open source software is very often developed in a public, collaborative manner. [1]

GIS software encompasses a broad range of applications which involve the use of a combination of digital maps and georeferenced data. GIS software can be sorted into different categories [2]:

- Desktop GIS usually serve all GIS tasks and are sometimes classified into three functionality categories: GIS Viewer, GIS Editor, and GIS Analyst.
- Spatial Database Management Systems (DBMS) are mainly used to store the data, but often also provide (limited) analysis and data manipulation functionality.
- Web Map Servers (WMS), Web Feature Servers (WFS) are used to distribute maps and data over the internet.
- WebGIS Clients are used for data display and to access analysis and query functionality from Server GIS over the internet or intranet.
- Libraries and Extensions provide additional (analysis) functionality that is not part of the basic GIS software, for instance functions for network and terrain analysis, or functions to read specific data formats.
- Mobile GIS are often used for field data collection.

Large number of open source projects is active today. A significant number of them have reached a remarkable level of maturity. That is one of reason why increase number of government institutions which use open source GIS software. However, there are still a significant number of customers are choosing a commercial GIS software. Causes for this are numerous, but it is undoubtedly one of the most important is that the open source GIS projects are specialized.

While commercial vendors usually offer products for all of software categories (e.g. ESRI Inc), open software projects often concentrate on a single category, e.g. desktop GIS or WebMap server.

In this paper are explored possibilities of integrating various opensource GIS software in order to create unique integrated Decision Support System (DSS). The survey was conducted on example of solving problems in local governance. Solution has been showed is integrated functionality: Desktop GIS software (gvSIG), spatial DBMS (PostGIS), server applications (GeoServer) and geoprocessing framework spatial data analysis library (Sextante).

### SPATIAL DATA INFRASTRUCTURE

The term "Spatial Data Infrastructure" (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general [3]. Establishing SDI creates the preconditions for rational spatial data collection, their standardization and marketing and its put to develop of any local community. All stakeholders who interesting for development specific community (investors, researchers, entrepreneurs and others.) will be able data which necessary for conduct complex searches and analysis as the basis of them decision-making processes [3], [4]. In this example was shown applied three-tier architecture of information system. (Figure.1). [5]

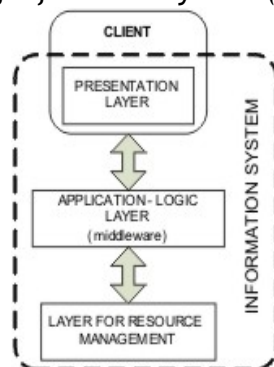


Figure 1. Tree-layer architecture of information system. Resource management layer is a base layer of the architecture, and includes data sources, most often databases (e.g. PostGIS DBMS).

Presentation layer provides communication between information system and external users who may be a person or another computer for example web browser (e.g. gvSIG, Sextant).

Application-logic layer namely middleware, includes a collection of programs that accept data from multiple data sources and transform it into a form that corresponds to the presentation layer (Web mapping service (WMS), Web Feature Service (WFS), Web Processing Service (WPS)).

Applying service-oriented SDIs compared to the traditional approach are achieved by the following advantages [4], [6]:

1. reduce costs,
2. reduce development costs by not developing all the components,
3. services allow avoiding incompatibility of software,

4. the cost of applying of services is less than the cost of construction.

Specifications of these services are defined by the standards of the Open Geospatial Consortium (OGC). OGC Web Services standards are defined frames which are provided by the dealer an independent, interoperable framework for web-based discovery, access, integration, analysis, exploitation and visualization of multiple online sources of spatial data and their processing capacity [8], [9].

During of this research it is executed simulation using of spatial data that was obtained through Geoserver's web services. In this way it is possible to analyze data which are stored in different locations. For example, spatial plans by the database of local government, water supply infrastructure by the database companies for management of water supply system or electrical network plans by the database of power supply company. Thus, we always have available update spatial data that is very important in decision making.

### THE RESEARCH PROBLEM

Integration differently oriented opensource GIS software, in order to develop GIS-based decision support system of local government, was made on the example of solving the problem of energy efficiency in poor lighting system. For instance, in Trebinje (Bosnia and Herzegovina) almost 4% of the city budget goes to the cost of electricity lighting. The main causes of this inefficiency are defined: inefficient lighting modules, a large number of lamps and the lack of an effective system of managing public lighting. Therefore, it was decided to choose the best variant of reconstruction of public lighting.

If we want to choose the best solution, we will define amount of saving electrical energy by existing lighting modules with mercury bulbs are being replaced with new energy efficient lighting modules with LEDs diodes or high pressure sodium lamps.

In addition, it was necessary to take into account assessment of fulfill the standards that define the nominal brightness of certain public areas. Furthermore, it is necessary to change deployment of available light module to illuminate so far darkened public space. The results of the analysis it was necessary to show in the form of maps that would clearly be identified which public space are satisfactory illuminated and which not, such as are presented that in numerical form.

### METHODOLOGY

To create a DSS for selecting the best options for increasing the energy efficiency of lighting were used the following opensource GIS software:

- 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, WCS and WFS). Some GIS professionals believe that gvSIG is becoming close to replacing ESRI ArcMap software. [10]

- *Sextante* is a spatial data analysis library written in Java and a powerful geoprocessing framework. It currently contains more than three hundred algorithms for raster and vector data processing, as well as tabular data analysis tools. *Sextante* integrates seamlessly with open source Java GIS (such as gvSIG), proprietary GIS (such as ArcGIS) and non-GIS tools (such as the 52N WPS server). The *SEXTANTE* for gvSIG extension makes it possible to use *Sextante* tools directly in gvSIG, using module Model Builder. [11]
- *Geoserver* is an open source software server written in Java that allows users to share and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards. *GeoServer* is the reference implementation of the Open Geospatial Consortium (OGC) Web Feature Service (WFS) and Web Coverage Service (WCS) standards, as well as a high performance certified compliant Web Map Service (WMS). *GeoServer* forms a core component of the Geospatial Web. [12]
- *PostGIS* is a spatial database extension for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL. The database can then be used to store and query spatial data (points, lines and polygons). [13]

The first is upgraded a software gvSIG with *Sextant* data analysis library. After that, spatial data are prepared by gvSIG software. On the base of aerial photographs have been made vector maps of streets of Trebinje, currently deployment of lamps lighting and currently deployment of lamps lighting with isolux diagrams. For each of the analyzed variants of public lighting reconstruction it has been prepared vector map that included isolux diagrams of new lamps with appropriate new spatial deployment. These vectors files and related raster file have been loaded in the spatial database and WMS and WFS Geoserver services. On this way, the data necessary to perform the analysis were provided.

The next step is being made algorithm of analysis. Namely, the steps of spatial and attribute analysis that needs to be done on the available spatial and attribute data would be defined in order to obtain the desired result.

For comparison of the current state of illumination of public areas with expected brightness is being used with the new energy efficient light bulbs is defined by the following algorithm:

- load vector maps backgrounds (the streets - line, the isolux of lights modules diagrams - polygon, the boundaries of analyzed area - polygon);
- overlapping vector map - streets and vectors map - isolux diagram over vector file in which borders are defined in the study area and is being copped (algorithm-Clip);
- depending on the width of streets, which is listed as attributive data the buffer function is executed. Results would be vector maps of polygon street view, depending on their width;
- to define public surfaces that are illuminated it would be done algorithm - intersection of vector

layer street - polygon and vector layer of isolux light diagram on specific the analyzed surface;

- finally, it would be got a vector polygon layer that display illuminated public areas and presented their statistics, the most important figure is the total amount is illuminated public surface in the analyzed area.

In addition is done algorithm that computes expected energy consumption of public lighting in the analyzed area. This algorithm had the following steps:

- load vector files (position lights - point, analyzed area - polygon) and attribute data (average daily working hours of public lighting - hours, time analysis - days);
- overlay vector files to define the area to be analyzed;
- using an algorithm that summarizes all the power lights that are located in the project area in one layer with the polygon will have this information as an attribute;
- do calculations under certain defined formula;
- present the expected total energy consumption for the whole period of time and analyzed area in KWh.

The above algorithms are implemented by combining and linking *Sextant* algorithms within their GUI Modeler (Figure 2).

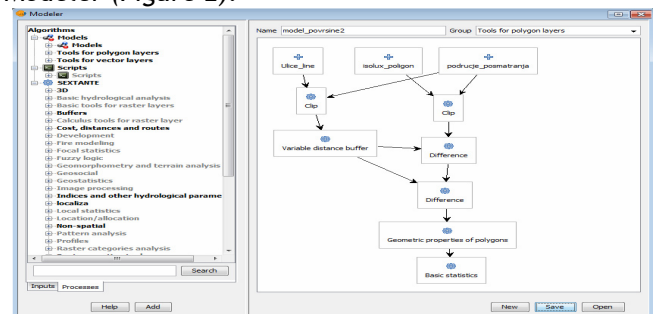


Figure 2. Workplace of Sextant library builder for geoprocessing

The graphical modeler allows to create complex models using a simple and easy-to-use interface. Using the graphical modeler, that chain of processes can be wrapped into a single process, so it is easier and more convenient to execute than a single process later on a different set on inputs. No matter how many steps and different algorithms it involves, a model is executed as a single algorithm, thus saving time and effort, specially for larger models.

In this example, the *Sextant* GUI modeler is started within an integrated environment with gvSIG software. GUI modeler interface are consist of a desktop where is dragged and associated algorithms from the list that is on the left side. Besides there is the possibility that offered to the user to combine all of algorithms have been offered by vendor or user-making. This allows to user creating algorithms which are performed really complex analysis. Algorithms are listed previously, can be activated in two ways:

- directly employed through gvSIG environment (Figure 3)
- executive through batch file (Figure 4)

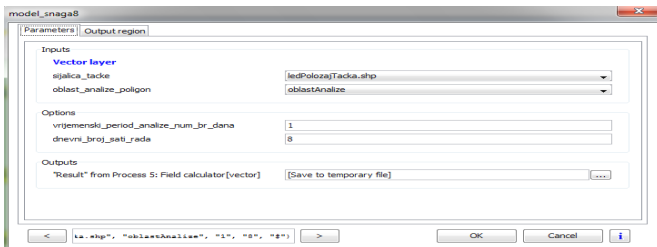


Figure 3. Windows of software Sextante for defining input of parameters in gvSIG workplace

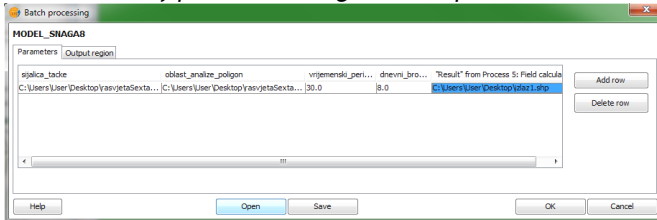


Figure 4. Windows software Sextante for defining input of parameters in batch mode

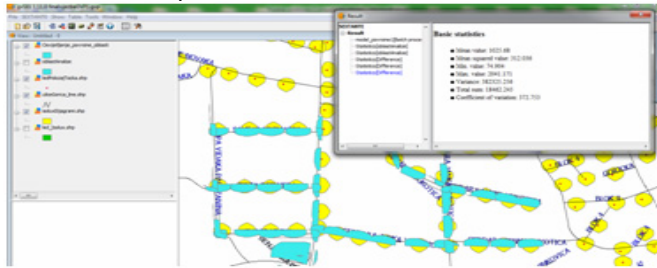


Figure 5. Windows of gvSIG software with result of spatial analysis with Sextante library

Input parameters can be loaded from the local disk, database or through WMS, WFS service. The following figure (Figure 5.) shows the result of the processing algorithm created for representing illumination of public areas by applying the appropriate model lamps.

## RESULTS

The main results of this research can point out the successful integration of more functionality opensource GIS software into a single decision support system for the local government.

Applying service of Geoservers is highlighted the importance of establishing a spatial data infrastructure at the local level. The SDI at the local level should provide the necessary spatial data for the analysis as support of decision-making processes. In beforehand examples are defined algorithms through which are successfully integrated spatial data from different locations. Moreover, using Sextant GUI modeler for development of algorithms for data processing with aim to solve complex problems, it is shown that for implementation of complex spatial analysis is not necessary to have a complex programming knowledge. The examples of complex geoprocessing algorithms it is showed possibilities that beginners GIS users with a basic introduction of geoprocessing might have done complex spatial analysis. The end result shows capability and benefits of applying geoprocessing to solve everyday problems faced up not the only in local government but also in any other organizations.

## CONCLUSIONS

Looking separately, currently opensouce GIS software can be concluded that none of them offers a complete solution for use in solving complex spatial

problems. The only if we integrate their functionality and with increasing their compatibility it will be possible to create one that system.

The paper research and its results clearly are showed that is achievable. The current trends of integration of existing opensource geoprocessing tools with desktop or web applications by are being taking advantage of service-oriented SDIs lead on there. In the future, with improvement of the existing capabilities of the opensource GIS software will be able to increase accessibility these technology to ordinary GIS users. Given methodology can be successfully are applied to a wide range of problems they encounter every day. In this way it will increase using these integrated systems by local authorities, state institutions, and other organizations.

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