

IMPLEMENTATION OF GIS IN SELECTION OF LOCATIONS FOR REGIONAL LANDFILL IN THE KOLUBARA REGION

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The selection of micro-location of the regional landfill represents the most sensitive step in spatial organization of the physical elements of the system for waste management¹. The methodological approach in selection of location is necessary due to the sensitivity of the problem and has to be based on multi-criteria evaluation of the space. The implementation of GIS in the process is especially useful for significant advantages recognized by all participants in the process of selection of the best location. This paper presents possibilities, advantages and limits in use of GIS at specific examples, during the selection of micro-location for the regional waste landfill in the region of Kolubara.

Key words: regional landfill, GIS, waste, Kolubara region.

INTRODUCTION

GIS is an orderly collection of information on features, facts and occurrences in the surrounding, aiming the acquaintance with the surroundings. The appropriateness of decision making, in planning and spatial organisation, greatly depends on quality and significance of information that the decision makers have, i.e. the knowledge based on it.

For the effective planning it is necessary to secure good quality information about natural and anthropogenous characteristics of the space. A unique information system should be organized in such a way to secure undisturbed use and dissemination of information throughout the established territory (Lješević M. 1997). One of such information systems is

Geographical (spatial) information system (GIS).

Some of the definitions of GIS might be sorted into the groups:

a) Definitions based on GIS as a working tool:

- "System for collecting, memorizing, checking, operating, analysing and presenting data spatially connected to the Earth" (Department of Environment 1987.);
- "Information technology which memorizes, analyses and presents both, spatial and non-spatial data" (Parker 1988).

b) Definitions based on data bases:

- "The system of data bases where the majority of data is spatially indexed and are managed by the series of processes in order to answer the questions on spatial elements that are in the bases." (Smith et al. 1987);
- Any set of processes based on manual or computer procedure used for memory and manipulation of geographically referential data (Peter A. Burrough, Rachael A. McDonnell, 1998).

c) Definitions in the organizational sense:

- "An automated set of functions provided by the experts with advanced capabilities for storage, retrieval, manipulation and display

of geographically located data" (Ozernoy, Smith, Sichertman 1981);

- "An institutional entity, reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time". (Carter 1989);
- "Supporting system in decision making that covers integration of the spatial referential data in the environment for problem solving" (Cowen 1988).

According to the above definitions it can be concluded that GIS represents a powerful set of tools for collecting, storage, browsing, transformation and display of spatial data from the real world for specific purposes (Peter A. Burrough, Rachael A. McDonnell, 1998). As one of the most complex information systems that cover the all spatial problems, GIS has series of advantages and the most significant are: it covers all elements of geo-space and ecological elements, includes natural and social elements of space and enable analyses, synthesis and visualisation.

GIS have largely been used as technology for complex management which, as a mean for coping with enormous volume of data associated with geographic information and the

¹ Physical elements of the waste management system are constructions necessary for functioning of the system. This primarily relates to the regional landfill as the most important object in the waste management system and in relation to it the spatial organization of the whole system is defined. Besides regional landfill, physical elements of the waste system are: recycling systems, composting equipment, mechanical-biological treatment of waste, rubble processing, transfer stations, recycling yards, traffic infrastructure, etc.

extensive calculations, need to rectify and analyze these data in decision-making context (Joksić D, Bajat B, 2004).

Implementation of GIS is suitable for: spatial planning, mapping for different purposes; traffic planning; **planning the waste management system**; list and register of natural resources; digital mapping of population and making census information; making hazard maps and emergency programs in such cases, etc.

Every GIS, as stated, contains spatial and descriptive data: **spatial data** (point, line or polygon) relates to location, i.e. spatial relations between occurrences and objects and are based on literature, maps, satellite photographs, terrain research, etc; **descriptive data** (attributes) are connected to locality/occurrence, and represent the accompanying context within the system.

Basic characteristics of GIS are: capability of search of the spatial occurrences, possibility of overlapping the content and combination of certain contents in a new information, logical operation with spatial and descriptive data.

Geographical information systems, as the most general are compatible with the others, specific systems (geodesic, agricultural, geologic, mining, waterpower engineering, forest engineering, urban planning etc.) as well as with the databases on population census, statistical information systems, technological databases, databases relating to health, education, science, etc. Implementing the information mapping/visualized by GIS enables making of any query, receiving answers, exercising possible solutions and solving problems.

A successful GIS is not created for the purposes of a single project. GIS cannot be bought, but it is developed, and its purpose is to enable the planner to get needed information for forecasting and planning in a specific space and for a specific problem (Kukrika M., Smiljanić S., Lazić I. 2001.).

IMPLEMENTATION OF GIS IN WASTE MANAGEMENT

Speaking about the role of GIS in planning the waste management, its role is dominant in the

selection of locations for disposal of waste. Besides, GIS are used for displacing and determination of location of the other physical elements of the waste management system, such as network of transfer stations, centres for selection and recycling of waste, definition of traffic lines within traffic corridors, but also as information support to the process in the same process of waste management.

For determining the locations of waste management elements in GIS the multi-criterion analysis and evaluations method are used. Such approach is inevitable when locating the complex objects such as the communal waste regional landfill. Its complexity is not only in the size and function of the object, but also in relation to different influences the space might have in positive and negative context.

The use of GIS in defining the strategy, analysis and visualization of solutions and alternatives helps to perceive and clearly express different scenarios and select the most suitable solutions through a prism of different relevant criteria (spatial, ecological, hydro-geological, etc) (Catalano A., Zhang M., Rice J., 2006).

Therefore two facts are the key ones when the GIS is implemented in selection of the best location for a landfill. According to Margeta J. and Prskalo G. (2006), these are:

- **analysis of "space"**, i.e. all its physical-geographic and anthropogenic characteristics. It is necessary to completely overview the space where the problem has to be resolved or it might serve for the problem solving. Due to the social sensitivity of the subject in this process, it is necessary to show objectivity in consideration of the possible locations. This can be achieved only if the whole space is treated by the same details and in the same way;
- **visualization of the space** and its characteristics and influence. This is necessary in order to obtain equal conditions for all participants in the project on perception and understanding of the undertaken problem. This enables active participation and streaming the solution towards acceptable compromise (Higs G., 2006). All participants must experience the space, its advantages and limits for locating the landfill. This is one of the most important

advantages for implementation of GIS in selection of locations for disposal of waste and other elements of the waste management system.

The basic process in the location selection process for the waste landfill, is definition of the criteria for selection of location.

In accordance with criteria of exclusion, locations which do not fulfill criteria are eliminated in the first phase of the process. The result of this process are spaces which are "conditionally suitable" within which is possible to look for the best solution. This phase represents activity of macro-zoning. Overlapping the cartographic descriptions of the certain space made on the basis of exclusion criteria, by implementation of GIS, it is simple to eliminate unsuitable locations (Figure 3.).

After that the attention is focused on nominated location for waste disposal within the remaining "conditionally suitable" zones. In this process a great significance might and must have local authorities and expert institutions, but certainly the most important are field researcher and collection of the relevant data on physical-geographic and anthropogenic characteristics of the space (Margeta J., Prskalo G., 2006).

By nomination of the potential locations the preconditions for selection of the most suitable location are created. Then the multi-criteria analysis and evaluation of the potential locations can begin. Criteria for location selection are entered into the tables and then on the basis of the entered value scale evaluated for each potential location. In this way, the evaluation process by implementation of GIS is done effectively and in a very short time period.

The role of GIS in the selection of landfill location process is in enabling quick separation and more clear presentation of suitable and unsuitable locations according to the previously determined criteria. In this context it is evident that the key importance in this process has a choice of criteria and value scale for evaluation of the potential landfill locations and that GIS are powerful device which the whole process greatly simplifies and speeds up. This stays not only for the process of landfill location selection, but also for

defining the spatial organization of the whole system of waste management and defining the network of transfer stations.

EXAMPLE OF IMPLEMENTATION OF GIS IN SELECTION OF THE REGIONAL LANDFILL

Kolubara region for waste management presents a functional region, formed in accordance with the recommendations of the National strategy for waste management of the Republic of Serbia. It was established by initiative of the six municipalities of the Kolubara region: Valjevo, Mionica, Osečina, Ub, Lajkovac and Ljig in accordance with the Regional spatial plan of Kolubara county (IAUS, 2002). Then the three municipalities of the Belgrade region joined this initiative: Obrenovac, Barajevo and Lazarevac, together with the two municipalities of Mačva region: Vladimirci and Koceljeva. In this way, the region of eleven municipalities is formed and it gathers over 382.000 inhabitants, which makes it the biggest region for waste management in South-East Europe. (Figure 1.)

When determining the location for disposal of communal waste of the Kolubara region for waste management, GIS are implemented in separation of the eliminating areas. The unsuitable areas have been selected according to nine elimination criteria:

- seismic over 9 MCS,
- distance less than 500 meters from the permanent watercourse,
- distance less than 1,5 km from a settlement if location is not protected,
- distance less than 500 meters from the source of water supply,
- collision with the existing planning documents,
- distance from the major roads less than 500m in the location if not protected,
- terrains with slope over 30%,
- terrains over 300 meters above the sea level,
- alluvial plains and karst terrains.

The belonging area is determined by the use of GIS for the eliminating criteria. Each of the elimination criteria is presented by a graph (cartographic) while the belonging area is determined by the GIS technology. Overlapping the maps of individual elimination criteria the negative areas are selected and in further

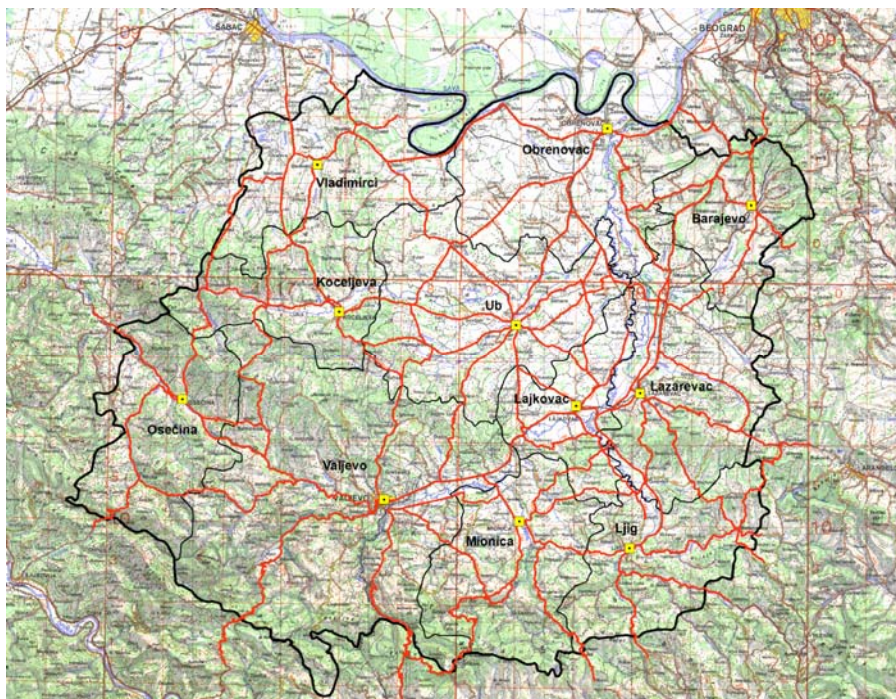


Figure 1. Location and coverage of Kolubara region

process of location selection for disposal of waste they would not have to be analyzed. The negative areas are presented at the synthesis map (Figure 3.).

Figure 2. shows the structure of the land use in Kolubara region based on the CORINE system (Coordination of information on the Environment)². CORINE Program represents the European information base as a support to the sustainable development policy of the European Union. The base contains data on:

² CORINE program started in 1984. At the beginning it was developed and tested on 10 regions of the European Union with demonstration of feasibility of such approach. Satellite photographs on which the information base CORINE is established, is supplemented by additional data and attributes on type of land use and the base which consists three level with the total of 44 classes is created. After the positive results which the Program realized, it was confirmed by the European Environment Agency in Copenhagen, in 1994. Since then, the period of full affirmation of the CORINE began and it reflected into inclusion of the greater number of European countries that with assistance of this Program more efficiently undertook the policy of the environmental protection and sustainable development and completed analyzes for different needs and development strategies (Cornært M., 2004). Today, 46 European countries are included in this Program within the frame of CORINE Land Cover 2000, with clearly defined and synchronized methodology of collecting, processing and display of data that are in function of elaboration of plans for management of the human environment (CORINE Land Cover, 2000.).

urban areas, agricultural surfaces, forests and natural vegetation, waters and other dynamic processes in the human environment. All mentioned data are presented cartographically enabling more simple analysis of the subject area.

When making the Study on selection of micro-location for the regional landfill with recycling centre in Kolubara region, the information base CORINE has not been available in Serbia, and likewise in Kolubara region. However, since the information on human environment from CORINE program became available to the users in Serbia, all results from the elimination phase of the selection of location in the mentioned Study have been checked, and even more important confirmed. By using the CORINE program in accordance with the defined eliminating criteria for Kolubara region, the selection of "negative" areas was much simpler and quicker. The information base CORINE in great measure satisfies the need of the elimination phase in selection of location for disposal of waste and it should be used to the maximum in this phase. At the synthesis map (Figure 3.) which is the last phase in the eliminating process of "negative" areas, the regions that do not fulfill basic conditions in relations to the determined elimination criteria are marked by red color. These are mainly the corridors which are represented by the

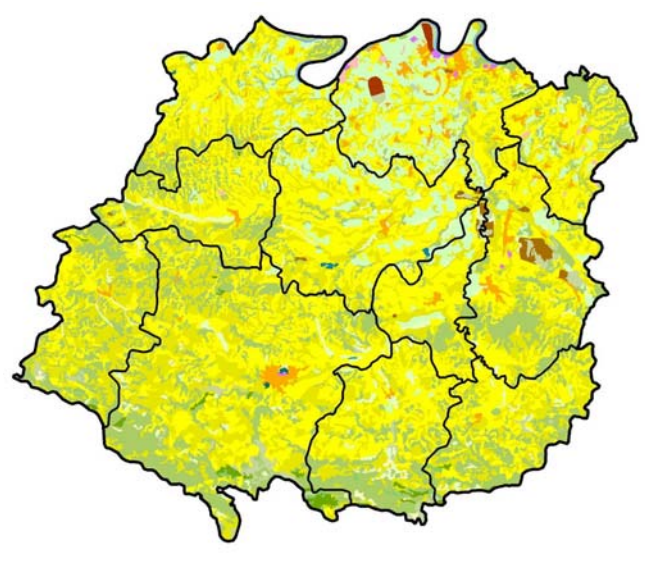
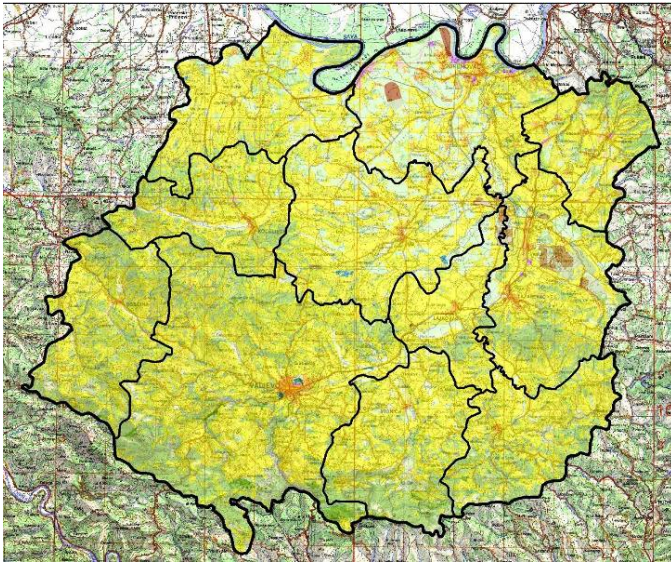


Figure 2. Analysis of structure of the land use based on information system CORINE

minimum required conditions to be met by the future locations for waste disposal.

In the elimination phase it is possible to use some additional criteria, such as the central position of a landfill in relation to the region. This considers that due to the economy of the waste management system, i.e. the cost of transport, it is necessary to position the future landfill within the radius of 20-30 km in relation to the central point in the region. However, in that case a great number of territories which by their characteristics require further analysis might be excluded, while the question of the central positioning of the landfill might be overcome by good organization of the transfer stations network in the region. In this context it is important to stress that there is no need to introduce a big number of eliminating criteria, but the selection of eliminating criteria is necessary to be limited to the most relevant ones, as stated on the example of the Kolubara region.

After the conducted consultations with the relevant subjects and preliminary analysis of the territory which are not eliminated in the first phase of the process for selection of location for disposal of waste, three locations are selected and are included in the process of detailed analysis for multi-criteria evaluation.

The contribution in implementation of GIS in this phase of the selection of location for waste disposal was the use of information base in GIS by which the evaluation process according to 32 determined criteria was significantly speeded up. Since the location Kalenić is

evaluated as the best and is selected as the most acceptable, the process of the selection of location is ended. That does not mean that this is the end for implementation of GIS. Their further role is in implementation of the unique information system for waste management which puts together data on a landfill, transfer stations, production of waste, flow of waste and other data which are important for effective waste management. In this content, GIS represent information support in functioning of the waste management. By simple use of

interface, all necessary information on the processes at the landfill can be gained. The system enables good quality and quick waste management, monitoring, data filing on waste and the ground for planning the strategy for waste management at the regional level (Figure 4.).

CONCLUDING CONSIDERATIONS

A comprehensive envisage of the problem in connection to the selection of location for physical elements of the waste management,

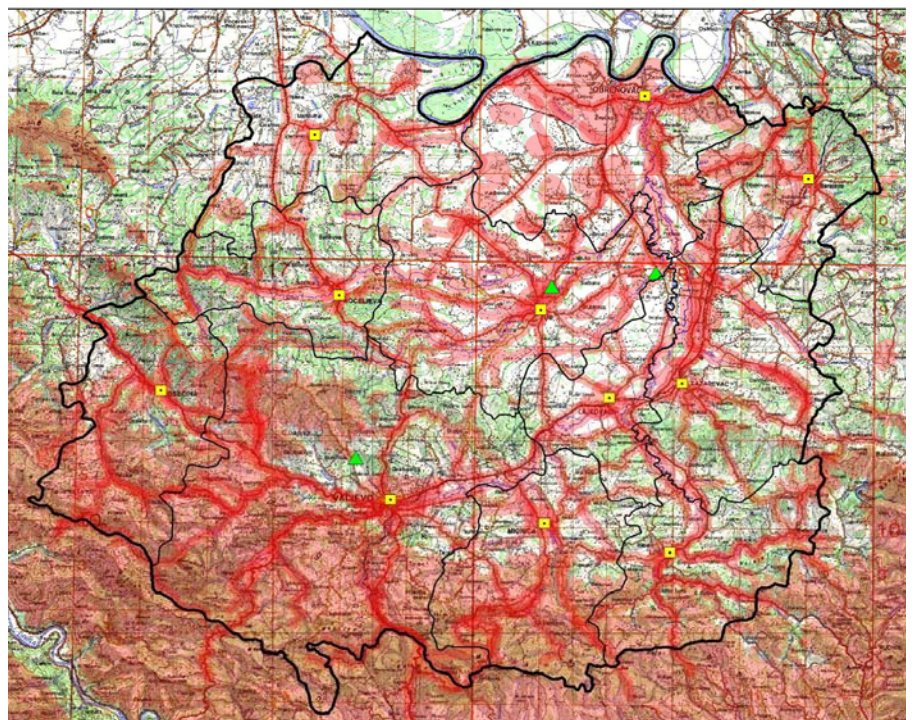


Figure 3. Suitability/eliminating map

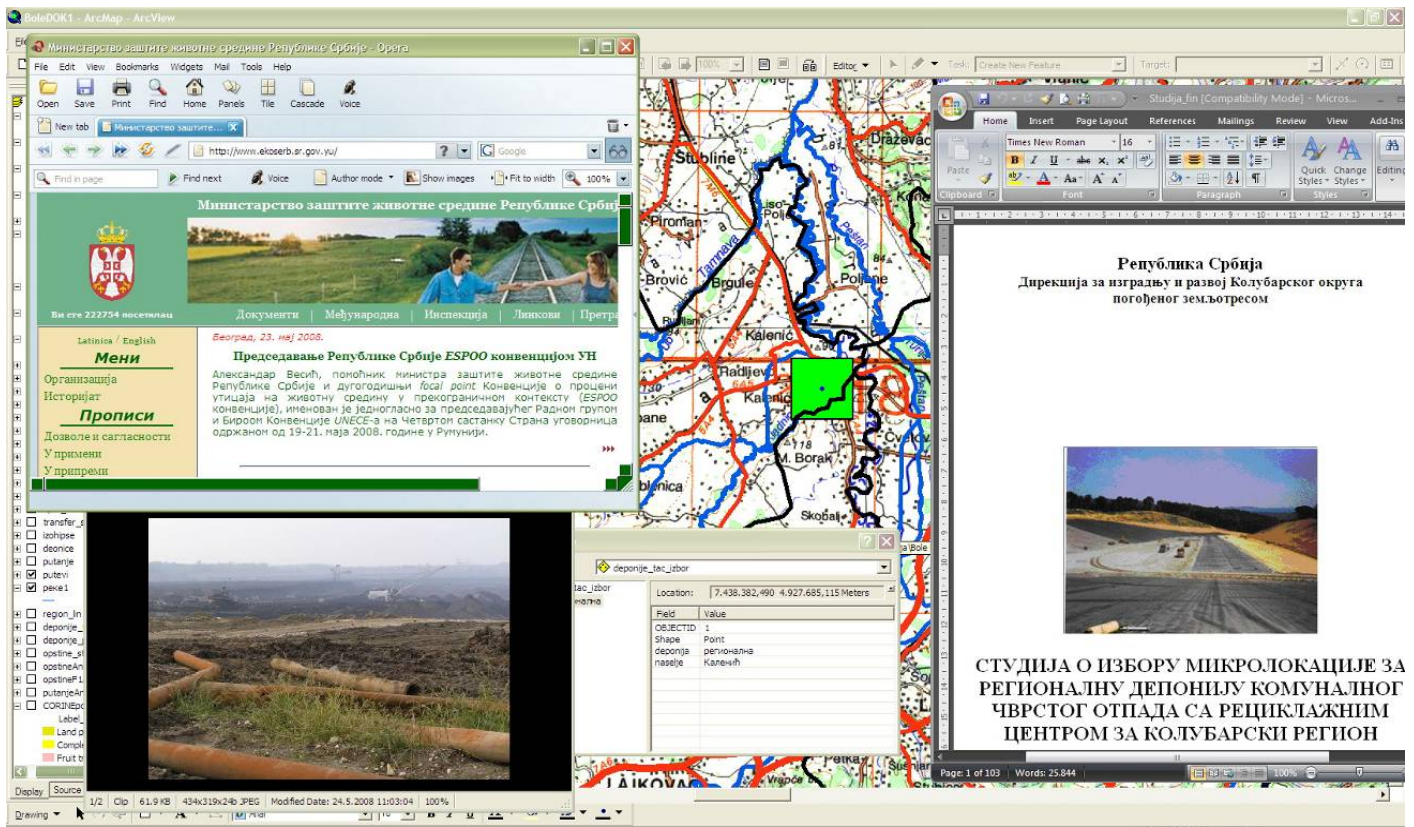


Figure 4. Possible aspect of GIS based system for waste management

understands application of GIS which the space analyzing process and search for the best options makes better in quality, speeds up the process and enriches it visually. The advantage of their implementation is in enabling the quicker selection and more clear presentation of the suitable and unsuitable locations according to the previously determined criteria.

This paper on a concrete example presents the advantages and possibilities of implementation of the GIS during the selection of location for the regional landfill in the waste management of the Kolubara region. The use of GIS is especially useful in the elimination phase, where, in accordance to the determined criteria and data about the space, very quickly and easily can be defined "negative" terrains where no further searching of the potential location is needed. The whole process is mapped. It is emphasized in the paper the possibility of applying CORINE data base, a unique European information base about the living environment and space use, which is especially suitable in the elimination phase of the location selection.

Also emphasized is the possibility for efficient waste management by application of the

information base in GIS. The system supported by the information enables qualitative and quick waste management, monitoring, filing of waste data and the best possible ground for planning the strategy for waste management at the regional level.

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