An overview of GIS-based Multi-Criteria Analysis of priority selection in humanitarian demining

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Abstract

This paper demonstrates how an application of GIS-based Multi-Criteria Analysis could be efficiently used to support humanitarian demining operations and restoration of mine-contaminated areas. The financial shortage usually triggers a need for priority setting in the mine removal process. This overview validates GIS-based Multi Criteria Analysis (MCA) as capable tool for priority setting within mine action management. A combination of GIS analysis and a multicriteria method is applied to set humanitarian demining priorities in order to optimally reduce the risk caused by mines. GIS is outlined as a powerful tool for aggregation of information used in multicriteria analysis. It is also shown that coupled GIS-MCA model is very efficient tool for both functional connection between hierarchic decision levels and determination of the objective priorities. Besides GIS-based MCA for priority setting the paper will also demonstrate a development of Web&GIS-based MCA. By functional integration with web, priority setting process become fully transparent since stakeholders and donors are able to actively join decision making process using on-line web application.

1. Introduction

In Croatia, over the past ten years, a priority setting using Multi-Criteria Analysis (MCA) coupled with GIS has been deployed in mine-action management (Mladineo&Knezic, 2003). A multi-criteria approach gives an opportunity for stakeholders to express their needs and requirements through a set of criteria. Therefore, the methodology provides full transparency of decision data (Benini et al, 2003), visible to all stakeholders, so that anyone who is either directly involved in Mine Action process or affected by landmines could follow the process. Priority setting (Van Der Merwe, 2003) should be used to ensure that the limited resources of a mine action programme can have the greatest possible impact in each planning cycle on the socio-economic blockages caused by landmines. The application of MCA tools to the decision making process has been widely recognised (De Leeneer&Pastijin, 2002; Jankowski, 1995) for its utility in offering fundamental help for the decision maker in the presence of possibly conflicting targets.

While using MCA two problems have been noticed. The first one refers to the size and scope of either minefields or mine suspected areas, so they could be mutually comparable. A result from comparison process is priority rank for mine clearance. Each minefield is an action in MCA having its own rank in relation to defined criteria. Second problem relates to the fact that each decision level demands different criteria set, as well as to the fact that demining process on different land cover areas (water, woodlands, etc.) needs distinctive criteria. Experience in the application of MCA resulted in GIS-based Decision Support System (DSS) which comprehend different decision levels and land cover areas.

2. Methodology

The proposed GIS-based DSS for risk management in mine-affected supports multi-level approach (Knezic&Mladineo, 2006): for each problem level, a specific procedure for criteria and action (solution) evaluation is developed (Figure 1). At each decision level a separate set of actions (projects for humanitarian demining of socio-political entities, such as counties, municipalities, villages, mine fields, homogenous areas, etc.) is created by GIS, and evaluated by applying multicriteria analysis (Mladineo et al, 2003).

At strategic level counties, regions, districts or, alternatively, homogenous zones defined as parts of territories with common characteristics, make up a set of actions being evaluated by multicriteria analysis. Actions are ranked according to the humanitarian demining priorities. At the tactical level, the problem should be treated at regional level, so municipalities, urban areas or similar homogenous zones make up a logical set of actions. The criteria that could be concerned are assembled in four basic groups, as follows:

- Terrain characteristics and infrastructure
- Economic impact of mine clearance,
- Social welfare,
- Land-mine risk reduction.

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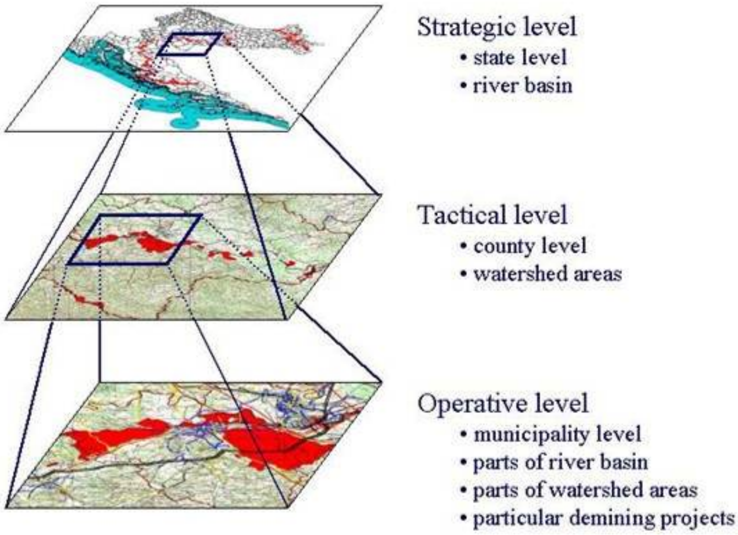

Figure 1: Hierarchic approach in humanitarian demining operations (example for water resources) (Knezic&Mladineo, 2006)

At the operational level, problems should be treated with respect to humanitarian demining projects, mine fields, selection of humanitarian demining company and technological support, etc., and particular criteria for each multicriteria evaluation has to be developed. For each decision level, a team of experts has to make the criteria set more detailed, by co-coordinating it with the demands characteristic of that particular level and with relevant stakeholders.

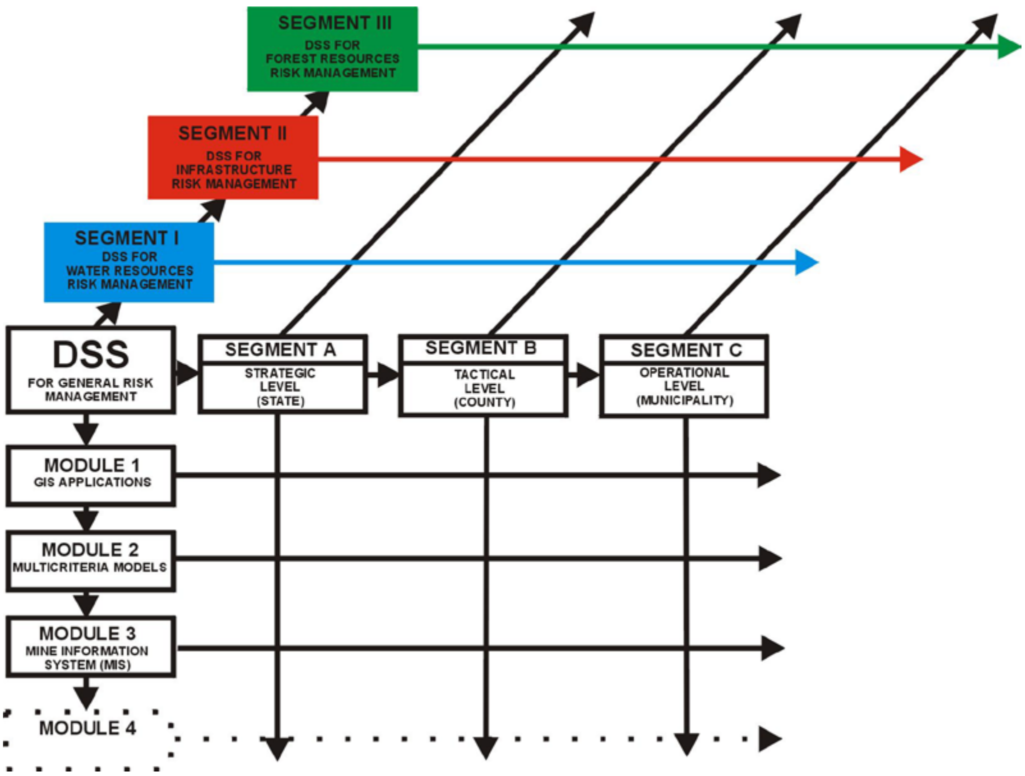

Figure 2: Structural layout of DSS for humanitarian demining operations (Knezic&Mladineo, 2006)

The hierarchic approach is very useful because, at each level, it makes distribution of money for the humanitarian demining of mine-affected counties easier by simulating results attained from multicriteria analysis.

Conceptualized DSS (Knezic&Mladineo, 2006) shown on Figure 2 consists of segments related to the hierarchic structure of DSS. Modules are related to both data and model bases. The database is based on GIS for general data, which contains topological, social, land-mine risk and economic data. In addition, the mine information system (MIS), functions as the central tool for mine risk-management. The model base, besides other models and various spatial operations, includes multicriteria models necessary for particular assessments and prioritizations. This approach avoids very expensive and sometimes imprecise terrain surveys, and at the same time enables very simple visual control of the parameters used.

3. Development of GIS-based MCA Web Application

Since several stakeholders, usually dislocated, are included in the priority setting process a new Web based GIS application has been developed. The application couples GIS thematic layers and MCA making it accessible via friendly user interface to different stakeholders. Consequently, priority setting has become fully transparent since stakeholders and donors are able to actively join decision making process using on-line web application.

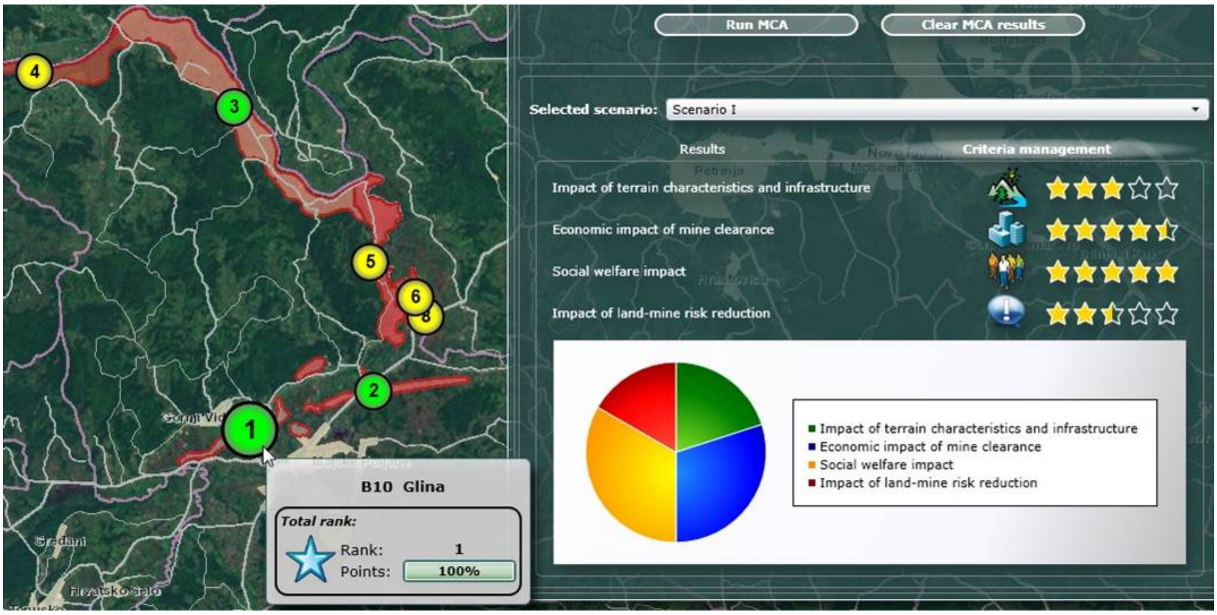

Figure 3: Display of results of Multicriteria Analysis for criteria weights predefined by "Scenario I"

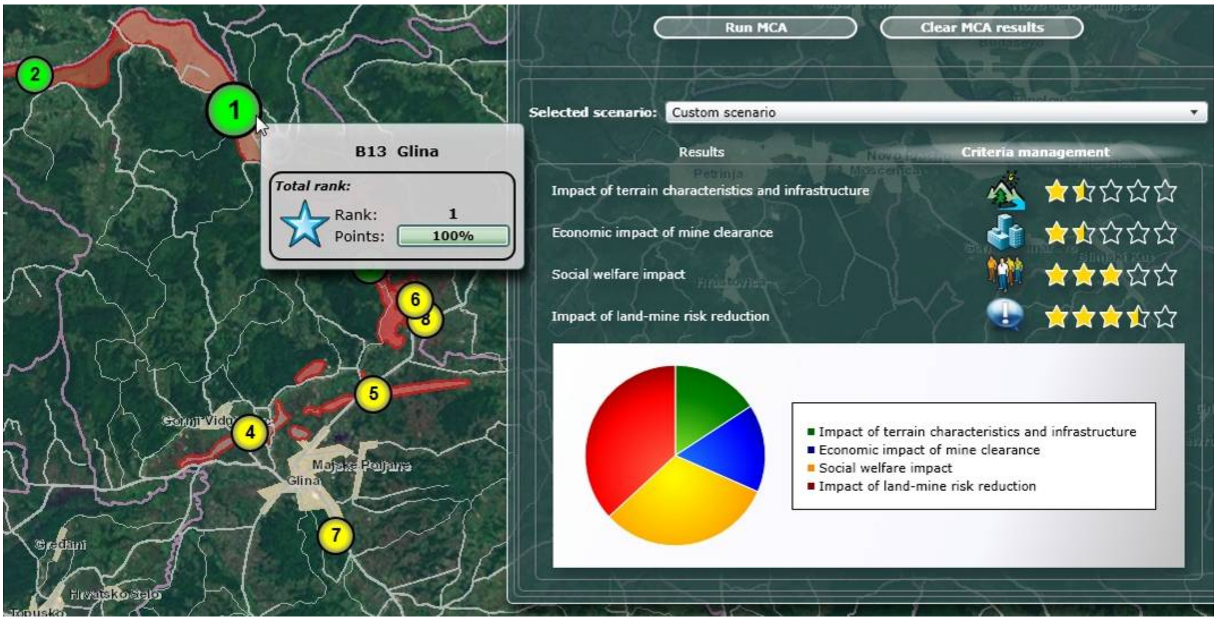

Figure 4: Display of results of Multicriteria Analysis for custom defined criteria weights ("Custom scenario")

Figures 3 and 4 show an example of priority setting in a municipality of Sisacko-moslavacka County. Weights of criteria groups could be easily changed on-line with automatic update of MCA results. The results of Multicriteria Analysis (MCA) are displayed in multiple ways: on a chart that represents PROMETHEE II output (Brans et al, 1984; Marinoni, 2005), on a map by placing a rank number on each suspected minefield, and on a suspected minefield 's "map tip" with details about each suspected minefield's rank.

By scenario selection a decision stakeholder attitude is transferred into MCA. On Figure 3 a predefined "Scenario I" has a greater weights of criteria groups "Social welfare" and "Economic impact of mine clearance". On Figure 4 a "Custom scenario" is used, in which greatest weight have criteria group "Land-mine risk reduction". Change of criteria weights affected ranks. Initially, 1^{st} rank had suspected minefield "B10 Glina" (Figure 3), but after change of scenario 1^{st} rank has suspected minefield "B13 Glina" (Figure 4). And the other ranks were also affected.

4. Conclusion

Mine action management often deals with limited funds, and thus requires efficient tools for the establishment of mine clearance priorities. Between the "small" farmers, whose backyards are contaminated, and county and community councils, forums and representatives, there are several levels that are directly or indirectly exposed to mine accident risks. All of them, more or less, expect that their problem should be treated as the priority one, so their involvement in the decision-making process lowers tensions and significantly reduces frustrations that may result from the prolongation of the problem solving process. This paper demonstrated how to easily include several stakeholders in decision process of priority selection in humanitarian demining. A new Web based GIS application has been developed. The application couples GIS thematic layers and MCA via friendly user interface. The further research will be based on defining of predefined scenarios and designing forms for MCA data input.

References

BENINI, A.A., CONLEY, C.E., SHDEED, R., SPURWAY, K. and YARMOSHUK, M., 2003, Integration of different data bodies for humanitarian decision support: an example from mine action. Disasters, 27, pp. 288-304.

BRANS, J.P., MARESCHAL, B. and VINCKE, P.H., 1984, PROMETHEE-a new family of outranking methods in multicriteria analysis. In Operational Research IFORS 84, J.P. Brans (Ed.), pp. 477-490 (Amsterdam: North Holland).

DE LEENEER, I. and PASTIJN, H., 2002, Selecting land mine detection strategies by means of outranking MCDM techniques. European Journal of Operational Research, 139, pp. 327-338.

JANKOWSKI, P., 1995, Integrating geographical information systems and multiple criteria decision-making methods. International Journal of Geographic Information Systems, 9, pp. 251-273.

KNEZIC, S. and MLADINEO, N., 2006, GIS-based DSS for priority setting in humanitarian mine-action. International Journal of Geographical Information Science, 20, pp. 565-588.

MARINONI, O., 2005, A stochastic spatial decision support system based on PROMETHEE.
International Journal of Geographic Information Science, 19, pp. 51-68.

MLADINEO, N., KNEZIC, S. and GORSETA, D., 2003, Hierarchic approach to mine action in Croatia. Journal of Mine Action, 7(2), pp. 41-45.

MLADINEO, N. and KNEZIC, S., 2003, Decision support system for demining waterways. Journal of Mine Action, 7(3), online only.

MLADINEO, N., MARGETA, J., BRANS, J.P. and MARESCHAL, B., 1987, Multicriteria ranking of alternative locations for small scale hydro plants. European Journal of Operational Research, 31, pp. 215-222.

MLADINEO, N., LOZIC, I., STOSIC, S., MLINARIC, D. and RADICA, T., 1992, An evaluation of multicriteria analysis for DSS in public policy decision. European Journal of Operational Research, 61, pp. 219-229.

MLADINEO, N., KNEZIC, S., PAVASOVIC, S. and SIMUNOVIC, I., 1993, Development of 'Land rent model' using multicriteria analysis and geographical information systems. Journal of Computing and Information Technology, 1, pp. 243-25l.

VAN DER MERWE, J., 2003, Priority setting for mine action. Journal of Mine Action, 7(3), online only.