Hierarchic Approach to Mine Action in Croatia

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Victim Assistance in Iraq

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continuing presence in central and southern Iraq since the first Gulf War in 1991. During their first few years in Iraq, they provided steady food, storage and logistics to over 300,000 people per month. They also provided logistical support and assistance to other U.N. Agencies. CARE's work in Iraq began in the northern Kirkush regions of Duhuk, Erbil and Sulaimaniyah and in parts of central and southern regions such as Arbil, Babil, Dhiawain and Najaf. As humanitarian need became more critical in the central and southern regions during the mid-90s, CARE's focus turned more toward providing these areas with basic health care, clean water and proper sanitation.

Conclusion

As expected, the recent conflict brought with it a torrent of new concerns and demands to the civilian population of Iraq. Large amounts of explosive remnants of war (ERW) such as artillery shells, grenades, mortar bombs, cluster bombs and other submunitions, rockets and missiles left in residential areas cause the number of victims to increase daily. Those dedicated to helping these victims must first create a means of keeping track of the number of victims and the nature of their injuries. Their second concern is finding a secure way in which to deliver or administer medical care and medical assistance. Finally, they must train Iraqi specialists, medical workers, and civilians in their various areas to help them to reach the ultimate goal of an efficient Iraqi health care system. Despite these hurdles, the UN and NGOs are slowly making progress in their efforts to beat the wounded in Iraq.

References

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For successful demining operations to occur, detailed data collection, planning and assessment must be made in order to meet the expectations of the many stakeholders involved in the demining process. This article discusses the hierarchical approach of priority assessment for demining, using a multicriteria analysis and geographic information system (GIS) support.

Introduction

The Republic of Croatia is one of the 10 most mine-contaminated countries in the world. There are almost 750,000 mines and 1,630 sq km of mine-suspected areas. About 170,000 sq km are actual minefields, while the rest of the area is contaminated with individual explosive ordnance. Mine-affected areas have not been used for years, pose a huge economic problem and obstruct infrastructure development, reconstruction and return of displaced persons to their normal lives. They also pose a significant safety problem. In particular, any activities carried out in mine-suspected areas significantly threaten human lives and material assets. It is estimated that removing all the mines in the Republic of Croatia would cost approximately $1.473 billion (U.S.) and would take an estimated 10 years.

Recent experiences indicate that the demining process is a "complex, slow and expensive" job. Nevertheless, efforts have been aimed at increasing the efficacy of demining activities, while still avoiding human casualties. Even small demining time-reductions present big savings, in an absolute sense, and on numerous occasions, overvalue investment and demining methods that can present conflict situations that are not sufficient motive to start research for new methodological approaches.

Background

As stated in a 2002 report, the existing system for developing the national mine action plan and for identifying priority areas in Croatia has evolved over time. In the immediate post-war period, mine clearance was seen as an integral part of the reconstruction effort and priorities for survey and clearance were determined by plans for reconstruction, the return of refugees and displaced persons and special projects to upgrade the national infrastructure (such as clearing the Sava River). Mine clearance was "demanded by" in its initial phases and, in general, the priorities were clear. However, the problem of identifying priorities became more complex as different groups and interests were addressed. The report states that: "to some outside observers, including donors, it was unclear how priorities were being established within each county; whether politicians in the different counties were setting priorities based on different criteria; and the degree to which socio-economic factors were considered when setting priorities." Conflicts among human demining objectives occur often, and currently involve outside objectives conflicting with objectives generated within the system. The conflicts are then transferred to the criteria. This inconsistency of the criteria led to the implementation of multicriteria analysis because "classical" methods, including intuitive decision-making, cannot determine the optimal solutions for the humanitarian demining problems. Therefore, in 2003, CROMAC, in collaboration with the Faculty of Civil Engineering University of Split, developed a hierarchical approach for the demining problem in Croatia. Within the pilot project for the "Medjimurje County Mine Clearance" analysis method was applied in order to provide an objective approach.
Hierarchic Approach in Priority Assessment for Humanitarian Demining

In developing a hierarchic approach in humanitarian demining, participants must consider different approaches at each decision level. Due to the characteristics of humanitarian demining in Croatia, the multi-level approach was developed. For different problem levels, a special algorithm for evaluation criteria and actions (solutions) was developed. This means that for each decision level, a separate "action set" is created (projects for demining of socio-political units, such as counties, municipalities, villages, minefields, homogenous areas, etc.). Such sets are evaluated by applying multicriteria analysis. This actually means that:

At the strategic level, problems should be treated at the state level; therefore, counties are a logical set of actions evaluated by multicriteria analysis. Alternatively, at the county level, homogenous zones can be defined as a set of actions that will be ranked according to the demining priorities related to the basic state orientation (Croatian, energetic areas, water supply zones, transportation, valuable ecological areas, fire-endangered areas, etc.).

As the tactical level, problems should be treated at the county (or canton) level, so the municipalities are defined according to a logical set of actions evaluated by multicriteria analysis. Alternatively, at the county level, homogenous zones can be defined according to a set of actions that will be ranked according to the demining priorities related to the basic state orientation (Croatian, energetic areas, water supply zones, transportation, valuable ecological areas, fire-endangered areas, etc.).

At the operational level, the problem should be treated at the demining project level (minefields, demining company selection, selection of technological solution(s)).

For the different problem levels a particular "criteria set" for multicriteria evaluation at each level has to be defined. However, for each decision level, expert teams from the Mine Action Center (MAC) have to make the criteria set more detailed, taking into account the users of that particular level, as well as the expectations of the "partners" in the decision process. For example:

- The strategic decision level is characterized by using macroeconomic and other global parameters and by coordinating with strategic partners such as governments, competent ministries and international organizations.
- The tactical level is characterized by an approach that favors those parameters that are the most important for a particular county's development, as well as parameters that are important for political stability and population satisfaction (understandable and global criteria that apprehend personal interest of each inhabitant, especially in areas where are possibilities for national conflicts, or conflict caused by ratio of domicile and new inhabitants, etc.).
- The operational level is characterized by using as inputs information reliability, mine types, socio-economic parameters such as demographic data (ageing, risk structure, education, information reliability, mine types) and socio-economic parameters such as economic data (ageing, income, information reliability, mine types).

Within the pilot project for Sisacko-Moslavacka County, the multicriteria analysis was applied at the tactical level. Namely, ranking mine-endangered municipalities was performed in order to check the above mentioned approaches in practice, and to judge its convergence for other decision levels. In the following section, the same basic extractions from the pilot project, "Application of Multicriteria Analysis to the Humanitarian Mine Action Problem" are given.

**Hierarchic Approach to Mine Action in Croatia**

According to the available parameters on the area of Sisacko-Moslavacka County (640 minefields were registered), by terrain surveying, as well as by identification of suspicious areas, a digitized database was created containing all mine-contaminated areas, including mine-contaminated areas with 72 polygons on 11 municipalities in total. Regarding the fact that all aforementioned polygons were not homogeneous, it was impossible to make them homogeneous by applying some simple procedure; it was decided that being part of the certain municipality should be a criterion for polygon joinling. For example, when forming a set of actions (projects) to be ranked and analyzed, multicriteria analysis should be applied in order to determine the optimal options for risk reduction. Such an approach is reasonable because municipalities are the smallest territorial and political units that are involved in the evaluation of optimal policies for risk reduction.

To the project demands and in order to ensure all relevant data and enable straightforward generation of more general data, GIS, containing various thematic layers, was created. ArcView and other Environmental Systems Research Institute (ESRI) tools that enable more complex spatial data analysis were used. When analyzing the problem, the following problem characteristics were given:
- High demining priority
- Conflict of interests
- Hierarchic nature of the problem (several solution levels)

Within the project, the following objectives were defined:
- Establishment of more objective criteria for the evaluation of demining priority (i.e., optimal policies for risk reduction)
- Gathering of all relevant data
- Modelling of the decision process that is acceptable to the majority of the group, which generally have conflict interests
- Involvement of more groups in the decision process

As the solving methodology, the following compromise steps have been worked out:
- System approach in problem characteristics definition
- Providing of relevant data for numerical process by GIS
- Support system
- Modelling of the decision process
- Multicriteria analysis for making objective of the subjective demands (approaches)

According to the fact that during the evaluation of the optimal policies for risk reduction, several groups are involved in the decision process, the activities in the process of problem solving were defined:
- Defining of the characteristics, namely, of the set of activities and set of the criteria (problem scope definition)
- Bringing together the sets of action and criteria with "partners" in the decision process (usually, some of the characteristics are added due to the partners' insistence during the group decision-making)
- Definition of the criteria weight and preferences
- Negotiating criteria weights in the iterative process
- Definition of the alternative scenarios of the criteria weight assessment, assessing more weight to the criterion group
- Model formulation publishing and presenting of numerical and graphical results of ranked actions (of mine-contaminated areas) by the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE method)
- Sensitivity analysis, namely, stability checking of the set of the criteria weight scenarios
- Usage of GAIA (Geometric Analytic Hierarchy Analysis) method for visualizing the problem characteristics via geometrical representation
- Presentation of the multicriteria analysis results to the participants in the decision-making process, as well as numerical solving of the additional scenarios (criteria weight variations as the results of the GAIA method)
- Elaboration of multicriteria analysis results including verbal and

[Figure 1: Layout of mine-contaminated counties in Croatia.](https://commons.lib.jmu.edu/cisr-journal/vol7/iss2/12)

[Figure 2: Layout of the hierarchic approach in demining operations in Croatia.](https://commons.lib.jmu.edu/cisr-journal/vol7/iss2/12)
Figure 3 shows a schematic procedure, which contains GIS analysis as a first step and evaluation of relevant criteria presented as thematic layers. For the criteria that can be spatially presented, using GIS analysis, concrete numerical values as input for multicriteria analysis are being evaluated. For the criteria that cannot be generated by GIS analysis, an expert team evaluation and mathematical estimation were performed. For example, by using data from "mine records" from both parties involved in the war conflict, it is estimated that on the territory of this county, 36,506 mines are placed—24,887 of which can be identified on the already known minefields in eight municipalities. For 5,623 mines, location is unknown, so the most plausible solution is that they are placed on the territory of 11 mine-endangered municipalities or less likely, on the territories of other municipalities in the county that currently are not contaminated with mines. Figure 4 shows the contrary that presents possible contact of population and UXO. The obtained area presents an "objective estimated risk" for the domestic population calculated by multiplying the number of inhabitants of settlement that is within, or on, the border of mine-suspected areas with an average population density on the study area.

The value of infrastructure parameters, which is situated on suspected minefields, is calculated indirectly as well (i.e., around digitized installation infrastructure, a 100 metre double-sided buffer is determined, and after that by implementation of "geoprocessing function" an intersection area of minefields and infrastructure installation is determined. In a similar manner, for the mine-contaminated areas of each of the 11 analyzed municipalities, the value of estimated parameters values for other criteria are evaluated (roads, agricultural areas, forests, parks of nature, etc.—see Figure 5).

During multicriteria analysis for each of the criteria, the weights were assigned by the stakeholder involved in the decision process. Namely, it is important to involve representatives of social and political associations from the municipalities’ territory, which are included in the priority ranking, in order to obtain results that would be accepted by them as optimal ones.

For the numerical part of multicriteria analysis, two methods, PROMETHEE and GAIA "Decision Lab 2008," are used. It is the commercial name of software distributed by Visual Decision from Canada. Contemporary architecture of this software, based on the Decision Support System (DSS) enables comfortable work and widespread support for the decision-making processes.

A large part of the information, most of which is possible to visualize, graphics, various colored diagrams gives the decision-maker a complete insight into the problem characteristics and possible results of various problem-solving scenarios. Table 1 presents results of the numerical analysis for Stipac-Moslavacka County by the PROMETHEE method. For example, look at the evaluated ranks that present priority assessment for the 11 contaminated municipalities (presented results are not the final spatial solution).

Achieved synthetic parameter "Phi" presents valorization of priorities based on defined criteria and weighting coefficients. Table 1 shows that municipality Slunj is ranked first and represents demining priority because the total Phi value of 0.564 dominates the second ranked municipality, Petrinja, with Phi value of 0.3077. Follow the ranks of other municipalities to the last one, municipality Gruda with negative priority value Phi -0.2397.

Synthetic parameter Phi is very convenient for the expression of differences or definition of priority "power," so it can be used for the determination of demining funds relations of each municipality. For example, if someone wants to distribute the total amount of money to the top four ranked municipalities, the proportion of the distribution can be based on Phi index value (Figure 6).

Figure 7 shows the layout of the relations between criteria obtained by GAIA software, namely by application of principal component analysis for Phi values for each criterion. Insight into the criteria relations is important for understanding the problem and recognition of the correlation between different criteria parameters. Figure 7 shows, it is easy to notice criteria with a high degree of correlation and criteria in conflicting positions.

**Conclusions**

The developed hierarchic approach of priority assessment for demining, using multicriteria analysis and GIS support, illustrated the possibility of objective valorization in humanitarian demining that is acceptable for most stakeholders in the decision process. The relatively small costs of data collection, editing and analysis with simple control and transparency through all hierarchical levels, as well as involvement of all stakeholders (directly or indirectly) in the decision process, give such an approach an advantage compared to the other methods being used.

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**References**