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A MULTICRITERIA DECISION SUPPORT SYSTEM FOR LANDFILL SITE SELECTION

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Abstract. A method for site-selection for waste disposal facilities on regional level has been developed using the often conflicting objectives and corresponding criteria between pre-finded promising sites in Greece. The objectives represent the interesting parties between the local community and government. The selected and used preference criteria are grouped in three categories: environmental, economic-land use/social, and technical operational. To apply these objectives and criteria in a rational and objective way, a multi-objective/multi-criteria evaluation method, the compromise programming is used. It is interesting that the method sets the factors clearly and helps experts and local communities to participate. So, the lack of information or any opposition (scientific, technical, social or other) can be discussed, scored and weighted separately. The method has been applied in a region in Greece. The results were accepted by the local communities.

Keywords: landfill site selection, compromise programming, decision support system.

AIMS AND BACKGROUND

In 1999, the biggest waste disposal facility in Greece, serving almost 2 million habitants, has finished its active life. In the selection of an approved site several local communities (Avlon, Chalkis) were opposed. Many similar problems in the main territory of Greece were revealed. It is noticed that projects that were not supported by the public were declined in favour of the location of other sites with a big relevant cost to the economy of these projects. The objective of this paper is to develop a method for landfill site selection based on compromise programming that set the factors clearly helping experts and local communities to participate in terms of a rational decision support system.

The selection of a landfill site is a multiobjective task where a number of participants are involved. All the facts and ideas must come together, be scrutinized, evaluated and finally combined in order to show the way to agreement of the participants. In the related literature the methods used for landfill sites selection to date[1] are based on single objective/multi-criteria decision-making. These methods are simple to use but they do not represent parties involved with often

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conflicting objectives in the selection of sites. Compromise programming is the method of landfill site selection that has been developed and applied in the region of West Macedonia in Greece. This method not only compares the alternative promising sites utilizing a multi-criteria decision analysis system, but also finds the "better" solution for all parties involved in the site selection process.

EXPERIMENTAL

THE COMPUTER PROGRAM

The siting selection process is one of the basic steps of a landfill site and involves several stages. Each stage, which consists of a routine computer program, tends to narrow the list of possible sites. This leads to the selection of one or more sites for detailed investigation and analysis.

In the selection of a landfill site the next steps are usually undertaken:

1. Definition of the needs of a geographical region.
2. Identification of candidate areas and candidate sites within these areas.
3. Comparison of the candidate sites and identification of the preferred site.
4. Dctailed investigation of the preferred site, if accepted according to constraints and criteria, or go to the next one.
5. Start of the licensing process.

The method of comparison which will be presented here is applied in the 3rd step of the process. The candidate sites come to detailed comparative evaluation using a set of environmental, land use/social and technical operational criteria.

CRITERIA

Therefore, the selected and used preference criteria are grouped in three categories: environmental, land use/social geological and technical operational as follows: environmental criteria consisting of surface water quality impairment, groundwater quality impairment, i.e. infiltration percolation and recharge from the watercourse, land cover and ecological character, absence of optical intrusion, odors nuisance, landfill gas management and public health, safety and nuisance; economic land use and social criteria consisting of the net present value, the depreciation cost, the distance from human settlements, industry and mineral exploitation or reserve, proximity to protected places, and impacts in housing/touristic development; technical-operational criteria consisting of climate, i.e. the altitude and protection from strong wings, the design of the site, i.e. hydrological evaluation and grading of the surfaces/protection of the slopes, the method of leachate containment, landfill capacity, cover material availability, access roads, and the distances from the main source of waste consumption.

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METHODS

Compromise programming is a linear multi-objective programming (MOP) technique originally introduced by Bogardy[2]. This technique allows one to find the complete set of efficient solutions from two or more objectives finding the most appropriate solution from this set of efficient solutions. The efficient set includes all feasible non dominated solutions, i.e. all the pareto-optimum solutions such that no better outcome can be achieved without making at least one objective worse off. An ideal solution is specified with co-ordinates by the optimum values for each objective (Fig. 1). The optimum solution depends on the distance function and the compromise set is composed of the optimum solutions from the following maximisation problem:

$$L_r = \Sigma w_i \Sigma |(R(x) - R)/R(x) - R(w)|$$

where L_r indicates the distance measure of the value criterion R, i – the number of objectives, $R(i)$ and $R(w)$ – the ideal and worst values, and w_i – the relative weights.

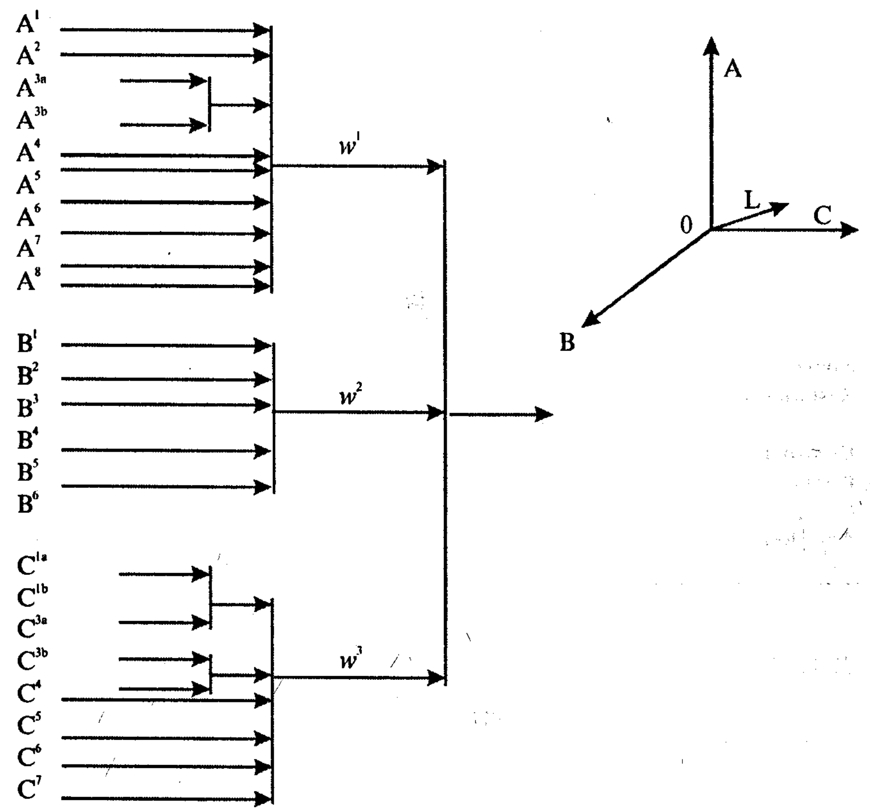

Fig. 1. Environmental (A), social economic (B), and technical operational (C) criteria

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The weight, assigned to the particular management performance index, w_i, reflects the relative preference to other elements within the same group and the weight assigned to the preference to the trade-off analysis. Therefore, the decision-maker must specify a value for the balancing factors. Evaluation of the alternatives is accomplished by calculating the alternative distances.

CASE STUDY

The district of Western Macedonia has decided to construct a waste disposal site. The 32 municipalities to be served, selected by the same geomorphological characteristics and geographical position, have a population of 104 916 habitants. The corresponding production comes up to 34 642 t per year. This district includes Agros Orestikon, Asproklhsia, Asproula, Horigos, Aidonohorion, Neapolis, Aliakmon, Road Eratyra-Sisanion, Germas and Ampelokipi.

Pre-finded promising sites-alternatives. Eight pre-finded promising sites were selected as alternatives. The characteristics of these sites are tabulated in Table 1.

Table 1. Characteristics of the proposed sites

No	Name	Visual contact	Altitude (m)	Access road	Lives tock	Vegetation	Hydrogeo-logical	Land use
1	Vogatsiko Kozanis	no	760	asphalt road	no	*Dianthus carthusianorum*	permeable	grazing
2	Kastri Kozanis	yes	800	asphalt road	yes	*Sparteum juncuem*	permeable	none
3	Mandra Kozanis	yes	620	asphalt road	no	*Dianthus carthusianorum*	semi-permeable	annual crops
4	Moloha Kozanis	no	720	asphalt road	no	*Dianthus carthusianorum*	semi-permeable	annual crops
5	Panagia Kozanis	no	770	road	no	*Sparteum juncuem*	semi-permeable	annual crops
6	Koukouli Kastorias	yes	700	asphalt road	no	*Dianthus carthusianorum Salix incana*	permeable	none
7	Dryovouno Kozanis	no	920	no entrance	no	*Anputus unebo Dianthus carthusianorum*	not permeable	none
8	Ampelorahe Kozanis	yes	720	not paved	no	*Dianthus carthusianorum*	semi-permeable	none

RESULTS AND DISCUSSION

The calculation of criteria is presented in Table 2. Examining the results in the terms of environmental criteria alternative 5 (53.8) is ranked first. In the terms of economic social criteria performance alternative 1 is ranked first (45). Finally, in the terms of the technical operational alternative 7 and 8 (61) ranked first. The score of each alternative computed as the relative distance of the ideal solution, assuming equal weight assigned to each index is as follows: 1 (155.30), 2 (134.90), 3 (145.50), 4 (134.50), 5 (158.30), 6 (130.80), 7 (152.60), 8 (162.10). Therefore, the solution that ranks first to all management options is alternative number 8 (Fig. 2), that has a better overall score.

Table 2. Calculation of criteria for the case study

Criteria/Position	1	2	3	4	5	6	7	8
ENVIRONMENTAL CRITERIA								
Surface water quality impairment	7	8	8	7	7	7	8	8
Groundwater quality impairment								
infiltration-percolation	10	10	10	10	10	10	10	10
recharge from the watercourse	10	10	10	10	10	10	10	10
Land cover and ecological character	10	5	7	7	10	5	10	10
Absence of optical intrusion	7	1	7	7	10	5	7	5
Odors nuisance	6	6	6	6	6	6	6	6
Landfill gas management	5	5	5	5	5	5	5	5
Public health, safety nuisance	5.8	8.5	7	5.8	5.8	5.8	7	8.5
Total	50.8	43.5	50	46.8	53.8	43.8	53	52.5
SOCIAL ECONOMICAL								
Net present value	5	8	5	5	5	5	5	8
Depreciation cost	8	8	5	8	8	8	5	8
Distance from human settlements	5	5	5	5	5	5	5	5
Industry and mineral exploitation or reserve	10	10	10	10	10	10	10	10
Proximity to protected places	7	3.4	7	5	7	5	5.6	7.6
Impacts in housing/touristic development	10	8	5	5	10	8	8	10
Total	45	42.4	37	38	44.5	41	38.6	48.6
TECHNICAL OPERATIONAL								
Climate								
altitude	7	3	7	5	7	3	7	7
protection from strong wings	5	3	10	1	3	1	5	5
Design of the site								
hydrological evaluation	10	10	10	10	10	10	10	10
grading of the surfaces/ protection of the slopes	7	3	7	7	7	5	7	7
Method of leachate containment	10	10	10	10	10	10	10	10
Landfill capacity	10	5	5	1	10	1	10	10
Cover material availability	8	8	8	8	8	8	8	8
Access roads	7	7	7	7	7	7	7	7
Distances from source of waste consumption	10	10	10	10	10	10	10	10
Total	59.5	49	59	49	60	46	61	60
TOTAL	155.3	134.9	145.5	134.5	158.3	130.8	152.6	162.1

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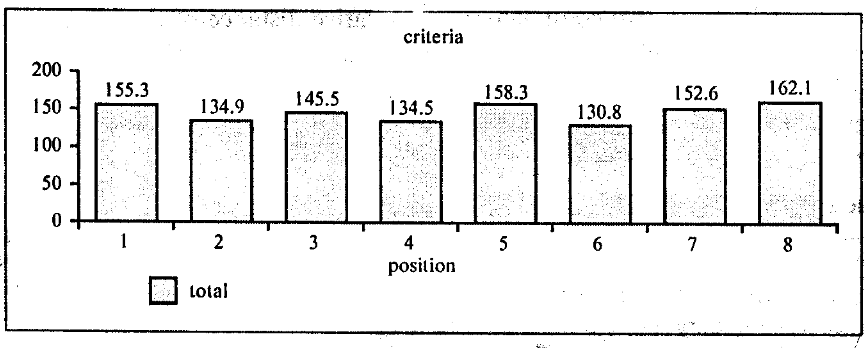

Fig. 2. Rank of the alternative positions

This work presents issues that a compromise programming approach can represent the conflicting objectives of landfill site selection. The primary objectives that often conflict are the environmental, the economic and the technical operational system performance. The approach used to select the final management alternative was to determine an alternative that is "the better existing alternative" with respect to different decision-makers and possibly not necessarily the best for all management options. In summary, the present research extends previous efforts in landfill sites selection decision-making using single objective approaches. It is felt that this extension using compromise programming provides a more realistic perspective of the management procedure. These features combined with the social concern warrant further investigation into decision support studies, multicriteria decision-making approaches and their incorporation of the landfill sites selection.

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