NEW TOOL FOR WASTEWATER TREATMENT UNITS LOCATION

V. Vasiloglou, F. Lokkas, G. Gravanis

Department of Infrastructure Engineering, School of Technological Applications,
Technological Education Institute of Larissa, 41110 Larissa, Greece

ABSTRACT

In the present paper a decision-making process for the potential location of new wastewater treatment units with wide community participation and acceptance is suggested. The main scientific contribution of this work is the elaboration of an independent decision-making tool, which can be used in site selection of wastewater treatment units. Specifically, at a first level it acts as an intermediary between experts (i.e. engineers, technical advisors) and decision-makers (i.e. electives, appointive advisors), helping decision-makers to use experts' knowledge. At a higher level, it acts as an independent processor of decision-makers judgments thereby giving a result that is in accordance with pre-chosen criteria. In this way, the local authorities can effectively participate in the decision-making process and avert the violation of possible agreements. Furthermore, the evaluation criteria and the methodology of multicriteria analysis for new wastewater treatment unit location are presented.

Keywords: *wastewater treatment units; site selection; multiple criteria decision making; multicriteria analysis; evaluation criteria*

1. INTRODUCTION

Site selection of new wastewater treatment units is one of the most serious local community problems. "Not In My Back Yard" (NIMBY) is often the watch cry for citizens in an area where a wastewater treatment unit is reportedly to be sited. Specifically, NIMBY is a syndrome that is contagious and often irrefutable.

Moreover, non-objective selection procedures, adopted in some cases by the local authorities, decreased the confidence of residents over their authorities. Nowadays, residents living near the candidate wastewater treatment units are skeptical about any procedure the qualified authorities suggest and pre-protest against any decision. In such cases, the failure of the procedure is inevitable (Vasiloglou 2004).

To go into more detail, a decision on environmental issues cannot be made without the residents' opinion. Local authorities' participation in any decision-making procedure is of great importance. However, such topics require high specialization knowledge. A solution to this problem can be found with special tools, which are used as intermediate factors between a complex problem and non-expert users (Vasiloglou 2000).

This paper proposes a decision-making process for the potential location of new wastewater treatment units with wide community participation and acceptance. Specifically, a new decision-making tool has been elaborated for improved site selection of wastewater treatment unit. In a first step, an independent team of specialists adopts the tool. In a second step, decision-makers are guided through the evaluation procedure in order to select candidate wastewater treatment units by using several attributes. Finally, data is processed and candidate locations are resulting. The number of stakeholders involved and the extended description of candidate wastewater treatment units by the questionnaire provide an improved basis for decision making.

2. PRESENTATION OF THE TOOL

The suggested tool constitutes a third generation MultiCriteria Decision Support System, MCDSS (Jelassi 1986). It includes data, dialoging and model subsystems (Siskos et al. 1999). Furthermore, the proposed tool belongs to level 6 regarding the computer architecture (Tanenpaum 1995) and for its development a high level 5 language (Visual Basic) was used.

The tool's main functions are to provide:

- An intermediary between experts (i.e. engineers, technical advisors) and decision-makers (i.e. electives, appointive advisors), helping decision-makers to understand experts' knowledge.
- An independent processor of decision-makers' judgments thereby giving a rational selection procedure.

Specifically, the tool includes the following steps:

- Preselection: It realizes the preselection of candidate areas, using a simple procedure of questions – answers between computer and experts and a list of technical specifications.
- Grades width definition: It composes an objective selection frame for the preselected areas, using a new procedure of evaluation questions. In this way, it defines the limits of freedom of graders (decision-makers).
- Decision-makers training: It helps the decision-makers to understand the wastewater treatment problem, what they are grading, and why they have certain limits in grading.
- Grades registration and data protection: It calls the responsible decision-makers to grade the candidate areas and ensures the necessary confidentiality, using different passwords.
- Multicriteria analysis and Decision making: It classifies candidate locations based on the Undoubted Evaluation method and suggests the selection of the candidate areas, according to the criteria that have been defined.
- Control step: It gives the interested person the option of a comparative evaluation of any two areas, referring analytically to the advantages and the disadvantages of one over the other.
- Verification step: It introduces tables with the grades of the candidate areas.
- Other tool's uses: The proposed tool is useful in the hands of qualified local authorities, because it includes:
  - a calculator of the basic equations for wastewater treatment units planning
  - a library of wastewater subjects
  - the Greek and European legislation of wastewater
  - an index of preselection and evaluation criteria
  - an legal and technical adviser of authority establishment for wastewater management and choice of new wastewater treatment units.

The preselection, selection and evaluation procedure of candidate areas are briefly introduced in figure 1.

3. MULTICRITERIA ANALYSIS

Site selection of wastewater treatment unit is a step-by-step process, in which environmental, financial and technical criteria must be applied successively. Therefore, the evaluation of candidate areas can be achieved using multiple criteria decision-making methods, because of the number and the non-uniformity of evaluation criteria. The proposed tool uses the multicriteria method EP+ [Undoubted Evaluation] (Vasiloglou 2000) so as to ensure a rational procedure. The suggested method of multicriteria analysis is mainly based on the foundations of the ELECTRE I (Roy 1968) and PROMETHEE II (Brans et al. 1985) methods. Specifically, it is a combination and an extension of them and consequently preserves intact several fundamental principles of these methods. This

methodology was analytically presented in the First Conference "Small and Decentralized Wastewater Treatment Units" (Vasiloglou et al. 2006). The entire modeling procedure of this method is presented in figure 2.

The main elements of the EP+ are:

- Set of activities *A* (Candidate areas).
- Consequent family of criteria *F* (Evaluation criteria: $g_1, g_2, \ldots, g_n$).
- Table of Multicriteria evaluation (Grades of decision makers: $g_i(a_i)$).
- Importance coefficients of criteria p_i (Weights of criteria $p_1, p_2 \ldots, p_n$, $\Sigma p_i = 1$).
- "Undoubted Evaluation" Indicator: $V_C(a,b) = \Sigma\{p_i[g(a)-g(b)]\}$ $\forall i$ *where* $g_i(a) > g_i(b)$.
- Superiority control threshold u_s (Dimensionless number, $u_s > 0$).
- Discordance thresholds v_j ($v_1, v_2 \ldots v_n$).
- Total discordance indicator: $V_D(a,b) = \Sigma p_j$ $\forall j$ *where* $g_j(b) - g_j(a) > v_j$ *when* $g_j(a) < g_j(b)$.
- Total discordance threshold V_T (Dimensionless number).
- Table of Undoubted evaluation: $aS_Vb \Leftrightarrow V_C(a,b) - V_C(b,a) > u_s$ *and the condition of total discordance is satisfied.*
- Core (Best areas): a subset *P* of *F where*: "$\forall$ b$\in$(F-P) $\exists$ a$\in$P for which aSVb" and "$\forall$ a$\in$P and a´$\in$P, a$Va´ and a´$Va"
- Subset of significant evaluation criteria.

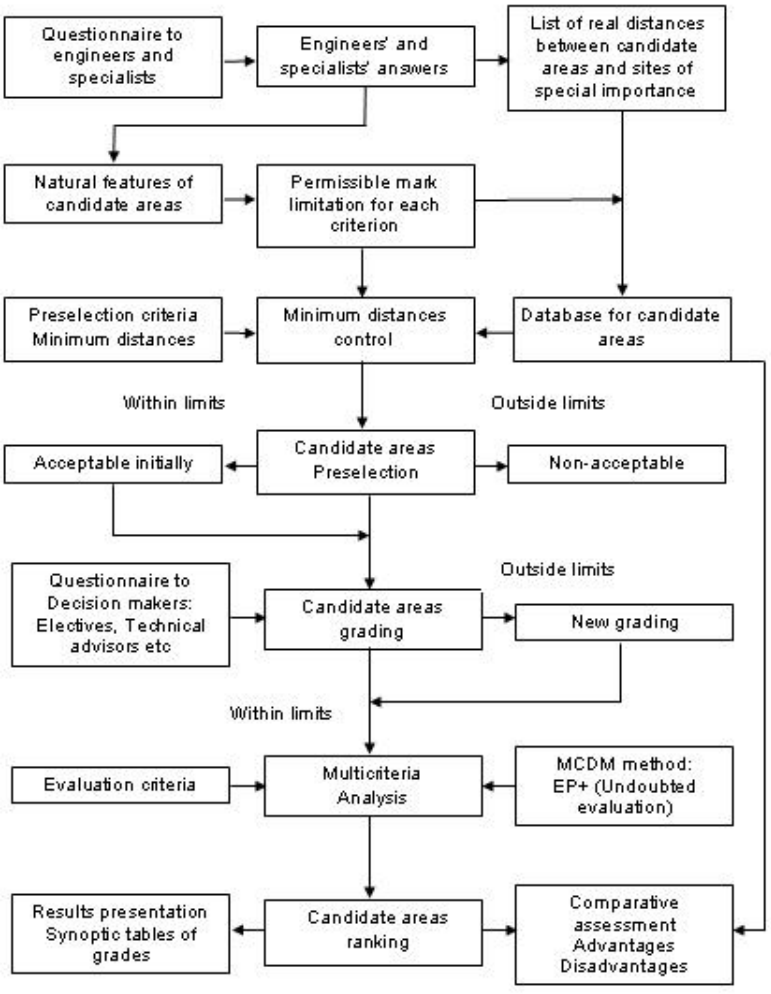

Figure 1. The preselection, selection and evaluation process for the candidate areas.

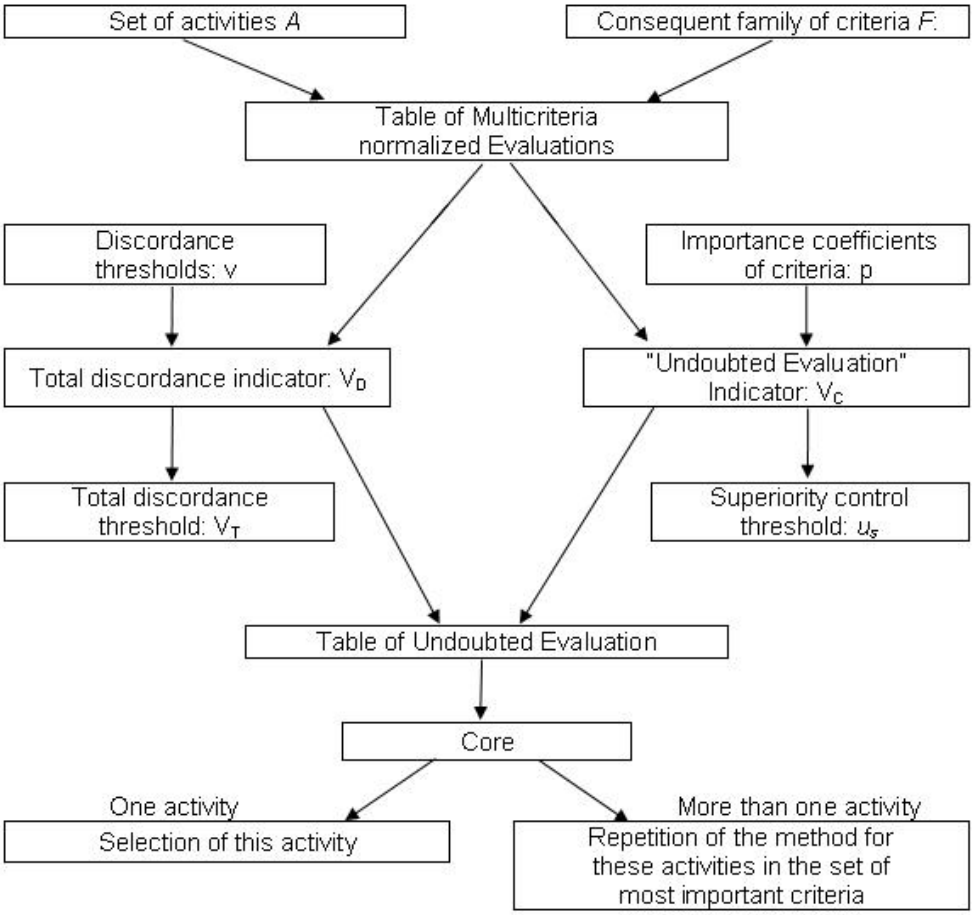

Figure 2. The MCDA algorithm of EP+ method (Undoubted Evaluation).

4. SUGGESTED EVALUATION CRITERIA

As mentioned before, site selection of wastewater treatment unit is a step-by-step process, in which environmental, financial and technical criteria (general, specialized, land-planning, geomorphological and hydrogeological) must be applied successively. These criteria are reconsidered, completed and represented so that they can be taken into consideration in defining a new site of wastewater treatment unit.

Aiming for complete objectivity of the selection procedure, and having in mind a large number of reports from the international bibliography (Association of Boards of Certification 2004, Cambareri et al. 2003, Colorado Department Of Public Health And Environment 2002, Correctional Service Canada 2003, Hazen and Sawyer 2005, Tsagarakis et al. 2003, Washington State Department of Health 1994, etc) the importance (weight) of every criterion has been defined. Nevertheless, these weights are always matters of discussion and can be modified by the researchers and the decision makers under the condition that new values will be defined before the beginning of the evaluation procedure. This is necessary in order to secure a rational and bias free selection procedure.

All these elements (evaluation criteria and their weights) are tabulated and presented in table 1, so that they can be applied in multiple criteria decision system procedures or independently.

Table 1. Suggested evaluation criteria of candidate areas.

	Weight		Weight
General criteria		**Geomorphological criteria**	
• Area surface	3	• Exclusion zone	2
• Area availability	3	• Visual isolation	3
• Ownership status	2	• Scenic environment	1
• Area cost	2	• Convenience in the construction of foundation projects	3
• Potentials of area use in future	1	• Access to the area	3
		• Existing road network	1
Land-planning criteria		• Traffic effects	1
• Distance from residential, tourist and developing areas	3	• Ground inclination	1
• Distance from areas of historic, archaeological, architectural or paleontological importance	2	**Hydrogeological criteria**	
• Distance from areas of natural scenic beauty or natural protection and habitats of protected species or wetlands	2	• Depth of water table	1
• Distance from municipal parks, sports centers and areas with recreation sites	3	• Soil media	1
• Distance from hospitals, medical centers and military bases	3	• Wells' density in solitary rural areas	2
• Distance from water supply resources, natural or artificial lakes and rivers	3	• Monitoring of groundwater	1
• Distance from flood zone areas and areas rich in water surface	2	**Specialized criteria**	
• Distance from unstable areas and areas with subsidence zones or expansive soils	2	• Expansion Potential	1
		• Distance from final receiver	2
		• Distance from site of sludge disposal	2
		• Energy conservation requirements	1
		• Centrobaric position (in case that many settlements use the same wastewater treatment unit).	3

5. CASE STUDY: APPLICATION OF PROPOSED TOOL

The proposed tool will be applied pilotly in the coastal settlements of Municipality of Down Olympus of Prefecture Larissa in collaboration with the Department of Infrastructure Engineering of A.T.E.I. Larissa. Specifically, in a first step the suitable sites for the operation of wastewater treatment units will be recognized having in mind the minimal distances of candidate sites from areas of particular importance. Then the evaluation criteria for the candidate places will be analyzed and the superiority control threshold, the discordance thresholds and the total discordance threshold will be determined. The process will be completed with the marking of candidate sites and the determination of core with the better places.

Furthermore, the proposed tool was applied pilotly (Vasiloglou 2000) for the selection of new landfill in West Thessaly of Greece (Karditsa and Trikala prefectures). A complete presentation of this work "New tool for landfill location" was published in the Waste Management and Research, Vol. 22, No. 6, 427-439 (2004).

6. CONCLUSION

The proposed tool seeks the rational selection of new sites of wastewater treatment units aiming for a wider community participation and acceptance. Initially, it acts as an

intermediary between experts and decision-makers, helping decision-makers' training by experts. In addition, it acts as an independent processor of decision-makers' judgments and gives a reliable result using a new multiple criteria decision method (EP+). In this way, it utilizes the experts' knowledge and takes into account local authority and public opinion, averting the violation of prospective agreements. The pilot application of this tool has shown that it can help significantly researchers and local authorities with wastewater treatment unit location.

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