APPLICATION OF MULTICRITERIA ANALYSIS IN THE MANAGEMENT AND PLANNING OF TREATED MUNICIPAL WASTEWATER AND SLUDGE REUSE IN AGRICULTURE AND LAND DEVELOPMENT: THE CASE OF SPARTI'S WASTEWATER TREATMENT PLANT, GREECE

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ABSTRACT

Reclaimed wastewater and biosludge reuse is a multifactor problem directly related to environmental planning and management. The rational and effective disposal in the agroecological environment depends on the balanced interaction of spatial, technological, environmental, social-political and economical parameters. Consequently, an optimum solution could be achieved by the application of a Multicriteria Decision Analysis (MCDA), which could take into account all the above parameters. This type of model taking into consideration the local constraints, is currently considered as offering the most compatible solution for such complex problems of conflicting and opposing interests.

A MCDA was applied to the management of the Sparti's Wastewater Treatment Plant (WWTP) output with the view to find an optimum solution of the wastewater and biosludge disposal. Three scenarios were formulated based on the above parameters. It was found that the best (optimum or compatible) scenario was the 2nd one, according to which the outputs of the Sparti's WWTP could be applied successfully to an agricultural area of Laconia's prefecture cultivated with horticultural citrus and olive trees.

KEYWORDS: Multicriteria Decision Analysis (MCDA); Wastewater and Sludge reuse; Land application; Agricultural recycling and irrigation; Management and Planning

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1. INTRODUCTION

The decision making could be defined as an effort of solving dilemmas which present opposing interests and goals [1]. These problems can be solved by means of the so called MCDA, or Multifactor analysis for decision making. This type of analysis is defined as the systematic and mathematically oriented procedure, aiming at solving problems of opposing goals [2]. Multicriteria analysis has been proven to provide a good framework for effective decision making, for selecting the best compromise among the available alternatives [3]. It must be underlined, however, that the fulfillment of these goals cannot be fully achieved during the process of the solution of these problems. The possible selections of such a problem may be optimal ones, only with respect to not more than one goal, because, otherwise, there should not be a problem for final decision: The selection that would satisfy such a condition should be the optimum. Consequently, a compromise between the opposing goals is necessary.

The multicriteria analysis can be very useful in this respect, because it quantifies an otherwise qualitative problem, and leads to a decision making, in spite of the fact that it may not be very objective. However, up today, MCDA is the most effective method and ordinary application tool for solving such multifactor opposing goal problems.

The MCDA analysis includes, first of all, a theoretical background, on which the main logic for the approach to such problems lies, and on the basis of this background, a number of techniques have been developed for solving problems of a great field's range, which pop up in every day practice. These techniques have been classified into a group of methods, which have been improved very much during the last 30 years [4].

The process of environmental planning and decision making includes the participation of many people, organizations and other groups of the Private and State sector, and it lasts usually from a few months, at least, up to 3 years [5]. Therefore, it is necessary to divide that work into various phases i.e. determination of the goals and structure of the problems.

- Determination of the alternative scenarios.
- Selection of the evaluation criteria, and analysis of possible actions.
- Determination of the significant coefficients.
- Analysis of the results.
- Selection of the best solution.

According to Georgopoulou *et al.* [6], the stages of the multicriteria analysis are the following ones:

a) Definition of the complex problem.

b) Elaboration of the evaluation matrix, which will include:

b1. Definition of involved actors in process

b2. The formulation of alternative strategies

b3. The selection of criteria for the evaluation

b4. The evaluation of alternatives according to the selected criteria.

c) Formulation of potential actions.

d) Selection of evaluation criteria.

e) Definition of criteria weights.

f) Aggregation of performances, (calculation of the result for the alternative scenarios by means of the appropriate multicriteria method).

g) Ranking of potential actions (alternative scenarios) from the best to the worst case.

h) Results discussion and examination in order to shed light into points of interest.

i) Recommendations on the basis of the results obtained.

It is recognized that the following difficulties are involved in the decision making supporting systems [7]:

a) Determination of the alternative choices.

b) Determination of the accurate role of the decision maker.

c) Schematization of the preferences of the decision maker.

d) Facing of the uncertainty, inaccuracy, and no determinability of the data.

e) Impossibility of the exclusive evaluation of the credibility of the decision making process, by means of a mathematical model.

The dilemmas, which are encountered with decision making, in the context of the environmental planning, are related to conflicting sociopolitical, economic, and environmental interests, which constitute a complex set of problems. The solution of these problems requires a multidimensional approach [5].

The complexity of the environmental problems makes extremely difficult their representation by means of descriptive models, and consequently the inaccuracy and the doubtfulness constitute, by necessity, part of their structural elements. It must also be stated that these opposing ideas, values and goals of the interested groups, are reflected in the process of their evaluation. Therefore, the participation of the public sector in the process of decision making with respect to environmental management, is necessary so as to secure *that the local values, traditions and habits will be incorporated into the decision making, and that justice and clarity of the process will be secured* [8].

The nature of the multicriteria evaluation makes impossible the introduction, by the scientific team, of anything useful, without the interaction with the various social groups. Of course, neither the latter groups could take any decision without the contribution of the former.

The following stakeholders or actors are participating in the decision making [9]:

a) Representatives of the Local Self-administration Organizations (Municipality), who have been elected and, therefore, legally representing the people of the area.

b) Various Political Groups representing Political Parties, Domestic Organizations, Environmental Organizations, and people of the area with interests in public problems.

c) Scientific Team.

d) Persons who are going to implement the program (Program implementation Group).

The purpose of the present paper is to apply the MCDA in the environmental planning, in relation to sludge and treated wastewater reuse, in the area of Sparti in South Greece, with the view to effectively exploit the Wastewater Treatment Plant (WWTP) output, in the context of agricultural production, environmental protection, and towards sustainability of natural resources.

2. MATERIALS AND METHODS

The WWTP under study is located near the river Evrotas, in a distance of 2.5 Km from the town of Sparti. The processing method used is that of the Active Clay with protracted aeration, while the excess P and N are removed by biological dephosphorization and denitrification. Finally, the disinfection is performed by chlorinating the WWTP output effluents.

The population of Sparti is 16,150 people with a potential possibility of increase up to 40,000, while the WWTP has been designed to produce 2,630 m^3/day, with a maximum flow of 201 m^3/h. The design parameters of the WWTP are given in Table 1.

TABLE 1 - The design parameters of the WWT Plant of Sparti, Prefecture of Laconia in South Greece.

Parameter	Value	Units
Population (served nowadays)	21 300	Equivalent inhabitants
Population (maximum)	40 000	Equivalent inhabitants
WWT Plant Flow		
Mean daily	8 000	$m^3\ day^{-1}$
Peak flow	150	$L\ s^{-1}$
Organic Polluting Loading		
Organic loading $^1BOD_5$	2 400 300	$kg\ day^{-1}$ $mg\ l^{-1}$
^2COD	5-100	$mg\ l^{-1}$
Suspended solids (SS)	2 800 350	$kg\ day^{-1}$ $mg\ l^{-1}$
Total nitrogen TKN	400 50	$kg\ day^{-1}$ $mg\ l^{-1}$
Phosphorus	120 15	$kg\ day^{-1}$ $mg\ l^{-1}$
Waste Sludge	10	$m^3\ day^{-1}$

^{1}BOD = Biochemical Oxygen Demand; ^{2}COD = Chemical Oxygen Demand

Environmental planning is lacking the exclusive objectivity by necessity and, therefore, partiality is its indispensable characteristic, which is made either by the scientific team or by the entangled social groups. As this condition affects the objective selection and choice of the evaluation criteria as well as their weight, it must be given special attention during the selection of the criteria [5].

The multicriteria analysis, therefore, presupposes the careful description of the evaluation criteria and their integration into a uniform mathematical expression which is known as *utility function* [10]. Also the second presupposition includes the risk of either over-evaluation or under-evaluation of some criteria in relation to the rest, with the consequence of partial expression of some functions. It must be underlined that the criteria are the necessary elements of multicriteria analysis, since they constitute the basis for the evaluation of the alternative scenarios. Unfortunately, the selection of the criteria is not done on the basis of a well defined procedure. However, there are some techniques which contribute to their more effective selection.

Various researchers have supported that the selection of the criteria should be done hierarchically through synthesis of various points of view, till the opinions approach each other [5, 11, 12]. In other words, the chosen criterion must be a product of participation process. In addition, the criteria must be complete and include all the basic aspects of the problem. Furthermore, they must be functional, accurate, and should minimize the size (dimensions) of the problem [13]. According to Brans [14], the following types of criteria are proposed: a) Economical, b) Technological, c) Social and d) Environmental ones.

The model of the multicriteria analysis was applied to Sparti WWTP outputs. The application of the model was done in order to find out the optimum management for the reuse of the sludge and wastewater produced by a potential population of 40,000 people.

For the application of the MCDA, a model simulation software program was developed in the MS Excel framework using Macros and Visual Basic for Applications (VBA) Programming Language coding. The algorithms, programmed in VBA, simulated the process of planning and the application of the MCDA wastewater and biosludge model including the following aspects:

a. The involved actors, i.e. actors can be classified into the following categories:
   a1. Local Self-Administration Organizations (Municipality of Sparti),
   a2. Regional Administration,
   a3. Non-governmental Organizations (NGOs),
   a4. Civil Groups and Unions,
   a5. Finance Institutions (Credit Banks, etc).
b. The weight (importance) of each one of the above, was determined (Fig. 1) in the scale 0-100 %, by the scientific (experts) team.
c. In cooperation with the above involved actors, the general criteria and the subcriteria were determined.
d. A special questionnaire was prepared to be filled in, by each of the involved actors, concerning the weight (or balance coefficient) that they assign to each of the determined criteria and sub-criteria.
e. The categories of the criteria chosen were Category A (Spatial, Technological, Environmental and Social-political) and Category B (Economical).
f. The weight (or balance coefficient) of each sub-criterion was determined in the scale 0-100 %, taking into account that the sum of the balance coefficients of all sub-criteria for the corresponding criterion will be 100 %.
g. The weight (or balance coefficient) of each criterion was determined in the scale 0-100 %, taking into account that the sum of the balance coefficients of all criteria will be 100 %.
h. The sub-criteria were graded from the scientific (experts) team, according to the scale 80-120, for every scenario. The calculated balance grading of each subcriterion and for every scenario was determined quantitatively by means of equation (1).
i. The criteria score was calculated according to the scale 80-120, for every scenario. The calculated balance grading of each criterion and for every scenario was determined quantitatively by means of equation (2).

The decisions of multicriteria problems are given in the form of a Table known as **"Evaluation matrix of alternative scenarios"** in which the columns represent the criteria, and the rows the alternative scenarios (choices) or selections.

The main virtue of the multicriteria analysis is that it aims at social welfare, which is considered as a multifactor issue directly related to social, economic and environmental parameters. Also, its goal is to succeed optimum management of the sludge and wastewater. On the other hand, the vice of this method of analysis is that it leads to a compromise rather than to definite solutions, due to the partiality of the chosen criteria, which are characterized by opposing interests [15, 16]. MCDA has been used in various field areas, such as lakes` water quality, problems of public interest, sustainability assessment, waste disposal, energy, sludge disposal, coastal zone management, cage sitting for marine aquaculture, etc [10-13, 15-18].

Based on the above philosophy, the case of the WWTP of Sparti, which administratively belongs to the Prefecture of Laconia, will be examined by means of Multicriteria Analysis, in order to establish scenarios for the optimum Management of the Sludge and Wastewater.

3. RESULTS AND DISCUSSION

The model of multicriteria analysis was applied using the developed simulation MCDA software [16] for the management and planning of the Municipal WWTP of Sparti, Prefecture of Laconia. The application procedure used was as follows:

3.1. Classification of the Evaluation Criteria into categories.

The categories of the criteria chosen were: Category A (Spatial, Technological, Environmental and Social-political) and Category B (Economical).

The above model was used with view to choose the optimum decision for the disposal of wastewater and biological sludge produced by the Sparti WWTP, equivalent to a population of about 40,000 people.

3.2. Application of the MCDA process with the Multicriteria Model

The conceptual schema of involved actors (stakeholders), the expert team and the hierarchical structure of the wastewater and biosludge MCDA model is depicted in Fig. 1.

The 1st step in the process (Fig. 1) was to determine and rank the involved actors and their corresponding weight in the scale 0-100 %, as it can be seen in the model simulation software snapshot data form named "*Selection of the involved actors and weight assignment for the MCDA*" in Fig. 2.

The 2nd step was the determination of the criteria and sub-criteria, and their weight assignment of the involved actors and the calculation of the balanced weight for the 2nd level criteria (Fig. 3). Both the main criteria and sub-criteria were ranked in cooperation with the involved actors, by means of a questionnaire prepared by the members of the scientific (experts) team and filled in by each actor. Therefore, by this method, the opinion of the involved actors is automatically taken into consideration by the MCDA model. The weight (or balance coefficient) of each criterion/ subcriterion was determined in the scale 0-100 %, taking into account that the sum of the balance coefficients of all criteria/subcriteria for the corresponding criterion will be 100 %. (Fig. 3). The subcriteria were graded from the scientific team, according to the scale 80-120, for every scenario. The calculated balance grading of each subcriterion and for every scenario was determined quantitatively by means of equation (1).

$$BK_{sx} = \sum_{i=1}^{n} (\acute{a}_i \ B_{isx}),\ i = 1,...,n,\ sx = 1,\ldots,m \qquad (1)$$

where α_i is the weight or balance coefficient of the involved actor *i* in the process of decision making, B_{isx} is the weight assigned by each involved actor *i* to the subcriterion *sx*, or the grading of the subcriterion.

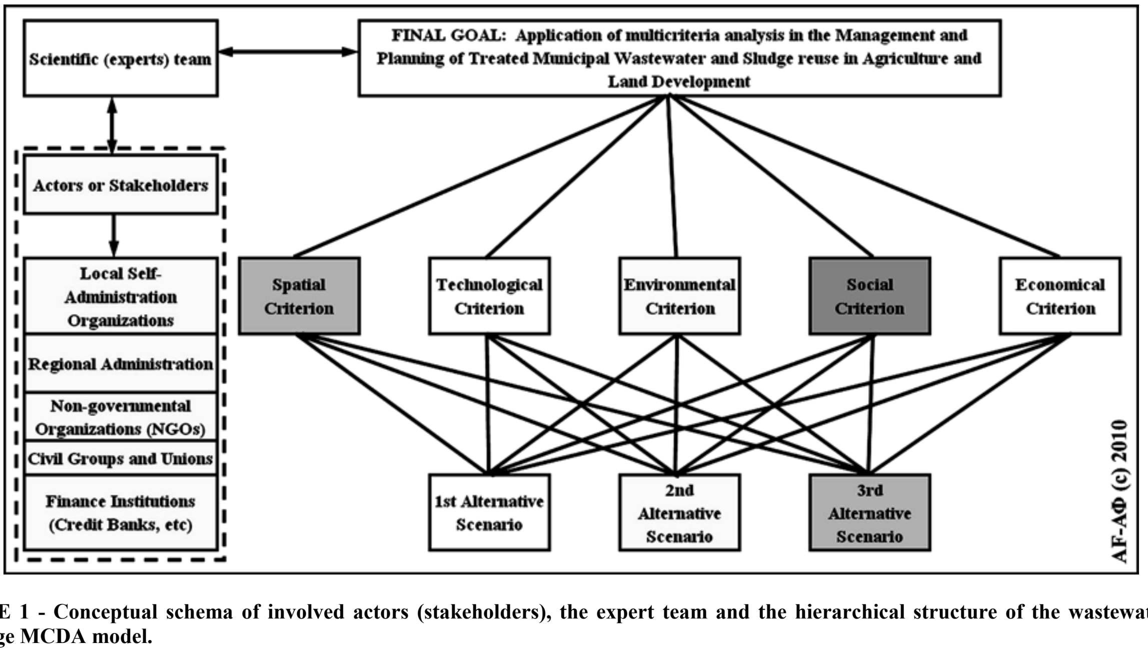

FIGURE 1 - Conceptual schema of involved actors (stakeholders), the expert team and the hierarchical structure of the wastewater and biosludge MCDA model.

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SELECTION of the INVOLVED ACTORS and WEIGHT ASSIGNMENT for the MCDA

SN	Code of Involved Actor	Involved Actor	Weight of Involved Actor
1	ΕΦ1	Local Self-Administration Organization	35 %
2	ΕΦ2	Regional Administration	30 %
3	ΕΦ3	NGOs	8 %
4	ΕΦ4	Civil Groups and Unions	15 %
5	ΕΦ5	Finance institutions (Credit Banks, etc)	12 %
		TOTAL:	100 %

FIGURE 2 - Selection of the involved actors and their assigned weights using the wastewater and biosludge MCDA simulation software model application.

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WEIGHT ASSIGNMENT of 2nd LEVEL CRITERIA for the MULTICRITERIA DECISION ANALYSIS

SN	Criteria Code	2nd Level Criteria	Weight ΕΦ1 (LSAO)	Weight ΕΦ2 (RA)	Weight ΕΦ3 (NGOs)	Weight ΕΦ4 (CG, CU)	Weight ΕΦ5 (FIs)	BALANCED WEIGHT for 2nd LEVEL CRITERIA
1	2-K1	SPATIAL	28 %	30 %	20 %	30 %	28 %	28.26 %
2	2-K2	TECHNOLOGICAL	22 %	22 %	25 %	25 %	24 %	22.93 %
3	2-K3	ENVIRONMENTAL	22 %	28 %	30 %	20 %	20 %	23.90 %
4	2-K4	SOCIAL	28 %	20 %	25 %	25 %	28 %	24.91 %
		TOTAL:	100 %	100 %	100 %	100 %	100 %	100.00 %

FIGURE 3 -. Determination of the weights of the 2nd level criteria using the wastewater and biosludge MCDA simulation software model application.
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By applying the above utility function, the balanced grading for each subcriterion and every scenario, is calculated, e.g. for the scenario j_2, the calculated balance gradings of spatial subcriteria are 32.58, 20.29, 31.74, 19.83 and 5.26. The calculated balance grading by means of equation (1) results from the data of Table 2, as follows:

BK_{sx1} = (29.62*(110/100)) = 32.58,

BK_{sx2} = (19.32*(105/100)) = 20.29,

BK_{sx3} = (26.45*(120/100)) = 31.74,

BK_{sx4} = (18.03*(110/100)) = 19.83,

BK_{sx5} = (6.58*(80/100)) = 5.26.

The criteria score was calculated according to the scale 80-120, for every scenario. The final calculated balance grading of each criterion and for every scenario was determined quantitatively by means of a mathematical utility function, e.g. for the scenario j_2, the calculated balance grading of spatial criterion is as follows [eq. (2)]:

$$\hat{A}\hat{E}_x = \sum_{i=1}^{n}\left[\left[(\acute{a}_1\, B_{11}) + (\acute{a}_2\, B_{21}) + (\acute{a}_3\, B_{31}) + (\acute{a}_4\, B_{41}) + (\acute{a}_5\, B_{51})\right] B_{ix}\right],\ i = 1,\ldots,n,\ x = 1$$

where α_i (α_1.. α_5) is the relative importance weight (or balance coefficient) of the involved actor i in the process of decision making, $B_{11}...B_{51}$ is the weight assigned by each involved actor i to the subcriterion $sx=1..5$, B_{ix} is the calculated balanced weight of involved actor i to the criterium x, i is the number of involved actors, and x is the number of criteria.

The above Utility Functions were computerized and automated using Visual Basic for Applications (VBA) Programming Language in MS Excel Framework for MCDA algorithms development, and were applied to each subcriterion and main criterion.

Therefore, the total balance grade for the scenario j=2 and for spatial criterion x=1, the BK_{x1} is as follows:

Total J_2-BK_{x1} = ((32.58+20.29+31.74+19.83+5.26) x (28.26/100)) = 31.00

TABLE 2 - Spatial subcriteria and their corresponding balance weight, grades and balance grades of the subcriterion.

1. SPATIAL CRITERIUM Subcriteria (*sx*)	Balance weight BW = 0,…,100	Grades of the subcriterion	Balance Grades
1. Character of the disposal region or section of it (agricultural, tourist, protected area (Natura 2000, corine biotopes, etc), archaeological, small industry-based region, urban etc)	29,62	110	32.58
2. Sufficiency of space in the installations of WWTP and availability for the loading of biological sludge and technical infrastructure of WWTP for the disposal of wastewater and the existence of a natural recipient.	19,32	105	20.29
3. Land uses - Availability of space in likely regions of disposal – Land property arrangement - morphology of disposal region (topographic bas-relief, slopes, hypsometric differences with the location of WWTP, etc), - Soil types of disposal region (mechanical constitution, permeability, etc).	26,45	120	31.74
4. Availability of basic infrastructures (the road network, accessability, energy supply, etc).	18,03	110	19.83
5. Aesthetic criteria of the disposal region (aesthetics of the disposal land, angles and visibility horizon of the disposal area, optical pollution by the trucks which transport the sludge and by the works of disposal and the imminent dust, etc).	6,58	80	5.26

Finally, the 3rd step was the evaluation of the scenarios themselves and the formulation of the final evaluation matrix of alternative scenarios (Fig. 4).

By means of function (3), the sum of the final balanced grading of all the criteria is calculated and the result found represents the Total Grading ($\Sigma T\Sigma \hat{A}TT_j$) of scenario j (j=1,….k) in the A category of the evaluation criteria.

$$\Sigma T\Sigma \hat{A}TT_j = \sum_{x=1}^{m}(BK_x),\ j=1,...,k,\ x=1,\dots,m \quad (3)$$

where BK_x is the final weight for each criterion x of the 2nd level of multicriteria analysis, j is the number of scenarios, and x is the number of criteria.

In the scenario j, with the higher score, equation (4) is applied and the highest ranking grade (100) taken, while the remainder scenarios are ranked proportionally in the scale 0-100.

$$\Sigma T\Sigma \hat{A}TT_{jmax} = 100,\ j = 1,...,k \quad (4)$$

where j is the number of scenarios.

The final results used for the calculation of the evaluation matrix of alternative scenarios of the multicriteria problem, and for determining the optimal ranking of the various scenarios concerning the optimum management planning and application of wastewater and sludge from the Sparti's municipal WWTP are shown in Fig. 4.

According to the resulting evaluation matrix, the optimum decision making is related to the 2nd scenario, on the basis of which it is proposed that the wastewater and sludge can be disposed in a cultivated region (area) with olive or/and citrus trees. The 3rd scenario, disposal of wastewa-

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EVALUATION MATRIX of ALTERNATIVE SENARIOS of the MCDA

ALTERNATIVE SCENARIOS	EVALUATION CRITERIA SCORE				
CC =	2-A-K2	2-A-K2	2-A-K3	2-A-K4	2-B-K1
	1. SPATIAL x_1	2. TECHNOLOGICAL x_2	3. ENVIRONMENTAL x_3	4. SOCIAL x_4	5. ECONOMICAL x_m
j_1 = SCENARIO 1st : Disposal of wastewater and bio sludge in a region (extent) cultivable with horticultural, cereals, medic, etc.	28,26	26,04	22,06	23,88	142,86
j_2 = SCENARIO 2nd : Disposal of wastewater and bio sludge in a region (extent) cultivable with arborescent cultures (olive trees or/and citrus trees).	31,00	23,68	25,00	25,03	100,00
j_3 = SCENARIO 3rd : Disposal of wastewater and bio sludge in a region (extent) of wasteland or wilderness-land (bare land, agricultural uncultivated fields, land with small shrubs etc).	26,21	22,76	23,34	27,97	117,65

FIGURE 4 - Evaluation matrix of alternative scenarios of the multicriteria problem, related to wastewater and sludge management planning, produced by the Municipal Wastewater Treatment Plant of Sparti.

ter and bio sludge in a region of marginal land (bare land, agricultural un-cultivated fields, land with small shrubs etc), is ranking second, and the last one (3rd position) is the 1st scenario (disposal of wastewater and bio sludge in a region cultivable with horticultural, cereals, plants for medical use, etc.), as it is the least acceptable (Fig. 4).

3.3. Sensitivity Analysis of the criteria weight

The aim of the sensitivity analysis is to explore how changes in the model influence the decision recommendation.

The weight of the criteria and their grading must actually be subjected to a sensitivity analysis study. However, since the grading is based on scientific principles, i.e. on the questionnaire, which was filled in by the involved actors (stakeholders), the usefulness of the sensitivity analysis study has obviously least value for these parameters. The procedure followed herein is actually an innovation of the proposed methodology. The prerequisites, however, which act as a safety valve, are:

a) Determination of the criteria and subcriteria.

b) The wide range of the involved actors based on the scientific validity, and the fact that they participate in the grading procedure as well as in the level of "political" influence for the decision making, make the multicriteria model quite sensitive, to the extent of minimizing the need for a sensitivity analysis study.

However, a sensitivity analysis study of this model was performed in relation to the alternative changes of the involved actors' weight, for the determination of the optimum alternate solution. This was made by giving high weight values to some involved actors, so as to investigate the extent to which they (actors) influence the final selection of the optimum scenario.

In total, nine main cases were investigated of different weight coefficients, of the involved actors, for the decision making, regarding the management planning of the wastewater and sludge disposal, produced by the Sparti WWTP. The examined cases were the following:

1st case: The weight coefficients for involved actors and criteria were applied to the simulation software model of the MCDA after their grading by the scientific (experts) team (Fig. 2).

2nd case: The weight coefficients were equally distributed (20% each) among the involved actors.

3rd case: Higher weight was given to the Local Self Administration which is responsible for Sparti WWTP.

4th case: Higher weight coefficients were assigned to the Public Services (Regional Administration, Ministry of Public works and Environment).

5th case: Higher weight coefficients were assigned to Non-Governmental Organizations (Ecological Societies, etc).

6th case: Higher weight coefficients were assigned to Civil Groups.

7th case: Higher weight coefficients were assigned to the Credit Organizations (Banks, etc).

8th case: Equally distributed weights (50-50%) were assigned to Governmental Organizations and to various Civil Groups Unions and Societies.

9th case: 50-50% of the weights were assigned to the Responsible (actor) of the Municipal Wastewater Plant, i.e. the Local Self Administration Organization and to the Regional Administration.

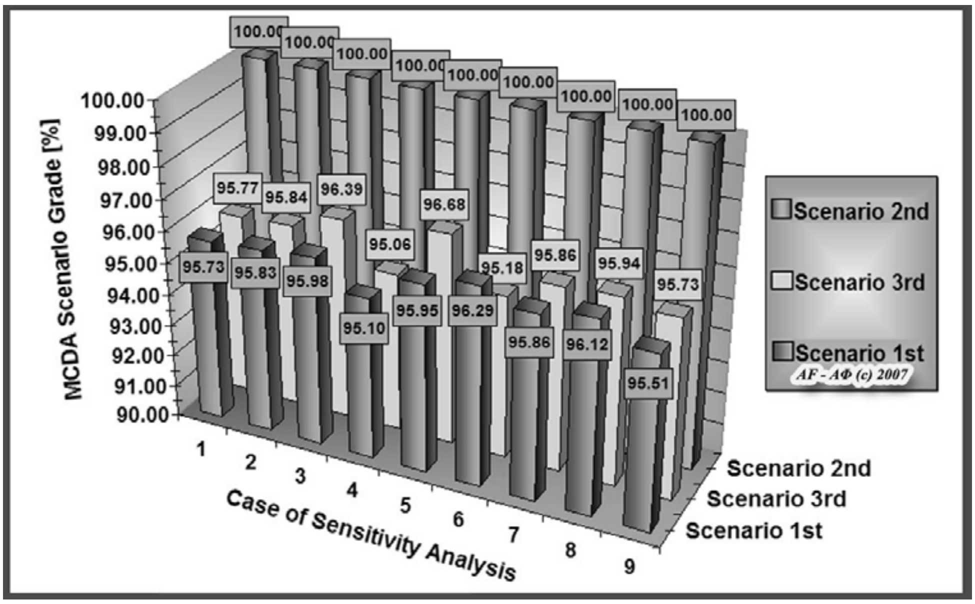

FIGURE 5 - Sensitivity Analysis results of the wastewater and biosludge MCDA simulation software model application for the three scenarios.

The wastewater and biosludge MCDA simulation software executed the MCDA model nine times using the corresponding data for each of the nine different cases of the sensitivity analysis. In each of the nine cases, as it was explained above, for the scenario *j* with the highest score, it was applied equation (4), and it was attributed the highest ranking grade, that is to say value 100, while the remainder scenarios were ranked proportionally in the scale 0-100. The results of the sensitivity analysis of the wastewater and biosludge MCDA simulation software model for the nine cases are depicted in Fig. 5.

Concertedly, from the results of the sensitivity analysis, it appears that, with absentee, the economical dimension of the subject, the results of the wastewater and biosludge MCDA model – despite intense and, in certain cases, extreme differentiation of weight factors of the involved actors in decision-making - they attribute, in all the alternative cases of the model's sensitivity analysis, as the most optimal selection the second scenario that is to say "Disposal of wastewater and bio sludge in a region (extent) cultivated with olive trees or/and citrus trees". This fact empowers the validity of the final scenario selection of the MCDA model, and shows its superiority as most optimal decision recommendation.

4. CONCLUSIONS

The application of the multicriteria analysis approach in wastewater and sludge planning and management policies decisions provides the possibility of incorporating a large number of different and often conflicting parameters into a criteria process, and makes the difficult task of assessing the various scenarios much more objective and acceptable.

It was found on the basis of Spatial, Technological, Environmental, Social and Economical criteria, that the most compatible and acceptable scenario of wastewater and sludge management was the 2nd one, according to which the outputs (wastewater and bio sludge) of the biological processing plant, could be applied to an agricultural area cultivated with olive and citrus trees.

It was concluded that the MCDA modeling, despite of its shortcomings, could help towards giving relatively satisfactory solutions of complex multifactor problems, which are faced by the modern societies.

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