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A multicriteria analysis application for evaluating the possibility of reusing wastewater for irrigation purposes in a Greek region

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ABSTRACT

The objective of the present study was the evaluation of the possibility that the use of reclaimed municipal wastewater for irrigation purposes in a Greek region is sustainable. The irrigation uses that were examined included agricultural as well as landscape irrigation ones. Thus, a model aiming at evaluating the procedure of wastewater reuse in Greece was constructed. This model incorporates the necessary economic parameters as well as the most important social and environmental ones. The main goal was the integrated evaluation of wastewater reuse procedure in a Greek region or area. The methodology that was used for our model construction was a multicriteria decision making one (PROMETHEE II). More specifically, six alternative scenarios of wastewater advanced treatment and disinfection were fixed and, were afterwards evaluated on the basis of their scores in specific economic, social and environmental criteria. The scores were fixed considering literature data as well as data collected from surveys and experiments taking place mainly in Thessaly region, Greece. The main results of our evaluation showed that wastewater reuse for irrigation purposes in the above region could be sustainable, when considering not only the necessary economic parameters but also the most important social and environmental ones. Indeed, the use of a simple advanced treatment (i.e. filtration or coagulation–filtration) in comparison with ozone use as disinfectant was the best secondary effluent treatment scenario for the cases of both agricultural and landscape irrigation.

Keywords: Wastewater reuse; Irrigation; Integrated evaluation; Multicriteria analysis; Thessaly region

1. Introduction

Recurring droughts appeared throughout the last decades in many countries all over the world and have revealed that water supply is often insufficiently balanced to demand and thus vulnerable to extreme climatic events and structural or seasonal demand peaks. In the context of an integrated and more sustainable water management, water reclamation and reuse appears to be an alternative dependable water resource [1]. Environmental ethics and public involvement are also extremely important and should be taken in mind when integrated water management is achieved [2,3]. Water reclamation is the processing of wastewater to make it reusable with

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definable treatment reliability and meeting specific quality criteria [3]. Until today, the most common application for treated municipal wastewater has been agricultural irrigation while landscape irrigation is gaining interest in recent years. In the case of agricultural irrigation, wastewater can serve as a source of both water and nutrients, reducing fertilization costs as well [4]. Wastewater reuse applications, especially for agricultural irrigation purposes, have already been developed and applied in many countries in the Mediterranean basin [5–8].

In Greece, wastewater reclamation and reuse has not been popular despite the fact that according to relative data more than 83% of the Greek treated wastewater effluents are produced in regions with a deficient water balance [7]. The main reason explaining such situation is that no guidelines or criteria regarding wastewater reclamation and reuse had been adopted in the country till 2008 [9]. However, and before that date, many research projects or studies had already been carried out aiming at determining such criteria for different uses [10,11]. The above studies set the basis for the legal solution of the problem. Furthermore, a lot of studies focusing on determining the effects of agricultural and landscape wastewater irrigation [12–14] have also been performed in recent years in the country. Finally, many researches have dealt with the social acceptability of water reuse in Greece [15–17] and the application of specific advanced treatment and disinfection technologies for processing secondary effluents in order to make them reusable for irrigation purposes [11,18]. However, a crucial point, which should be given attention, is whether it is worthwhile for recycled municipal wastewater to be exploited as an alternative water resource in a Greek region and how this project could be sustainable. The sustainability of such a project depends mainly on some crucial factors such as economic, social and environmental ones. Such factors should be evaluated in an integrated way so that practical conclusions can be drawn.

Taking in mind the above data, we propose in the present study the construction of an evaluation model which incorporates the relative economic aspects as well as the most important social and environmental ones and aims at determining how a wastewater reusing procedure could be incorporated in water management plans in a Greek region in a sustainable manner. The methodology used for our model construction was a multicriteria decision making one while the selected criteria were evaluated by considering literature data as well as data collected from surveys and experiments taking place mainly in Thessaly region, Greece. Thessaly region was selected since it is a Greek region which suffers from water stress, especially in summer months, because of increased agricultural activity and high ambient temperatures, thus wastewater reclamation and reuse could be an appealing solution to the water shortage observed in the region.

2. Materials and methods

2.1. Evaluation model description

2.1.1. Decision making methodology selection

Dealing with any decision problem, the intent is to select the best alternative choice among those available or to create alternative choices better than those readily apparent. Determining what is a good, better or best decision is a value judgement [19,20]. Without taking in mind value judgements, the decision making process will fail.

The concept of "good" decision may relate to the decision-making process or it may relate to the outcomes of the decision. Decisions involve taking risks and, from this perspective, good process and good outcomes are linked to probabilities. If good process is followed and there is minimal uncertainty involved, then there is a high probability that the final outcome will be good. Environmental decisions, however, tend to present considerable uncertainty. Under these circumstances, the link between good process and good outcome is less certain and the concept of a good decision involves elements of both criteria and weighting given to them. In the context of environmental decision-making, it may be a long time before the outcomes are known, and, therefore, the process aspect may be weighed more heavily [20]. On the other hand, the concepts of environmental planning and decision making are based upon conflict analyses characterized by socio-political, environmental and economic value judgements. Several alternatives have to be considered and evaluated in terms of many and different criteria, resulting into a vast body of data that are often inaccurate or uncertain. To complicate the process further, there are typically a large number of decision-makers with conflicting preferences. The different points of view of various interest groups should also be considered in the process [21].

Taking in mind the above-mentioned information, it is concluded that the concept of making a really good and simple decision does not exist in environmental planning, and the planning process can be characterized as a search for acceptable compromise solutions. Success of this process depends on selecting the most suitable decision making methodology and applicable criteria. The main steps followed generally in a decision-making procedure are the following [22]:

- Identify the problem
- Identify alternative options (alternatives)
- Identify criteria
- Weigh criteria and score options
- Evaluate results (i.e. by use of a sensitivity analysis for example)
- Make a decision or resume the procedure, if the results are not of practical value

Popular decision making methodologies used for complex environmental problems solving include cost–benefit analysis as well as multicriteria analysis [23–26]. Cost–benefit analysis (CBA) is an example of a rational choice based technique which emphasizes in maximising an objective function subject to constraints. CBA is based on real or simulated markets where people are defined as "consumers". Their willingness to pay for buying a good is used for placing monetary values on non market goods [27], thus CBA can be used only for evaluation of quantitative variables, where the gains of any criterion can be traded off against the losses of other criteria. However, the complexity that characterizes environmental processes makes trade-off risky since important criteria may not be evaluated at all. On the other hand, the "consumer" definition during CBA decision making procedure is also risky since in environmental planning, which is a participative procedure, the decision maker should act more like citizen than like consumer. In environmental planning decision problems, the decision makers should try to value goods from a wider perspective taking into account not only their own ethical values, but also other people's interests and values.

On the other hand, multicriteria analysis (MCA) is a tool helping decision makers to effectively handle complex decision situations characterized by conflicts. MCA does not provide a right solution, like CBA does, but it can lead to a variety of solutions suitable to the problem. This fact makes MCA better for use in environmental planning problems since in such participative procedures not only one solution but a variety of such ones exist [28]. In most MCA methods, preferences between alternative options are established through a set of criteria identified and set in a process between decision makers and other stakeholders. The criteria used for assessing the extent to which the alternatives have been achieved may be quantitative or qualitative and this could be characterized as an important advantage of MCA methods. In general, MCA enables people to think about their values and preferences from several points of view through communication about problem definition, the setup of alternatives and criteria [27]. This fact, among others, makes MCA a convenient method to be used for evaluation of environmental problems like wastewater reuse planning in a region. The most important disadvantage of MCA methods is the fact that they are characterized as subjective methods while CBA methods are generally objective methods [29]. This subjectivity stems from emphasis of MCA on the judgement of the decision making team in establishing objectives and criteria, estimating relative importance of criteria weights and, to some extent, in judging the contribution of each alternative to each performance criterion. This subjectivity, however, can be important since, thus, MCA can bring a degree of structure, analysis and openness to classes of decision that lie beyond the practical reach of CBA.

2.1.2. Model construction

MCA is an approach helping decision makers to effectively handle complex decision situations. As referred above, MCA methods can be characterized as appropriate tools to support a decision making process characterized by conflicts. MCA analysis establishes preferences between alternatives by reference to an explicit set of objectives that the decision makers have identified, and for which they have established measurable criteria to assess the extent to which the objectives have been achieved. The above criteria may be both quantitative and qualitative.

In general, every multicriteria decision making problem can be structured in a model which includes: a set of alternative options (alternatives, scenarios) A (a_1, a_2, a_3,…,a_n), a consequent family of criteria F (f_1, f_2, f_3, …, f_n) as well as the table of multicriteria evaluation, which in general depicts the contribution of each alternative to each performance criterion. In our case, all pertinent factors regarding wastewater reuse procedure (economic, social and environmental) were incorporated in the multicriteria model as criteria f_i. The criteria selected for our model construction are presented in Table 1. The selection was done taking in mind mainly the principle of sustainability. Moreover, the alternatives a_i selected for the evaluation are presented in Table 2. In general, each alternative examines a different scenario of secondary effluent advanced treatment and disinfection aiming at making the effluent suitable for reuse in irrigation. The alternatives selection was done taking in mind mainly the current status regarding municipal wastewater treatment and disposal in Greece as well as literature data [3,4] concerning the feasible advanced treatment and disinfection technologies for the case of using reclaimed wastewater in irrigation purposes.

The alternatives presented in Table 2 were evaluated in basis of their score in each criterion described in Table 1. The scoring was based on literature data for selected environmental criteria and alternatives [30,31], but mainly on results of surveys and experiments taking place in Thessaly region, Greece and having as a goal to evaluate the contribution of the majority of the above alternatives to each criterion. The main results of the above surveys and experiments are presented in other research studies [9,15,16,32]. Especially, the economic criteria were evaluated by using data collected from Greek companies dealing with construction of wastewater treatment systems. The raw data coming from the above search as well as from a social survey [16] were used as inputs in cost–benefit analyses in order to have the

Table 1
Criteria and sub-criteria selected for our model construction

Criteria	Sub-criteria
Economic	Recycled water production cost (€/m^3)[a]
	Probable economic benefit coming from recycled water use/sale (€/m^3)
Social	Farmers' acceptability of using recycled water for their crops irrigation[b]
	Citizens' acceptability of consuming products irrigated with recycled water[b]
	Citizens' acceptability of landscape irrigation (i.e. park irrigation, etc.) with recycled water[c]
Environmental	Toxicity removal from the treated effluent
	Chemical compounds' removal from the treated effluent
	Microbiological burden removal from the treated effluent
	Environmental benefit[d]

[a]This cost includes computations of construction cost as well as operation and maintenance cost corresponding to each alternative option of advanced wastewater treatment and disinfection that was examined (*see* Table 2). Furthermore, it includes computations of recycled water storage and distribution cost.
[b]This criterion was evaluated for the case of agricultural irrigation.
[c]This criterion was evaluated for the case of landscape irrigation.
[d]This refers to the water saving benefit and it is scored the same in all alternatives where the recycled water is used for beneficial purposes.

production cost and the probable benefit for each alternative and population equivalent (*see* also Section 2.2) that was examined in our evaluation [9].

Apart from the above data, the multicriteria evaluation model demanded the fixing of positive criteria weights which comply with the relation of normality. Thus, a criteria significance evaluation was completed. The criteria significance (weight) fixing was done by using the Simos method for criterion weighting [33]. The Simos method is a simple procedure using a set of cards and allowing the decision making team to determine indirectly numerical values for weights. The decision making team structure and number was selected according to literature data [23,24,34]. The communities represented in the decision making team included authorities from water and wastewater management sector, scientists, researchers, farmers and citizens, thus making the decision making procedure participative, which is desirable in environmental planning.

Table 2
Alternatives selected for our model construction

a/a	Alternative description
First	The first alternative includes the evaluation of the present status regarding municipal wastewater treatment and disposal in Greece. This encompasses the secondary treatment of municipal wastewater based on activated sludge systems, chlorine disinfection and, afterwards, disposal to rivers or sea. This alternative includes no use of the effluent for beneficial uses.
Second	The second alternative evaluates the possibility the treated effluent described in the first alternative could be used for irrigation purposes. Actually, this alternative examines no advanced treatment method for the secondary effluent handling.
Third	The third alternative examines the possibility of use of a simple advanced treatment method for the secondary effluent treatment. This includes the use of coagulation—filtration procedure. A sand filtration technique is selected for the filtration procedure. The produced effluent is disinfected by use of UV irradiation method. The treated effluent can be used for irrigation purposes.
Fourth	The fourth alternative includes the evaluation of the possibility the treated effluent of the third alternative could be disinfected by use of ozonation. Actually, this alternative differs from the third one only in the disinfection method used for the effluent handling.
Fifth	The fifth alternative evaluates the use of a complex advanced treatment method for the secondary effluent treatment. This includes the use of a membrane filtration technology (i.e. ultrafiltration) followed by reverse osmosis. Afterwards, the treated effluent is disinfected by use of UV irradiation method. In this case, the treated effluent could be used not only for irrigation purposes, but also for other beneficial uses since the above treatment could assure the removal of the majority of compounds of concern from the wastewater body.
Sixth	The sixth alternative includes the evaluation of the possibility the treated effluent of the fifth alternative could be disinfected by use of ozonation. Actually, this alternative differs from the fifth one only in the disinfection method used for the effluent handling.

The criteria weighting and alternatives scoring are presented in Table 3 for the case of agricultural irrigation and Table 4 for the case of landscape one (*see* also Section 2.2). The range used for alternatives scoring was

Table 3
Criteria weighting and alternatives scoring for the case of agricultural irrigation (100,000 p.e. serviced)

Criteria	Economic		Social		Environmental			
Alternatives	Production cost	Probable benefit	Farmers' acceptability	Citizens' acceptability	Toxicity removal	Chemical compounds' removal	Microbiological burden removal	Water saving benefit
First	100	0	10	20	0	100	100	0
Second	100	0	75	0	0	10	10	100
Third	70	0	90	70	75	70	90	100
Fourth	70	0	90	80	90	70	100	100
Fifth	0	0	30	90	90	100	100	100
Sixth	0	0	30	100	100	100	100	100
Criterion weight (%)	10	15	10	15	10	12.5	15	12.5

Table 4
Criteria weighting and alternatives scoring for the case of landscape irrigation (100,000 p.e. serviced)

Criteria	Economic		Social	Environmental			
Alternatives	Production cost	Probable benefit	Citizens' acceptability	Toxicity removal	Chemical compounds' removal	Microbiological burden removal	Water saving benefit
First	100	0	10	0	100	100	0
Second	83	100	10	0	10	10	100
Third	58	92	80	75	70	90	100
Fourth	58	92	90	90	70	100	100
Fifth	0	74	100	90	100	100	100
Sixth	0	74	100	100	100	100	100
Criterion weight (%)	11	17	17	11	14	16	14

between 0 and 100, where 100: the best scoring alternative in the specific criterion.

2.1.3. MCA technique selection and description

MCA includes a variety of different techniques. They differ mainly in how they combine the used data. MCA techniques can be used to identify a single most preferred alternative, to rank alternatives, to short-list a limited number of alternatives for subsequent detailed appraisal, or simply to distinguish acceptable from unacceptable possibilities [29]. The majority of specialists [21,35,36] agree that MCA methods can be divided into three groups:

- Methods based on utility function (i.e. AHP, UTA, distance based techniques) that aggregate different criteria into one global criterion, called utility function; those methods eliminate incomparability between variants.
- Methods based on the outranking relation (i.e. ELECTRE, PROMETHEE) that take into account the incomparability between variants.
- Interactive methods (i.e. multiobjective mathematical programming) that are based on the "trial and error" approach; those methods are characterized by phases of computation alternating with phases of decision making.

Relative literature review among MCA methods that have been used in water and waste management planning problems [37–40] has shown that outranking methods, especially ELECTRE and PROMETHEE, use is most popular for evaluation of such environmental problems. Preferences in outranking methods are modelled by using binary outranking relations, S. Four possible preference situations may occur when two alternatives a and a' are compared [41]:

- a is better or presumed better than a'.
- a' is better or presumed better than a.
- a is indifferent to a'.
- a is incomparable to a'.

Incomparability is a preference situation appeared mainly in ELECTRE methods. Such preference situation is important because in complex environmental problems the decision maker may not be able to compare two alternatives, however, in our case the incomparability modelling was not desirable since, this way, it would be impossible to have a complete ranking of alternatives. So, a PROMETHEE technique, and especially PROMETHEE II, use was preferred.

The main features of PROMETHEE methods are simplicity, clarity and stability. The notion of generalized criterion is used to construct a valued outranking relation. Two ways of treatment are used in PROMETHE methods: it is possible to obtain either a partial preorder (PROMETHEE I) or a complete one (PROMETHEE II), both on a finite set of feasible actions [42]. The reason why PROMETHEE II was selected for our model has to do with its ability to offer a complete preorder of alternatives.

In general, and in every multicriteria decision making problem resolved by a PROMETHEE method, we consider a preference function P: $P{:}A \times A \rightarrow (0,1)$, which expresses the result of the comparison of two alternatives $a, b \in A$ in terms of preference. Actually, the above function represents the intensity of preference of action a with regard to action b. In practice, this preference function will often be a function of the difference between the two evaluations, so that we can write $P(a,b) = P[g(a)–g(b)]$. $P(a,b)$ is a non-decreasing function, equal to zero for negative values of $d = g(a) - g(b)$. For each criterion f we consider a generalized criterion as described in Brans et al. [42]. In our case, the usual criterion was used. Afterwards, the decision maker has to specify a weight π_i, for every criterion f_i. The weight π_i is a measure of the relative importance of criterion f_i. The multicriteria preference index Π is then defined as the weighted average of the preference functions P_i. $\Pi(a, b)$ represents the intensity of preference of the decision maker of action a over action b, when considering simultaneously all the criteria. It is a figure between 0 and 1 and [42]:

- $H(a, b) = 0$ denotes a weak preference of a over b for all the criteria.
- $H(a, b) = 1$ denotes a strong preference of a over b for all the criteria.

Afterwards and in order to obtain the desirable rankings, two leaving flows are defined for each alternative action, as follows [42]:

$$\varphi^-(a) = \sum_{x \in K} \Pi(x, a) \quad (1)$$

$$\varphi^+(a) = \sum_{x \in K} \Pi(a, x) \quad (2)$$

The second leaving flow provides a measure of the outranking character of an alternative a over the rest ones belonging to A, while the first flow expresses the opposite thesis. For each alternative, the net flow is also defined as follows:

$$\varphi(a) = \varphi^+(a) - \varphi^-(a) \quad (3)$$

By using the computed net flow corresponding to each alternative belonging to A, a complete alternatives ranking is obtained as: $a\ S\ b \Leftrightarrow \varphi(a) > \varphi(b)$. In case that $\varphi(a) = \varphi(b)$, this means that a is indifferent to b.

2.2. MCA application

The application of the PROMETHEE method was repeated twice, first for the case of agricultural irrigation and second for the case of landscape one. Furthermore, a sensitivity analysis was applied aiming at determining how sensitive the result of the analysis application is, to changes in wastewater flow rates and, therefore, in serviced population equivalents (p.e.). Actually, the cases of 40,000, 100,000, and 160,000 p.e. were examined for both agricultural and landscape irrigation use. The above p.e. numbers were selected as representative of the majority of municipal wastewater treatment plants currently operating in Greece.

Therefore, the PROMETHEE method was applied six different times following the procedure described in Section 2.1.3, while the main results are presented in the Section 3.

As referred above, Tables 3 and 4 present the criteria weighting and alternatives scoring for the cases of agricultural and landscape irrigation respectively and for a specific examined population equivalent (100,000 p.e.). The above Tables, and for the other population equivalents examined (40,000, 160,000 p.e.), differentiate a little only in economic criteria scoring. Thus, for 40,000 p.e. and agricultural irrigation case, the first two alternatives are scored with 100, the third with 66, the fourth with 62, the fifth with 3 and the sixth with 0 in the production cost column. On the other hand, and concerning the same p.e. and landscape irrigation use, the first alternative is scored with 100, the second with 90, the third with 49, the fourth with 46, the fifth with three and the sixth with 0 in the production cost column while in the probable benefit column the first alternative is scored with 0, the second with 100, the third with 79, the fourth with 78, the fifth with 55 and the sixth with 54. Furthermore, for 160,000 p.e. and agricultural irrigation case, no differences are expected regarding the production cost column in comparison with the case of 100,000 p.e. On the other hand, and concerning the same p.e. and landscape irrigation use, the first alternative is scored with 100, the second with 78, the third with 72, the fourth with 72, the fifth with 0 and the sixth with 0 in the production cost column while in the probable benefit column the first alternative is scored with 0, the second with 100, the third with 99, the fourth with 99, the fifth with 82 and the sixth with 82.

3. Results and discussion

The results coming from the application of the PROMETHEE method for every examined case of population equivalent and irrigation kind are the following:

- Agricultural irrigation case (40,000 p.e.): $\varphi(4) > \varphi(3) > \varphi(6) > \varphi(5) > \varphi(1) > \varphi(2)$
- Agricultural irrigation case (100,000 p.e.): $\varphi(4) > \varphi(3) > \varphi(6) > \varphi(5) > \varphi(1) > \varphi(2)$
- Agricultural irrigation case (160,000 p.e.): $\varphi(4) > \varphi(3) > \varphi(6) > \varphi(5) > \varphi(1) > \varphi(2)$
- Landscape irrigation case (40,000 p.e.): $\varphi(4) > \varphi(6) > \varphi(5) > \varphi(3) > \varphi(2) > \varphi(1)$
- Landscape irrigation case (100,000 p.e.): $\varphi(4) > \varphi(6) > \varphi(5) > \varphi(3) > \varphi(2) > \varphi(1)$
- Landscape irrigation case (160,000 p.e.): $\varphi(4) > \varphi(6) > \varphi(5) > \varphi(3) > \varphi(2) > \varphi(1)$

As it is presented in the above results, the fourth alternative is the most preferable to be applied in all examined cases of population equivalent and irrigation kind. The first alternative which corresponds to the scenario of no water reuse (*see* Table 2) is evaluated as the worst in the case of landscape irrigation and the second worst in the case of agricultural irrigation. It seems, therefore, that the case of no water reuse (first alternative) or water reuse without any additional treatment (second alternative) is not evaluated as sustainable despite the fact that studies already carried out in Greece [43] and focusing on feasibility investigation of wastewater reuse projects concluded that the application of such projects may not be feasible from an economic perspective. This fact highlights the importance of taking in mind not only the necessary economic parameters, but also the most important social and environmental ones when an evaluation procedure of such projects is under operation.

Furthermore, the fact that the fourth alternative appears as the most preferable can mainly be attributed to the use of ozone as disinfectant. According to relevant studies [44,45], ozone is effective in the majority of the microbiological burden, including viruses and protozoa, as well as colour and odour removal. Furthermore, ozonation is effective in degradation of the majority of chemical compounds of concern (i.e. pharmaceuticals and personal care products) as well as toxicity removal [30,31]. The disadvantage of ozonation in comparison with UV is that it is a little more expensive. However, according to findings from our cost analyses [9], ozonation construction and operation cost can be competitive to the corresponding UV irradiation cost in cases of high population equivalents (100,000, 160,000 p.e.), while in case of 40,000 p.e. the difference between the two costs is very low.

On the other hand, if the results concerning agricultural and landscape irrigation are compared, it is concluded that the third alternative is competitive only in the case of agricultural irrigation, while in the case of landscape irrigation the sixth alternative is the most preferable after the fourth. This is attributed to the fact that in the case of the landscape irrigation, an important economic benefit can be obtained from the use of the reclaimed wastewater, while in the case of agricultural irrigation no such benefit could be obtained (*see* also Tables 3 and 4). Thus, it is more feasible to apply the advanced treatment described in the sixth alternative in the case of landscape irrigation. It seems that in the case of landscape irrigation the prospective economic benefit offsets the high economic cost of ultrafiltration and reverse osmosis. However, the fact that in all cases the fourth alternative is evaluated as the best highlights the important advantages of ozonation in improving the secondary effluent quality of a Greek wastewater treatment plant and making this kind of water suitable for use in irrigation purposes.

4. Conclusions

The main conclusion from the above analysis is that wastewater reuse procedure for irrigation purposes in a Greek region and more specifically Thessaly region can be sustainable. This was concluded when all the necessary parameters concerning the problem were included and evaluated under the same model. It is important that the sustainability of such project was proved for the cases of both agricultural and landscape irrigation uses and for the majority of population equivalent serviced by centralized wastewater treatment plants in Greece. Thus, the reclaimed wastewater could be an alternative water resource, which is important for solving a part of water stress problems observed in many regions in Greece, especially in summer months.

The model used for our evaluation was a multicriteria one. Such models are generally characterized by subjectivity which, in most cases, refers to the alternatives and criteria selection as well as the judgement of the decision maker regarding the contribution of each alternative to each criterion and especially to non measurable criteria such as the social and environmental ones. However, in our case we tried to overcome the subjectivity by using criteria and alternatives representative of the Greek status regarding wastewater treatment and reuse as well as the desirable uses (agricultural and landscape irrigation) and by making judgements based mainly on data coming from surveys and experiments which took place in a Greek region characterized by a deficient water balance. In any case, it is strongly believed that it is more important to evaluate all the necessary parameters regarding the wastewater reuse problem under the same model than making decisions based mainly on measurable criteria such as the economic ones. This way, the general strategy aiming at promoting sustainable management of water resources and protection of natural resources from pollution is accomplished. More alternatives (i.e. activated carbon use) and criteria (i.e. technological, territorial and more environmental ones) could be evaluated by a model similar as this described in the present study. However, it is believed that the proposed model could serve as a basis for wastewater reuse sustainability evaluation in a Greek region or area.

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