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Decrease of non-point water pollution: A practical algorithm for the user-friendly presentation of the cost-effectiveness comparison of management measures

ABSTRACT

The European Water Framework Directive (WFD) establishes the framework for the water quality protection in EU. This legislation defines the use of the "Cost-Effectiveness Analysis" (CEA) for the identification of the least cost related management measures (WFD, Article 5, Annex III) and requires involvement and close cooperation with users (WFD, Article 14). Within these principles a practical and simple algorithm is constructed for the user-friendly presentation of the cost-effective measures, applied for the decrease of the water pollution by agricultural run-off. Furthermore, in the disseminated information to users, regarding the CEA procedures, data for the estimation of the cost of a measure should be also included.

Keywords: Water Framework Directive, Cost-Effectiveness Analysis; Agriculture; Water Management

ΠΕΡΙΛΗΨΗ

Η Ευρωπαϊκή Οδηγία Πλαίσιο για τα Νερά εγκαθιστά το πλαίσιο για την προστασία της ποιότητας των νερών στην Ε.Ε. Η νομοθεσία αυτή καθορίζει τη χρήση της "Ανάλυσης Κόστους Αποτελεσματικότητας" (CEA) για τον προσδιορισμό των σχετικών διαχειριστικών μέτρων, ελαχίστου κόστους (άρθρο 5, Παράρτημα ΙΙΙ) και θεωρεί απαραίτητη τη συμμετοχή και στενή συνεργασία με τους χρήστες (άρθρο 14). Βάσει αυτών των αρχών ένας πρακτικός και απλός αλγόριθμος δημιουργήθηκε για τη φιλική προς το χρήστη παρουσίαση των μέτρων αποτελεσματικού κόστους, που εφαρμόζονται για τη μείωση της ρύπανσης των υδάτων από τις γεωργικές απορροές. Επίσης, στα πλαίσια της διάδοσης της πληροφορίας στους χρήστες, όσον αφορά τις διαδικασίες της CEA, θα πρέπει να συμπεριλαμβάνονται και δεδομένα για το κόστος του κάθε μέτρου.

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INTRODUCTION

According to the European Water Framework Directive (WFD) [1-3] the Cost-Effectiveness Analysis (CEA) is used for the economic evaluation of water quality measures, in order to select the most economical measure, which meets the required environmental target.

From the reviewed CEA literature, in water quality, results that the management measures focus on the decrease of the anthropogenic eutrophication by agricultural run-off (non-point pollution) ([4-11] and for a CEA review: [12]). In this sector of production there are many alternative measures [13] which could be applied for the decrease of water pollution. A different combination of theses measures should be studied, taking into account that more than one measure should be applied, in order to achieve the required environmental target, in each case study. These combined measures should be examined regarding their cost and their effectiveness, with the use of CEA, in order to identify the appropriate combination with the least cost. It is noted that the effectiveness of each combined measure it is not the sum of the addition of the effectiveness of each measure, included in a combination, because the nutrients leaching (hydrological and biogeochemical processes in the area studied) changes if upstream measures are applied [6-7,11,14].

If the environmental target is the decrease of the water pollution caused by the untreated industrial and domestic wastewaters there is not the preceding plurality of management measures, because the policy responses are prescribed practices referred to the construction of wastewaters treatment plants or the adoption of Best Available Techniques (BATs). Moreover, the effectiveness of their combination is the sum of the effectiveness of each measure, per point pollution source.

Thus, for the estimation of the cost of a measure in point pollution control we need data only of the cost of the measure at the emission source, while in the agricultural sector data on nutrients leaching and retention are also required (Table 1).

Table 1: Average effectiveness of principal agro-environmental measures

Management Measures	Bibliography references with rates for the environmental effectiveness	Average reduction of nitrogen (N) and phosphorus (P)
Organic farming	[40-42]	N = the level of the E.U. Nitrates Directive
Catch crops	[6, 36]	50% N
No-till	[43-44]	55% N, 45% P
Winter crops	[6, 8]	45% N
Reduction of fertilizers	[8, 25, 45, 51]	Little reduction in short term horizon
Buffer zones	[6, 43, 46-47]	60% N, 75% P
Restoration of wetlands	[5, 7, 25, 35, 48-50]	70% N, 35% P
Terasses	43	20% N, 70% P

Note: In this table there are not included the CEA studies which have no exact determination for the N and P reduction (N and P rates)

According to the CEA literature, mentioned earlier, linear or no linear programming is used, for the estimation of the cost-effectiveness of water quality measures. For the measures which should be applied in the agricultural activity, there are many calculations, via the nutrients simulation model, in order to have the spatial and temporal nutrients' concerns for the combined measures.

In other words, in order to understand the CEA results as well as the parameters which affect the cost-effectiveness of the agricultural measures, it is necessary to be familiar with applied economic analysis.

Nevertheless, it is probable that some of the users or others interested and affected do not have this knowledge and therefore, their understanding is likely to be complicated. It should be noted that a consideration of environmental-quality variables is also needed, in order to understand what leaching and retention means, what is the magnitude of the less variations in the transport coefficients, why the cost of a measure changes if it is applied close to the water body studied, etc.

In the introduction of the WFD [1] is cited that "it is necessary to provide to users with proper information of planned measures" (p.5, paragraph 46) and also in the Article 14 its refers that "Member States shall encourage the active involvement of all interested parties in the production, review and updating of the river management plans which are available for comments to the users".

Thus, the users' information-understanding of CEA results could be included in the frame of participatory efforts of water scientists [15-16], for the effective adoption of intended policy plans.

As stated by van Asselt and Rijkens-Klomp [17], it is of crucial importance that principles, considerations, arguments, etc., are documentated in a structured and transparent way to encourage collective learning.

Cain et al. [18] suggest the importance and the success of having generic and flexible tools, in the agricultural management, which could be used by non-specialists.

In this framework of a "common understanding" a simple algorithm is designed, in order to have an easily and comprehensive structure for the presentation of the cost and the environmental effectiveness of alternative management measures, for water pollution control by the agricultural run-off. It is noted that this algorithm could be also used for the comparison of all the measures, for point and non-point water pollution control. The particular attention given to the agricultural sector is due to the elaboration of a lot of data (plurality of combined measures and change in their effectiveness caused to nutrients' concerns).

In the disseminated information to users, regarding the procedures of CEA for the estimation of the cost of a measure, data about the cover of probable profit reductions as well as the cost of a work-investment should be included. However, for the estimation of the total cost of a measure additional cost components should be also studied, such as the cost of: (i) the data gathering, for the application of the measure, (ii) the education of end-users, (iii) the public

control and (iv) the results' monitoring. These cost components affect the decision for the application of the measure, the correct application and the effectiveness of the measures. On the application of CEA, to water quality, there are few studies with specific data for these additional cost components [12], while they are included in a large amount of applied studies in water management where other evaluation methods are used (Cost-Benefit Analysis, Multicriteria Analysis, etc.).

In the following sections a presentation of the cost function components and a description of the proposed practical algorithm will be realized.

TOTAL COST OF A MANAGEMENT MEASURE

The cost of a measure is referred to as the Present Value of Total Cost (PVTC) [19-22] and/or the Total Annual Economic Cost (TAEC) [22-24]. In order to identify the PVTC and the TAEC the estimation of the cost components is acted out.

Elementary information to stakeholders about the procedure and the data used for the identification of the cost of the measures will help their understanding to the CEA, building their participation in management proposals. This information could also include the terminology used in the management reports concerning the lifetime of a measure, the discount rate, etc. A context of the disseminated information for the terminology and cost components could be the following:

Economic life of measures and discount rate

The economic lifetime of a measure is based either on the nature of the investment (e.g. a wetland restoration has a life expectancy of 30 or 50 years [5, 21, 25]) or on its legal-administrative nature (e.g. the duration of a concession granted [20-21]). The lifetime used has a great influence on the PVTC and the TAEC of a measure. For example, if the calculation of the cost of a measure is based on 20 years' lifetime and we will recalculate the cost with a smaller lifetime, then the PVTC would be reduced. In the cases where only the TAEC is estimated then this would be increased. Reverse results will exist, if a greater lifetime is used.

As regards the financial discount rate, a proposed rate in CEA framework is 6% [20-21] or, in general, the discount rate is based on the interest rate earned on state bonds in each country. The discount rate used has a great influence on the PVTC and TAEC of a measure. For example, if the calculation of the cost of a measure is based on a discount rate of 5% and we recalculate the cost with a lower discount rate, then the PVTC is higher and the TAEC is lower. Reverse results exist, if a greater discount rate is used.

Moreover, for the estimation of the cost of a measure it is necessary to know: (i) if the measure is mutually dependent on other measures (e.g. planting + irrigation) and (ii) if other measure/s must be implemented beforehand (e.g. the construction of a drained ditch it is needed before the restoration works in a wetland).

Finally, for the comparison of the cost of the measures all the values are expressed in prices of the same year.

Cost components

The application of a new control option, for the water quality improvement (e.g. reduction of the use of chemical fertilizers, change of crops or land use, etc.), in many cases results in profit reduction for the economic user. In these cases, the principal cost component of the measure is the sum of this reduction. In other words, if a subsidy is given for the application of the new measure then its cost is this subsidy plus perchance difference of profit reduction not covered by the subsidy. Moreover, the cost could be based on the difference in profit between the most profitable crop, in the studied area, and the newly proposed crop or, in general, the cost is calculated as the opportunity cost of land. Furthermore, in the cases of purchase/modification of equipment or of the construction of an infrastructure project the cost is estimated according to the capital cost and the maintenance-operation cost.

However, the cost function of a measure should also include the estimation of other essential cost components, such as:

- the cost of data collection-elaboration, for the application of the measure,
- the cost of education of end-users,
- the cost of the application-control by public authorities and
- the monitoring cost.

Analytically:

The cost of data collection

In some cases, the application of a measure requires data which are not available and the elaboration of a feasibility study is required (e.g. study for the imposition of a tax on the fertilizers, for the identification of infrastructures needed, for the restoration of a wetland, etc). The estimation of the cost of a new study is needed.

An indicative example, for the importance of the identification of this cost component, in order to decide for the application or not of a measure, is the work of Kozloff and Wang [26], where the management measures concern various subsidies to farmers for removal from highly erodible land. These payments were dependent on the existing erosion per field. However, the cost for the elaboration of a study with data for the erosion per field was very high. For this reason, while these variations of payments at first seem to be the most cost-effective solution (see also [9]) in the end they are not, since the cost of the additional data is high and a uniform subsidy will be the cost-effective solution.

In addition to the estimation of the cost for the elaboration of studies, the cost of other works could be also included in this cost component "data collection", such as the cost of:

- aerial photos/satellite images, in the cases where information for the area state is needed before the application of a measure,
- questionnaires to the economic users about their opinion for the successive implementation of the measure,
- meetings, workshops and/or "open discussions" with users and all those involved in the management of the area studied, for the identification of the actions needed for the application of each measure studied (e.g. new legislation or new administrative framework, etc.).

The cost of education / information of end-users

The education/consultation of the end-users before the implementation of a management measure as well as their cooperation-exchange of opinions with the scientists during its implementation process will increase the effectiveness of the measure and consequently will decrease its total cost.

The cost for an educational seminar for Best Management Practices (BMPs) could be used as the value of this cost component. Moreover, the following could be added to this amount of:

i) agronomists' visits to the fields during the implementation of the measure, as an additional support to farmers. This cost could not be included if the measure is subsidized and there is a relevant amount given to the farmer for the payment of an agronomist consultant.

ii) farmers' visits to other sites where successful farming has been implemented, in the cases of their opposition to the use of a BMP proposed.

The cost of the application-control by public administrative authorities

The implementation of many management measures requires the control of the public administrative authorities. As indicative price, for this cost component, the relevant amount per hectare could be used, included in many subsided agri-environmental programs, which concerns the cost for the administrative control needed for given the relevant subsidy to the farmers. Moreover, for the monitoring of a new measure training courses for the public servants may be needed or the employment of new personnel, etc. Furthermore, satellite images such as Landsat7 and IKONOS or aerial photos could be used, for the control of the correct implementation of the measures. So, in each case study the cost of these remote-sensing technologies with the cost of public servants' control should be compared, in order to select the lowest.

The cost for monitoring the water quality improvement

The comparison of the environmental effectiveness of an applied measure with its effectiveness expected, before its implementation, by the watershed simulation model, will provide information for the real cost-effectiveness of the measure. This information will contribute to an adaptive management as well as it will be used as principal element for the application of this measure in other case studies (see Table 1).

For the estimation of this cost component the following amounts are calculated:

i) The travel expenses of an environmental scientist for the selection of two samples[2], of the river or of a close stream, per parameter studied (nitrogen and/or phosphorus, etc.).

ii) The cost for the laboratory' study of samples.

In addition to the cost estimation, the identification of the authority which will be competent for this monitoring is also required. Furthermore, in some of the subsidized management measures this monitoring cost is already included in their budget. However, it is necessary to examine if this amount is transferred to a general economic code "travel expenses", covering all the measures administrated by the relevant public authority. In these cases the dissociation of the relevant amount is needed.

A PRACTICAL ALGORITHM FOR THE COMPARISON OF THE COST-EFFECTIVENESS OF WATER QUALITY MEASURES

Considering all the above mentioned cost components the cost (PVTC, TAEC) of each management measure is defined. As it is already cited, in the agricultural sector combined measures are needed, in order to achieve the water quality target, in each case study.

For an easily understanding of the cost-effectiveness comparison of these combined measures, an algorithm is designed. The software package needed for the use of this algorithm has been developed in QBasic programming language.

The proposed algorithm could be used easily by anyone who has access to an Excel programme. The steps for its application are the following:

a) In each measure a code number should be given. For example, if the first examined measure is the "restoration of a wetland", the code number "M1" is used. For the second measure we use the code number "M2", etc.

b) Registration of these code numbers and of the cost of the measures, in two columns in the Excel worksheet. These data are elaborated by the algorithm and the user could view:

- Automatic presentation of all potential combinations of measures (e.g. if we register 5 measures (M1-M5), 31 combined measures will be presented in the sheet of the Excel, if we register 6 measures (M1-M6) they are 63 combinations, etc.)

[2] *One sample in the inlet of water, in the area where the measure is applied, and one at the end of the measure-outlet.*

- Automatic presentation of the total cost of these combined measures.

c) Registration of the environmental effectiveness of each combined measure (e.g. registration of the rate of nitrogen and/or of phosphorus decrease, or of the ratio N/P, etc.). This information is provided by the nutrients-watershed simulation model.

After this registration we have a new running of the algorithm and the user could view:

- Automatic classification of the cost-effectiveness of the combined measures with a descending order of the effectiveness and an ascending order of the cost (Figure 1).

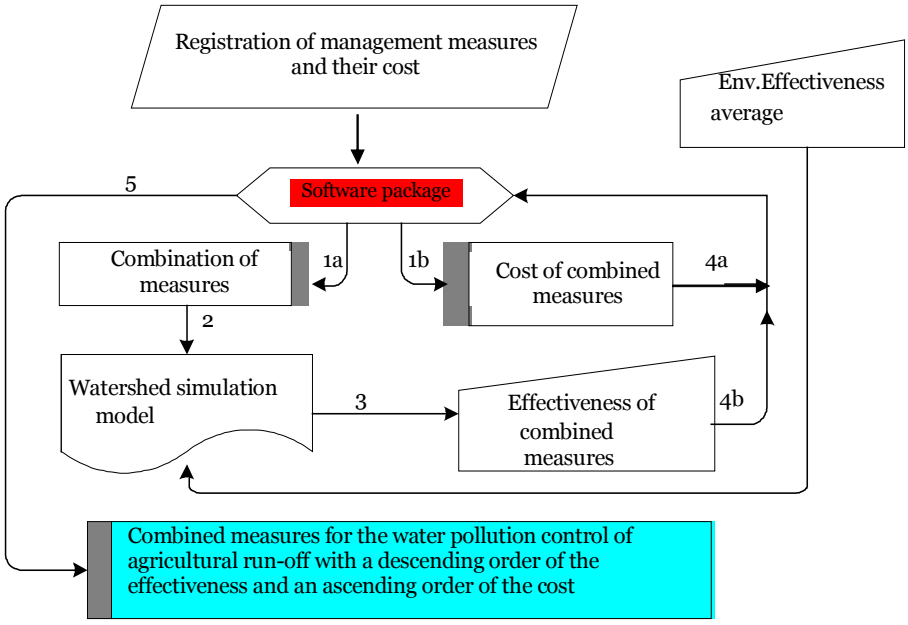

Figure 1: Algorithm for the cost-effectiveness evaluation of the measures for water pollution control of agricultural run-off

Therefore, by the running of the proposed algorithm, the following information is automatically presented to users:

i) The cost of the combined measure, which achieves the determined environmental target with the minimum cost.

ii) The cost of combined measures, which achieve minor environmental rates (marginal analysis).

iii) The cost and the effectiveness of combined measures when one or more measures included in each combination are not applied (sensitivity analysis).

Moreover, if the user would like to have as information the new CEA results provided by the consideration of a different amount as cost, of the combined measures, or of other rates as their environmental effectiveness (sensitivity analysis) a registration is needed of the new

supposed cost and/or the environmental rate, in the two columns, in the Excel worksheet. A re-application of the algorithm is realized automatically.

Thus, the users not familiar with the cost-effectiveness analysis, the marginal or the sensitivity analysis, etc. could understand the results of these analyses.

Finally, it is noted that there is no problem in the running of the algorithm if not all data for cost or effectiveness, of combined measures, is registered (see measures M4-M5, Table 4).

APPLICATION OF THE ALGORITHM

For a better illustration of the results provided by the proposed algorithm an example will be presented.

Let us suppose that in the river basin "x" three management measures have been selected as most appropriate for the control of the eutrophication phenomena and erosion problems existing in this studied water body level. These measures are: (i) the restoration of a previously drained wetland, (ii) the construction of buffer zone and (iii) the culture of winter crops.

At this point it is considered essential to make a point of the needed cooperation of the scientists with the stakeholder groups [27-30], in order to select the most appropriate measures for each case study. This participatory appraisal could be considered as the basic condition for their implementation with effectiveness and also the least costly way.

The reason for the selection of the above mentioned measures among other BMPs, as an example for the application of the algorithm proposed, is based on their high environmental effectiveness (Table 1) as well as in the fact that their adoption is subsidised, in the countries with agro-environmental policy. Furthermore, these measures could be applied in many countries-case studies, in relation to other measures such as the no-tillage that could not be applied in countries where the soils are drythermic or the organic farming which is not often applied in soils with great productivity or the catch crops and the culture parallel to slopes which are not easily adopted by the farmers in countries where the agricultural holdings are small, etc.

A short analysis of the environmental effectiveness of the selected measures, which should be presented to users, can be summarized as follows:

i) A wetland has many values, such as flood protection, biodiversity, recreation, irrigation water etc. Among these, its capacity to provide protection against erosion and nutrients abatement is included. This measure is described as a low cost option and first priority regarding other abatement measures ([8, 31-33], see also the references in Table 1, with exact N and P rates). Nevertheless, the application of this measure presupposes the existence or the elaboration of relevant hydrological studies. As cited in Zalidis et al. [34] the more common cause of wetland restoration actions' failures is the insufficient scientific information in terms of the hydrological fluctuations and constraints.

ii) Buffer strips (or filter strips) which are strips of land with permanent vegetation (grass or shrub) that intercept runoff and reduce nutrients emission ([35-36], see also the references in Table 1, with exact N and P rates).

iii) The use of winter crops in the period between successive annual crops is an effective measure in order to prevent soil erosion and to reduce nitrate losses ([37-39], see also the references in Table 1, with exact N and P rates).

Let us suppose that we have selected the area for the application of the measures (hectares) and we have estimated the cost (PVTC) of five, measures as presented bellow, with the code numbers of the measures (M1-M5).

M1: Restoration of 100 hectares of a wetland area, with a PVTC of 4 millions €.

M2: Buffer strips 5 meters wide on each side of the main river, with a PVTC of 1.39 millions €.

M3: Buffer strips 100 meters wide on each side of the main river in the 2 first sub-basins, with a PVTC of 11 millions €

M4: Winter crops in 10,000 hect. cotton in the first sub-basin, with a PVTC of 60 mill. €

M5: Winter crops in 10,000 hect. maize, in all the sub-basins, with a PVTC of 50 mill. €

The preceding PVTC of the measures M1-M5 will be registered in the column "COST"[3] of the first worksheet "METRA" of Excel (see Table 2).

Table 2: First worksheet "METRA" in Excel

S/N of measure	COST
M1	4,000,000 €
M2	1,390,000 €
M3	11,000,000 €
M4	60,000,000 €
M5	50,000.000 €
M6	
M7	
M8	
M9	
M10	

The sequential sheets in the Excel' file are named:

S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}

According to how measures will be examined, the relevant sheet will be selected.

In our example we have five measures and the sheet **S_5** will be opened.

[3] *In the column "COST" it is possible to select the registration of the TAEC, instead of PVTC.*

Opening this sheet the combined measures and their cost are presented automatically (Table 3).

Table 3: Worksheet "S_5"

CLASSIFICATION OF THE COST AND EFFECTIVENESS OF 5 COMBINED MEASURES			
COMBINED MEASURES	**COST**	**REDUCTION N (%)**	**REDUCTION P (%)**
M1	4.000.000 €		
M1 + M2	5.390.000 €		
M1 + M2 + M3	16.390.000 €		
M1 + M2 + M3 + M4	76.390.000 €		
M1 + M2 + M3 + M4 + M5	126.390.000 €		
M1 + M2 + M3 + M5	66.390.000 €		
M1 + M2 + M4	65.390.000 €		
M1 + M2 + M4 + M5	115.390.000 €		
M1 + M2 + M5	55.390.000 €		
M1 + M3	15.000.000 €		
M1 + M3 + M4	75.000.000 €		
M1 + M3 + M4 + M5	125.000.000 €		
M1 + M3 + M5	65.000.000 €		
M1 + M4	64.000.000 €		
M1 + M4 + M5	114.000.000 €		
M1 + M5	54.000.000 €		
M2	1.390.000 €		
M2 + M3	12.390.000 €		
M2 + M3 + M4	72.390.000 €		
M2 + M3 + M4 + M5	122.390.000 €		
M2 + M3 + M5	62.390.000 €		
M2 + M4	61.390.000 €		
M2 + M4 + M5	111.390.000 €		
M2 + M5	51.390.000 €		
M3	11.000.000 €		
M3 + M4	71.000.000 €		
M3 + M4 + M5	121.000.000 €		
M3 + M5	61.000.000 €		
M4	60.000.000 €		
M4 + M5	110.000.000 €		
M5	50.000.000 €		

In this sheet the environmental effectiveness of the combined measures should be registered, according to the results of the nutrients-watershed simulation model (Table 4) [4].

[4] *Notice that the data existing in the columns "REDUCTION N %" and "REDUCTION P %" (Table 4) are also hypothetical and they are presented only for the application of the algorithm. These rates are provided taking into consideration the average effectiveness of the measures according to the literature (Table 1). For the estimation of the environmental effectiveness of a measure, beyond the estimation of nutrients (N and P) reduction, could be also used the parameter "Aquatic flora" or the "Benthic fauna" or, in the cases where the water body studied is not a coastal zone, the parameter "Fish fauna". According to the WFD [1] these biological indicators should be identified in order to achieve the "good status of water". These indicators will be used for the assessment of the ecological quality, in an area studied, when references conditions will be*

Table 4: Worksheet "S_5" with effectiveness data (N,P)

CLASSIFICATION OF THE COST AND EFFECTIVENESS OF 5 COMBINED MEASURES			
COMBINED MEASURES	**COST**	**REDUCTION N (%)**	**REDUCTION P (%)**
M1	4.000.000 €	15	10
M1 + M2	5.390.000 €	25	20
M1 + M2 + M3	16.390.000 €	35	50
M1 + M2 + M3 + M4	76.390.000 €	45	50
M1 + M2 + M3 + M4 + M5	126.390.000 €	55	50
M1 + M2 + M3 + M5	66.390.000 €	40	50
M1 + M2 + M4	65.390.000 €	38	20
M1 + M2 + M4 + M5	115.390.000 €	45	20
M1 + M2 + M5	55.390.000 €	35	20
M1 + M3	15.000.000 €	28	35
M1 + M3 + M4	75.000.000 €	37	35
M1 + M3 + M4 + M5	125.000.000 €	42	35
M1 + M3 + M5	65.000.000 €	35	35
M1 + M4	64.000.000 €	25	10
M1 + M4 + M5	114.000.000 €	38	10
M1 + M5	54.000.000 €	25	10
M2	1.390.000 €	10	10
M2 + M3	12.390.000 €	22	30
M2 + M3 + M4	72.390.000 €	32	30
M2 + M3 + M4 + M5	122.390.000 €	42	30
M2 + M3 + M5	62.390.000 €	30	30
M2 + M4	61.390.000 €	20	10
M2 + M4 + M5	111.390.000 €	30	10
M2 + M5	51.390.000 €	20	10
M3	11.000.000 €	10	28
M3 + M4	71.000.000 €	22	28
M3 + M4 + M5	121.000.000 €	35	28
M3 + M5	61.000.000 €	20	28
M4	60.000.000 €	10	
M4 + M5	110.000.000 €	20	
M5	50.000.000 €	10	

estimated, the metrics will be selected and deviations from the references will are found. However, their use in the assessment of the environmental effectiveness of a measure should be tested once adequate data become available. Until today nutrients (N,P) conditions are used for the identification of the water quality status as well as of the environmental effectiveness of a policy option. As cited in WFD, these chemical elements will also used in the future for the support of the biological indicators [52].

Considering the data in Table 4, with a click on the menu "Data" (Excel programme, see: Figure 2) and selecting "Sort" the combined measures are presented automatically, with a descending order of their effectiveness and an ascending order of their cost).

Figure 2: Sort in Excel program

Table 5: Automatic classification of the combined measures with a descending order of the effectiveness (N, P) and an ascending order of the cost

CLASSIFICATION OF THE COST AND EFFECTIVENESS OF 5 COMBINED MEASURES			
COMBINED MEASURES	**COST**	**REDUCTION N (%)**	**REDUCTION P (%)**
M1 + M2 + M3 + M4 + M5	126.390.000 €	55	50
M1 + M2 + M3 + M4	76.390.000 €	45	50
M1 + M2 + M4 + M5	115.390.000 €	45	20
M1 + M3 + M4 + M5	125.000.000 €	42	35
M2 + M3 + M4 + M5	122.390.000 €	42	30
M1 + M2 + M3 + M5	66.390.000 €	40	50
M1 + M2 + M4	65.390.000 €	38	20
M1 + M4 + M5	114.000.000 €	38	10
M1 + M3 + M4	75.000.000 €	37	35
M1 + M2 + M3	16.390.000 €	35	50
M1 + M3 + M5	65.000.000 €	35	35
M3 + M4 + M5	121.000.000 €	35	28
M1 + M2 + M5	55.390.000 €	35	20
M2 + M3 + M4	72.390.000 €	32	30
M2 + M3 + M5	62.390.000 €	30	30
M2 + M4 + M5	111.390.000 €	30	10
M1 + M3	15.000.000 €	28	35
M1 + M2	5.390.000 €	25	20
M1 + M5	54.000.000 €	25	10
M1 + M4	64.000.000 €	25	10
M2 + M3	12.390.000 €	22	30
M3 + M4	71.000.000 €	22	28
M3 + M5	61.000.000 €	20	28
M2 + M5	51.390.000 €	20	10
M2 + M4	61.390.000 €	20	10
M4 + M5	110.000.000 €	20	
M1	4.000.000 €	15	10
M3	11.000.000 €	10	28
M2	1.390.000 €	10	10
M5	50.000.000 €	10	
M4	60.000.000 €	10	

CONCLUSION

According to the European Water Framework Directive (2000/60/E.C.) the Cost-Effectiveness Analysis (CEA) is the economic evaluation method used in watershed quality improvement, in order to identify the least cost management measures which achieve a predetermined environmental objective.

The application of this method in the agricultural sector (nonpoint pollution) requires many considerations, in order to find the most appropriate combination of BMPs with the lowest cost, for the area studied. According to the relevant CEA literature, through linear or no linear programming we have these results.

Thus, the understanding of the procedures, which affect the cost-effectiveness of the examined BMPs, as well as the understanding of the relevant CEA results requires knowledge of linear/ no linear programming. Moreover, a consideration of environmental-quality variables is needed in order to understand different considerations related to what leaching and retention means, what is the magnitude of the less variations in the transport coefficients, etc.

According to the WFD it is necessary to encourage the active involvement of users, in the design of management plans as well as to providing them with proper information about planned measures.

In this concept, an algorithm in QBasic programming language is developed for the user friendly presentation of the cost-effectiveness comparison of the BMPs. The application of the algorithm can be carried out easily by anyone who has access to an Excel programme.

Through the results of the algorithm there is, automatically, the following information:

i) The cost of the combined measure, which achieves the determined environmental target with the minimum cost.

ii) The cost of the combined measures, which achieve minor environmental rates (marginal analysis).

iii) The cost and the effectiveness of combined measures when one or more measures included in each combination are not applied (sensitivity analysis).

iv) The new CEA results provided by the consideration of a different amount as cost, of the combined measures, or of other rates as their environmental effectiveness (sensitivity analysis).

Furthermore, in the frame of disseminated information to users, regarding the CEA, the data used for the estimation of the cost of the studied measures should be included. This data concern the cost through profit reduction and/or the cost of a work-investment. However, additional cost components, which affect the application and the effectiveness of each measure and also let us know its impact in the water ecosystem, should be also considered. These cost components are:

- The cost of the collection-elaboration of the supplementary data required for the application of a measure, which in some cases is very high and influences the decision for its adoption.
- The cost of the end-users' education and the cost of the public control, which add a small percentage burden to the total cost, while they increase significantly the possibilities for the correct and least costly implementation of a measure.
- The cost of the quality monitoring, in order to know the real effectiveness of a measure and consequently its real cost, in the studied area.

Therefore, the transfer of the information, to users, about the way to calculate the cost of the management measures as well as the presentation of the CEA results in a form easily understood, increases the possibilities for their acceptance and the implementation of the most cost effective measures, in the control of the water pollution by the agricultural run-off.

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