WATER TABLE MANAGEMENT STRATEGIES FOR IRRIGATION WATER SAVING[1]

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ABSTRACT

Today, the world and especially the development countries are facing the challenges of providing water and food for the expanding population. These challenges necessitate reducing the losses of irrigation water and optimising the use of each drop of water to maximise the agriculture production. In order to select the best water table management strategy among different strategies under the conditions of Western Delta of Egypt, the water table management problem is formulated in a multi-criteria context, 13 alternative strategies have been selected and evaluated by 9 criteria. The impact assessments of each alternative with respect to each criterion are estimated. The selected WTM alternative strategies have been evaluated using a multi criteria decision analysis model called Multi Deci Mode and four different weights for criteria have been applied using four multi criteria analysis techniques. The results of evaluating the different water table management strategies indicate that by increasing the spacing between drains to 2 times the design spacing and applying the controlled drainage (CD) at depth 60 cm at the beginning of the growing season and switching to the free drainage (FD) during the rest of the growing season we can save about 20% of irrigation water. By applying the CD at 60 cm at the beginning of the growing season with increasing drain spacing to 1.5 times and switching to the FD at the rest of the season we can save 15% of irrigation water.

1 INTRODUCTION

Today, the world and especially the development countries are facing the challenges of providing water and food for the expanding population. These challenges necessitate reducing the losses of irrigation water and optimising the use of each drop of water to maximise the agriculture production. Traditionally, irrigation and drainage systems were designed, constructed and managed separately. Almost of time the applied irrigation water exceeds the crop water requirement (over irrigation), the subsurface drainage system is over designed, and the drains are always designed at depths suitable for deeper root crops. All these lead to a lot of losses of irrigation water and in the applied fertilisers, which lead to the pollution of ground and drainage water.

Many of the recent studies indicate the importance of the integration between irrigation and drainage systems to avoid the negative impacts of working separately by each of the systems and some results of these studies recommended that the maximum intensity provided by surface drains is not usually needed at all times during the growing season, so there is opportunity to reduce drainage rates during some periods without compromising objectives of the drainage system (Skaggs, 1999). Removing the excess water to permit farming of poorly drained soils, Protecting the crop from excessive soil water conditions, controlling soil salinity, conserving soil water, increasing yield by reducing or eliminating stress caused by deficit soil water conditions, and reducing losses of nutrients and other pollutants via drainage water are the main objectives of water table control.

The objectives of this paper, is to select the proper water table management strategy among different strategies under the conditions of Egypt according to a variety of conflicting criteria, such as: technical performance, economics, social acceptability, environmental impacts, and water availability.

2 WATER TABLE MANAGEMENT STRATEGIES

Three main systems, which are suggested for the water table management strategies: Conventional Drainage (FD), Controlled Drainage (CD), and combined drainage (FD-CD), which is combination between conventional and controlled drainage. For each of these systems, different management strategies were designed by changing each of the drain depth, drain spacing, and the amount of applied irrigation water. About 31 water table management alternative schemes were generated but after screening all the alternatives, only 13 alternatives were selected for this study for the selection of the proper water table management. Descriptions of the selected alternatives are described below as following:

1. Alt-1: which is the existing water able management strategy in the field (FD), as the spacing between drains is 32m and lateral drain at 1.15m depths, and normal amount of irrigation water (100%) is applied for the cultivated crops.

2. Alt-2: which is FD strategy, a subsurface drainage system with the spacing between drains is increased to 45m and lateral drains at 1.15m depths, and the applied amount of irrigation water for the cultivated crops is reduced by 10%.

3. Alt-3: which is FD strategy, a subsurface drainage system with the spacing between drains is increased to 60m and lateral drains at 1.15m depths, and the applied amount of irrigation water for the cultivated crops is reduced by 15%.

4. Alt-4: which is CD strategy, a subsurface drainage system with the spacing between drains is 32m and lateral drain at 1.15m depths, the water table is controlled at 60 cm depth during the study periods and normal amount of irrigation water (100%) is applied for the cultivated crops.

5. Alt-5: which is CD strategy, a subsurface drainage system with the spacing between drains is increased to 45m and lateral drain at 1.15m depths, the water table is controlled at 60 cm depth during the study periods and the applied amount of irrigation water for the cultivated crops is

reduced by 20%.

6. Alt-6: which is CD strategy, a subsurface drainage system with the spacing between drains is increased to 45m and lateral drain at 1.15m depths, the water table is controlled at 60 cm depth during the study periods and the applied amount of irrigation water for the cultivated crops is reduced by 15%.

7. Alt-7: which is CD strategy, a subsurface drainage system with the spacing between drains is increased to 45m and lateral drain at 1.15m depths, the water table is controlled at 70 cm depth during the study periods and the applied amount of irrigation water for the cultivated crops is reduced by 10%.

8. Alt-8: which is CD strategy, a subsurface drainage system with the spacing between drains is increased to 60m 1.c (85%) and lateral drain at 1.15m depths, the water table is controlled at 60 cm depth during the study periods and the applied amount of irrigation water for the cultivated crops is reduced by 20%.

9. Alt-9: which is CD strategy, a subsurface drainage system with the spacing between drains is increased to 60m 1.c (85%) and lateral drain at 1.15m depths, the water table is controlled at 70 cm depth during the study periods and the applied amount of irrigation water for the cultivated crops is reduced by 10%.

10. Alt-10: which is CD strategy, a subsurface drainage system with the spacing between drains is 32m and lateral drain at 1.15m depths, the water table is controlled at 60 cm depth during the study periods and the applied amount of irrigation water for the cultivated crops is reduced by 20%.

11. Alt-11: which is FD-CD (combined) strategy, the spacing between drains is 32m and lateral drain at 1.15m depths. The management in this strategy depends on applying controlled drainage at depth 60 cm during the initial stage of each growing season (November, December and January for winter crops, May, June, and July for summer crops), in these periods there is no need to the deeper drain depth and to switch to the FD strategy at depth 1.15 during the rest of each growing season where the roots start to grow and applying the drain at deeper depth will help in leaching the salts which may be accumulate during applying the CD strategy. In this strategy, the applied amount of irrigation water for the cultivated crops is reduced by 15%.

12. Alt-12: which is FD-CD (combined) strategy, the spacing between drains is 45m 1.c (40%) and lateral drain at 1.15m depths. The management in this strategy depends on applying controlled drainage at depth 60 cm during the initial stage of each growing season (November, December and January for winter crops, May, June, and July for summer crops). In these periods there is no need to a deeper drain depth and switching to the FD strategy at depth 1.15 during the rest of each growing season where the roots start to grow and applying the drain at deeper depth will help in leaching the salts which may be accumulate during applying the CD strategy. In this strategy, the applied amount of irrigation water for the cultivated crops is reduced by 15%.

13. Alt-13: which is FD-CD (combined) strategy, the spacing between drains is 60m 1.c (85%) and lateral drain at 1.15m depths. The management in this strategy depends on applying controlled drainage at depth 60 cm during the initial stage of each growing season (November, December and January for winter crops, May, June, and July for summer crops). In these periods there is no need to a deeper drain depth and switching to the FD strategy at depth 1.15 during the rest of each growing season where the roots start to grow and applying the drain at deeper depth will help in leaching the salts which may be accumulate during applying the CD strategy. In this strategy, the applied amount of irrigation water for the cultivated crops is reduced by 20%.

Under the conditions of Western Delta of Egypt, field experimental study has been carried out in the experimental station in Western Delta of Egypt (figure.1) and the DRAINMOD-S model has been calibrated for the simulation of water table management under these conditions (Wahba et al 2002). Long-term simulations for the different scenarios of water table management using the DRAINMOD-S model for ten years have been carried out. One of the most crop rotation in the Nile delta will be used, which is a two-year crop rotation as following; wheat, maize, barseem, and cotton (table 1).

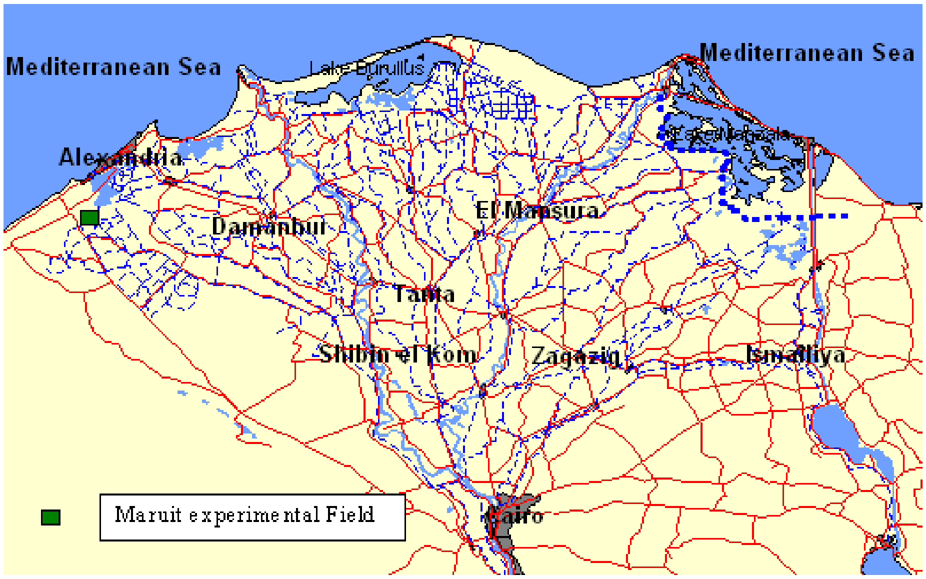

Figure 1 Location of experimental field.

Table 1 Two years crop rotation.

3 EVALUATION CRITERIA

Water table management strategies are evaluated by the following nine criterion:

- **Crop yield**. Crop yield criterion is considered quantitative criteria and is estimated for each water table management strategy by using the results of long-term simulation for 10 years using the DRAINMOD-S model. The 10 years consists of 5 rotations and each rotation consists of four crops, wheat, maize, barseem, and cotton.
- **Soil salinity.** The output results of ten years simulation using the DRAINMOD-S model is used to calculate the average soil salinity for each management strategy.
- **Total applied irrigation water.** The total applied irrigation water is estimated by calculating the total amount of irrigation water in m^3 used under each management strategy for all crops during the 10 years study.
- **Total drainage water outflow.** The total amount of drainage water outflow was estimated for each of strategy during the ten years by using the results from DRAINMOD-S simulation.
- **Total Nitrate losses.** The average Nitrate concentration was estimated from the results of field study. The average Nitrate concentrations from the outlets were multiplied by their respective total drain flow depths and converted to total load on a kilogram per feddan basis.
- **Benefits /Costs ratio (B\C).** The Benefits / Cost ratio (B/C) is calculated as follows:

  Benefit-Cost ratio:

$$B/C = \frac{\sum_{t=i}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=i}^{t=n} \frac{C_t}{(1+i)^t}} \qquad (1)$$

  B_t = benefit in each year, C_t = cost in each year, n = number of years, and i = interest (discount) rate.

- **Farmer acceptance.** A scale range from 1-10 is given as basis for evaluating the different strategies concerning this criterion (El-Shorbagy, 1994). The number 10 is given for the strategy that gains the highest acceptance and 8 for the least preferred strategy.
- **Irrigation water availability.** A scale range from 1-10 is given as basis for evaluating the different strategies concerning this criterion. The number 10 is given for the strategy that gains the highest suitability for the irrigation water availability conditions and the number 7 for that gains the moderate suitability, and number 3 for that gains the least suitability.

- **Integrated management efficiency.** A scale range from 1-10 is given as basis for evaluating the different strategies concerning this criterion. The number 10 is given for the strategy that achieves the highest integrated management efficiency; the number 7 for that achieves a moderate efficiency and the number 5 is given for that achieves the lowest efficiency

4 ASSESSMENT OF WEIGHTS

Three groups of specialists and experts of water management in Egypt have assessed the weights for the selected criteria. The first group is the decision makers group, which consists of 10 experts from the Ministry of water resources and Irrigation. The second group consists of 10 professors specialised in irrigation, drainage, agricultural, soil and water from the Egyptian universities. The third group consists of 10 researchers from the National Water Researcher Centre (NWRC) (table. 2).

5 EVALUATION OF MANAGEMENT STRATEGIES

The multi criteria decision analysis model **MultiDeciMode**, which has been developed (Wahba, 2002) is used for the evaluation of these strategies, and this model is described below:

5.1 MODEL DESCRIPTION

A **Multi** criteria **Deci**sion analysis **Mode**l called (**MultiDeciMode**) was developed to help the decision makers in water resources management problem, it is based on the used of three multi criteria decision analysis methods, the Weighted Summation (WS), Compromised Programming (CP), ELECTRE-II, and the ELECTRE-II method was modified to overcome its complexity and to be more simple for the users.

Table 2 Weights for the different criterion

Criterion	Decision makers group (W1)	University group (W2)	NWRC group (W3)	Equal weights (W4)
Crop yield	8.9	8.55	8.8	10
Soil salinity	6.9	7.2	8	10
Total irrigation water	8	7.8	7.1	10
Total drainage water	6.9	7.05	5.3	10
Total nitrate losses	6.1	6.7	4.6	10
B/C ratio	7.6	8.65	8.4	10
Farmer acceptance	8	7.8	6.1	10
Irrigation water availability	8.4	9	7.4	10
Integrated management efficiency	9.2	8.55	6.9	10

The **MultiDeciMode** was developed for specific purposes: 1) to be able to evaluate the different alternatives for integrated water table management and to select the best alternative among them 2) to the DM in solving sophisticated problems in water resources management 3) to provide useful tool for the DM, without requiring experience with the MCDA techniques 4) to have an easy, quick and practical user friendly interface valid for multi purposes application.

A software program for the four MCDA methods, and the interface were developed and written using visual basic programming language and one version for windows was developed.

The interface was designed in a simple way to guide step by step the DM who has little computer experience to find solution for his complicated problems and to help users to get the information they need as quickly, as clearly, and as easily as possible. The interface provides graphs for alternatives utilities and ranking and text file for the output from each of the applied methods. Flow chart guide for the use of **MultiDeciMode** has been shown in Annex.1 and the user can follow all program steps easily without the need of any manual.

6 INPUT DATA

- **Criteria and Alternatives number**
  Criteria Number = 9
  Alternatives Number = 13

- **Normalization conditions**
  The given scores values are not normalised and are normalised by the model

- **Max and Min values**
  The model will calculate the maximum and minimum values of the scores for each criterion.

- **Criteria scores**
  The criteria scores, which have been estimated for all water table management strategies are presented in table 3 as the evaluation matrix (impacts matrix).

- **Criteria weights**
  Four weights are used for the evaluation, the average of decision-makers' group (W1), the average of University group (W2), the average of NWRC group (W3) and the equal weights (W4). All these weights are given in table 2. The model will normalise the weight values by using equation 2 as follows:

$$Normalized\ weight_i = \frac{weight_i}{\sum_{i=1}^{n} weight_i} \qquad (2)$$

Where: - i = criterion No and n = Number of criterion

- **Criteria conditions**
  The model consider two conditions for weight, the number 1 for maximisation and number 2 for minimisation and the values used for criteria conditions in this evaluation are given in table 4.

7 MODEL RUN

7.1 Selection of techniques to Run

The weighted summation, Compromised programming, ELECTRE-II and modified-ELECTRE-II (Wahba, 2002) methods were selected to evaluate the water table management strategies and each method was applied for the four different weights. For ELECTRE-II method, the threshold values are 0.8, 0.7, and 0.6 for concordance and 0.4, and 0.2 for discordance.

Table 3 Criteria Conditions

Criteria	Criteria conditions
Crop yield	1 (maximisation)
Soil salinity	2 (minimisation)
Total irrigation water	2 (minimisation)
Total drainage outflow	2 (minimisation)
Total Nitrate losses	2 (minimisation)
Benefits/Costs ratio (B/C)	1 (maximisation)
Farmer acceptance	1 (maximisation)
Irrigation water availability	1 (maximisation)
Integrated management efficiency	1 (maximisation)

7.2 Sensitivity analysis

To study the effect of changing criterion scores on the final ranking of water table management strategies, a sensitivity analysis has been carried out only for the quantitative criteria which are: crop yield, soil salinity, total irrigation water, total drainage water, total nitrate losses, and B/C ratio. The scores of these criteria could be changed due to spatial variability of field data or changes in field measurements, and simulation model approximation where these changes will affect ranking of the suggested strategies. A change from +25% to –25% with a step 5% is applied to the soil salinity criterion scores and from +10% to –10% with a step 5% is applied to the rest of the mentioned criteria for all weights using weighted summation, Compromised Programming, ELECTRE-II, and modified ELECTRE-II methods. The output of applying all the mentioned changes to the selected criteria using the **MultiDeciMode**, is average ranking for each alternative and the coefficient of variation for its ranking due to all changes in criteria scores.

8 RESULTS

The results of the ranking for all alternative strategies according to their ranking scores obtained for the different weights are presented in figure 2 for the weighted summation method, in figure 3 for the Compromised Programming method, in figure 4 for the ELECTRE-II method, and in figure 5 for the modified ELECTRE-II methods. The results indicate that the most preferred alternative strategy by all methods and for all different weights is alternative 13, and the most preferred alternatives after alternative 13 are 12, 11 and 3. Alternative 4 is ranked the last alternative by all methods and for all the different weights. It is notable that the top ranking alternative strategies 13, 12, and 11 are FD-CD (combined) strategies.

The results of sensitivity analysis for all methods are given in tables 5, 6, 7, and 8 for W1, W2, W3, and W4 respectively. The final ranking for any alternative in these tables is the average of 429 rankings due to all changes in criteria scores. All the methods agreed in ranking alternative 13, as the most preferred alternative followed by alternative 13 followed by alternative 12 and alternative 4 is ranked the last alternative. It is observed that the coefficient of variation (C.V) for alternatives 13 ranking is ranged between 13.41 to 18.61% for W1, W2, W4, and ranged between 17.27 to 25.93% for W4 with all methods, for alternative 12 is ranged between 12.47 to 18.29% for W1, W2, W3, and W4 for all methods, and for alternative

11 is ranged between 7.4 to 16.56% for W1, W2, W3, and W4 for all methods. This means that there is effect for the change of criteria scores on the ranking of these alternatives, and sometimes these alternatives exchange their ranking as the first, the second and the third, but the average of all these ranking is alternative 13 is the first, alternative 12 is the second, and alternative 11 is the third and they are the most preferred alternatives. It is observed that the C.V for alternatives 3 ranking is ranged between 5.98 to 10.52% for all weights with all methods, which means there is a little effect for the change in criteria scores on the ranking of this alternative, sometimes it ranked No 5, and 6, but most of times it ranked the fourth and it is the most preferred alternative after alternatives, 13, 12, and 11. It is observed that the C.V for alternatives 4, 1, 9, 7 ranking is ranged between 0 to 4.59% for all weights with all methods, which means that there is no much effect for the change of criteria scores on the ranking of these alternatives, and these alternatives are ranked the last. No much effect for the change of criteria scores on the ranking of the rest of alternatives, which almost of time are ranked in the middle.

Table 4 Sensitivity analysis results for all methods- decision-makers group weight (W1).

Alternative	Weighted summation		Compromised Programming		ELECTRE-II		Modified ELECTRE-II	
	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)
Alt-1	12	0.57	12	0.57	9	3.71	12	0.95
Alt-2	6	8.25	6	8.25	7	4.99	8	3.02
Alt-3	4	6.7	4	6.7	4	6.41	5	10.6
Alt-4	13	0	13	0	13	1.74	13	0.91
Alt-5	7	6.76	7	6.76	6	10.02	6	8.15
Alt-6	9	2.68	9	2.67	10	3.24	9	2.21
Alt-7	10	1.73	10	1.73	11	3.55	10	1.52
Alt-8	8	4.2	8	4.2	8	7.32	7	4.2
Alt-9	11	0.88	11	0.88	12	2.05	11	0.44
Alt-10	5	7.52	5	7.52	5	14.86	4	12.81
Alt-11	3	7.58	3	7.58	3	15.99	3	13.22
Alt-12	2	12.93	2	12.93	2	17.9	2	15.33
Alt-13	1	18.61	1	18.61	1	17.53	1	15.69

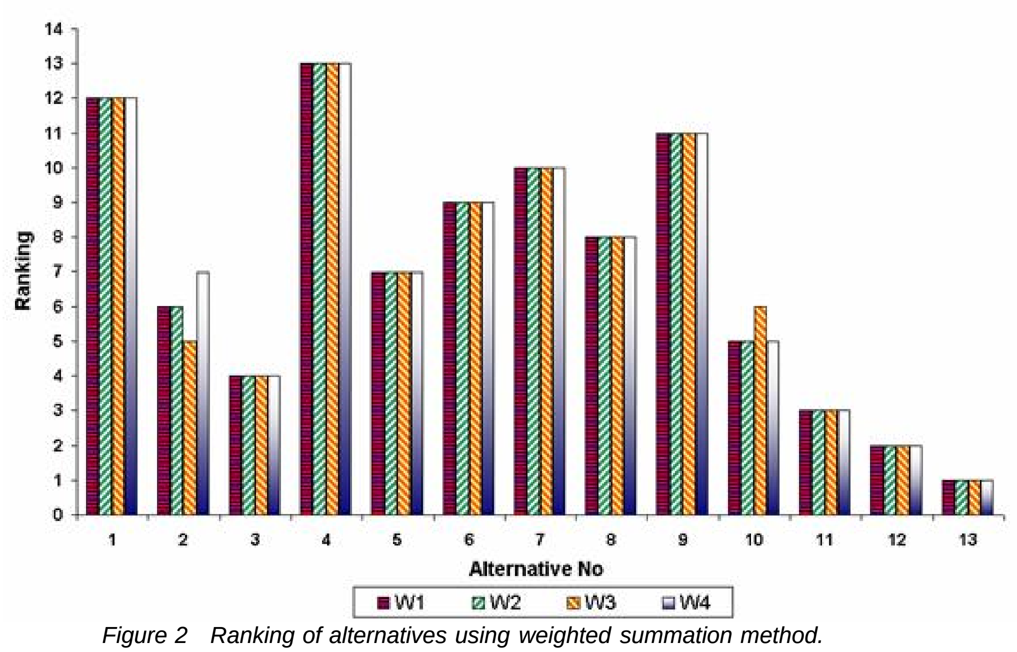

Figure 2 Ranking of alternatives using weighted summation method.

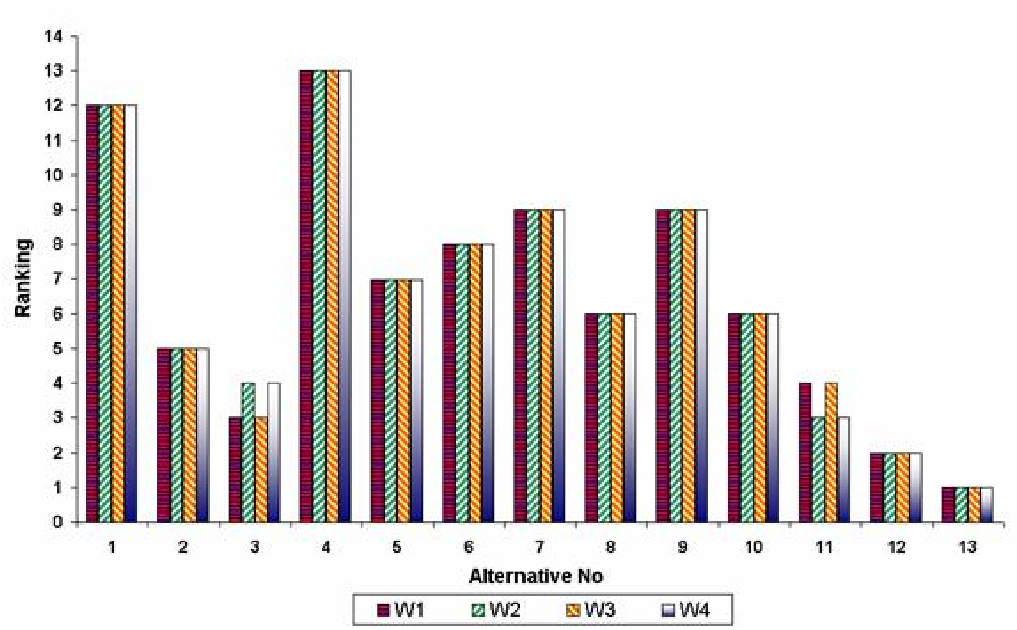

Figure 3 Ranking of alternatives using Compromised Programming method.

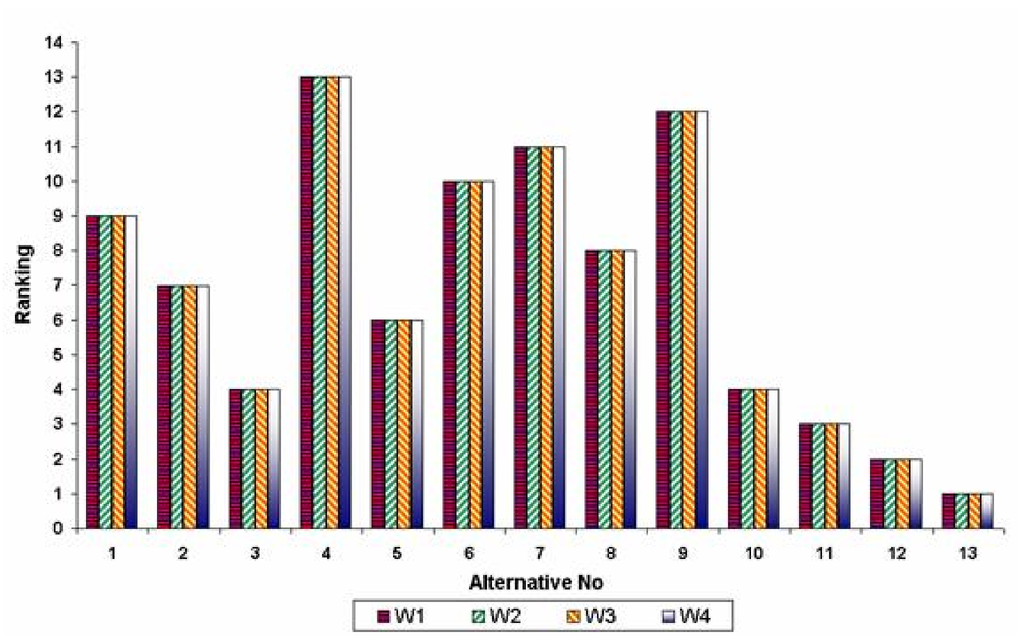

Figure 4 Ranking of alternatives using ELECTRE-II method.

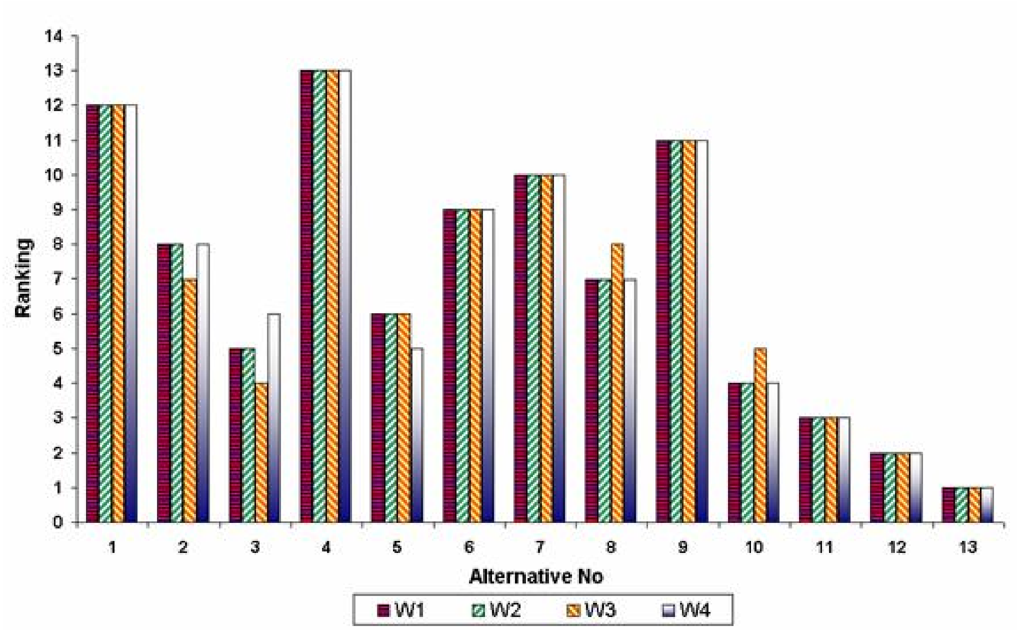

Figure 5 Ranking of alternatives using modified-ELECTRE-II method.

Table 5 Sensitivity analysis results for all methods- University group weight (W2).

Alternative	Weighted summation		Compromised Programming		ELECTRE-II		Modified ELECTRE-II	
	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)
Alt-1	12	0.4	12	0.4	9	3.71	12	0.98
Alt-2	6	9.1	6	9.1	7	4.99	8	2.96
Alt-3	4	7.31	4	7.31	4	6.41	5	12.47
Alt-4	13	0	13	0	13	1.74	13	0.83
Alt-5	7	7.46	7	7.46	6	10.02	6	10.74
Alt-6	9	2.46	9	2.46	10	3.24	9	2.28
Alt-7	10	1.66	10	1.66	11	3.55	10	1.59
Alt-8	8	4.44	8	4.44	8	7.32	7	4.31
Alt-9	11	0.61	11	0.61	12	2.05	11	0.44
Alt-10	5	7.34	5	7.34	5	14.68	4	12.65
Alt-11	3	7.4	3	7.4	3	15.99	3	13.19
Alt-12	2	12.72	2	12.72	2	17.9	2	15.37
Alt-13	1	18.61	1	18.61	1	17.53	1	16.34

Table 6 Sensitivity analysis results for all methods- NWRC group weight (W3).

Alternative	Weighted summation		Compromised Programming		ELECTRE-II		Modified ELECTRE-II	
	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)
Alt-1	12	1.49	12	1.49	9	4.01	12	0.69
Alt-2	5	10.25	5	10.25	7	5.46	7	6.2
Alt-3	4	6.41	4	6.41	4	7.7	4	10.52
Alt-4	13	0	13	0	13	1.74	13	0.64

Alt-5	7	5.49	7	5.49	6	10.65	6	7.35
Alt-6	9	3.56	9	3.56	10	4.59	9	2.93
Alt-7	10	2.14	10	2.14	11	4.28	10	2.13
Alt-8	8	4.28	8	4.28	8	9.18	8	6.07
Alt-9	11	1.37	11	1.37	12	2.05	11	0.44
Alt-10	6	8.79	6	8.79	5	14.59	5	8.73
Alt-11	3	9.83	3	9.83	3	16.56	3	12.33
Alt-12	2	13.4	2	13.4	2	17.9	2	15.75
Alt-13	1	25.93	1	25.93	1	17.53	1	23.27

Table 7   Sensitivity analysis results for all methods- Equal weight (W4).

Alternative	Weighted summation		Compromised Programming		ELECTRE-II		Modified ELECTRE-II	
	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)	Avg.-Rank	C.V (%)
Alt-1	12	0	12	0	9	3.78	12	1.06
Alt-2	7	6.97	7	6.97	7	5.07	8	3.6
Alt-3	4	7.75	4	7.75	4	5.98	6	5.99
Alt-4	13	0	13	0	13	1.74	13	0.98
Alt-5	6	7.2	6	7.2	6	10.11	5	8.57
Alt-6	9	2.57	9	2.57	10	3.17	9	3.06
Alt-7	10	1.8	10	1.8	11	3.33	10	1.98
Alt-8	8	6.28	8	6.28	8	8.36	7	5.47
Alt-9	11	0.62	11	0.62	12	2.05	11	0.44
Alt-10	5	7.09	5	7.09	5	15.54	4	10.88
Alt-11	3	7.4	3	7.4	3	16.25	3	15.0
Alt-12	2	12.47	2	12.47	2	18.29	2	13.79
Alt-13	1	18.08	1	18.08	1	30.44	1	13.41

9 SUMMARY AND CONCLUSION

Based on the long-term simulation (10 years) of the different water table management strategies using the DRAINMOD-S, the impacts of each strategy on the crop yield, soil salinity, total irrigation water, and total drainage water have been estimated. The impacts on total nitrate losses have been estimated from the total drainage outflow (DRAINMOD-S results) and the average concentration during field experimental test. The impacts on the rest of criteria have been estimated from interview with farmer and experts. The selected WTM alternative strategies have been evaluated using the **MultiDeciMode** and four different weights for criteria have been applied and the results indicate that for the integrated water table management, **four alternatives** are identified as the most preferred strategies and ranked as alternatives, 13,12,11, and 3 as described above.

The results of the water table management strategies indicate that by adopting a combined (FD-CD) strategy i.e. by increasing the spacing between drains to about 2 times the conventional design spacing and controlling the water table to a 60 cm (CD) at the beginning of each growing season (November, Dec, Jan for winter crops, May, June, July for summer crops and switching to conventional drainage (FD) during the rest of the growing season, saving of 20% of irrigation water will be achieved.

Another alternative saving of 15% of irrigation water will be achieved for an increase of 1.5 times the design spacing between lateral drains and keeping drain depth at 1.15m, controlled water table depth at 60cm is applied during the initial stage of the growing season and switching to (FD) drainage at the rest of the season.

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11 ANNEX. 1

11.1 MultiDeciMode Flow Chart

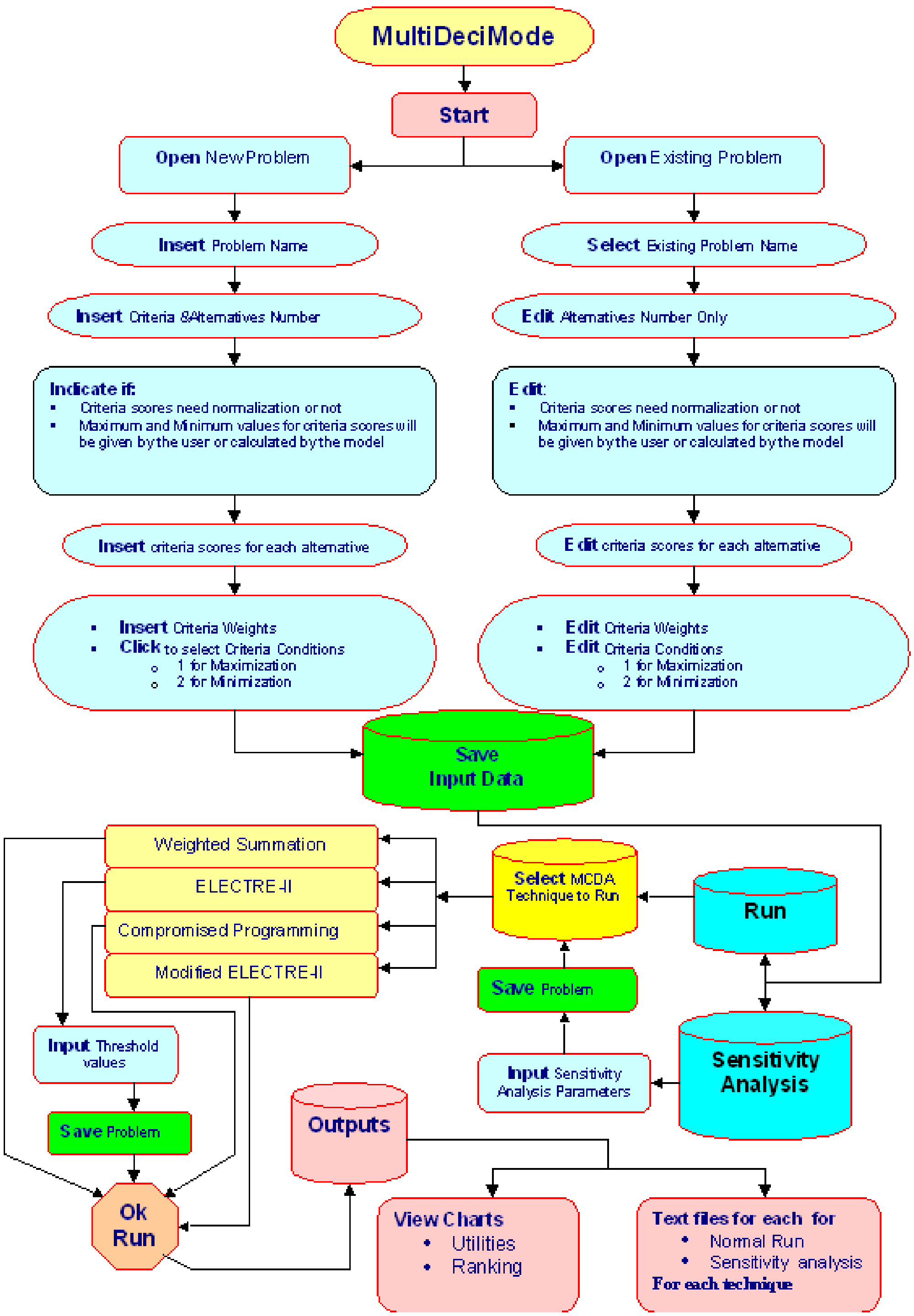

Table 8 Evaluation matrix.

Criterion	ALTERNATIVES												
	Alt1	Alt2	Alt3	Alt4	Alt5	Alt6	Alt7	Alt8	Alt9	Alt10	Alt11	Alt12	Alt13
Crop yield	0.99	1.0	1.0	0.91	0.95	0.95	0.95	0.93	0.92	0.97	1.0	0.9998	0.9999

(%)													
Soil salinity (dS/m)	2.01	1.73	1.19	2.4	1.92	1.73	1.66	1.72	1.55	2.07	1.67	1.43	1.54
Total-Irrigation-water (m3)	47302.5	42966.0	40746.3	47302.5	38623.3	40746.3	42966	38623.2	42966.0	38623.2	40746.3	40746.3	38623.2
Total Drainage Water (m3)	14595.8	11210.22	9303.42	8090.88	2928.24	4348.68	6105.12	3134.46	6378.12	2631.30	5217.24	5024.04	3560.34
Total Nitrate.Loss (kg/fed)	23.07	17.72	14.71	11.12	4.03	5.98	8.39	4.31	8.77	3.62	7.71	7.42	5.26
B/C ratio	1.55	1.58	1.58	1.43	1.50	1.49	1.50	1.46	1.40	1.53	1.57	1.58	1.58
Farmers Acceptance	10	10	8	8	8	8	8	8	8	8	8	8	8
Irrigation water Availability	3	7	7	3	10	7	7	10	7	10	10	10	10
Integrated Management Efficiency	5	7	7	7	7	7	7	7	7	7	10	10	10

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