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Evaluation of Irrigation Projects in saline soils Based LCC Approach

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ABSTRACT

Egypt is considered one of the agricultural countries that used to export all grain and crops to the world. During recent decades, there has been deterioration in irrigation projects in Egypt as a result of the shortage of water and the deterioration of agricultural lands, which led to an ineffective economic return, and loss of agricultural lands due to soil salinity and the deterioration of the economic return from irrigation projects in Egypt. Therefore, it is necessary to develop irrigation systems and study the feasibility of those systems through feasibility studies, which will cause an increase in the return and interest in developing irrigation systems. Feasibility study carried out to determine the best irrigation system and crop pattern with different value of soil salinity till to 15 ds/m in order to overcome salinity of soil, increase income generation and alleviate poverty. Using tolerant crops to overcome the soil salinity and drought help in high salinity soils without needing to reclaim the soil and save water specially the time of need for water and poverty. Three cases are suggested: I. Surface irrigation system and clay soil, II. Trickle irrigation system and sand soil and III. Trickle irrigation system and clay soil. These cases are studied with six different salt-tolerant crop patterns. Adopting the suggested strategies are to reduce or eliminate the impact of salinity by maximizing the revenue of irrigation project especially in degraded land with salts without reclamation the lands. Cost estimation is carried out to initial cost and annual cost to evaluate the three different cases using four life cycle cost (LCC) method and evaluated using four economic feasibility studies methods: I. Net present value (NPV), II. Benefit cost ratio (B/C), III. Internal rate of return (IRR) and IV. Pay-back period (n). Design curve is drawn for different studied salinity values for the three cases to find the best alternative and best crop pattern for each salinity value.

1. Introduction

Irrigation project aims to provide food and energy. Managing irrigation project (MIP) is necessary to maximize the profit of this project. Type of irrigation system, soil type, soil salinity and crop pattern are main parameters in managing projects, problems associated with irrigation projects such as soil salinity and reduction of yield urges the need to improve these projects. Irrigation project improvement have many methods [1] such as;

- Reclamation the land,
- Changing crop pattern,
- Improving drainage system and
- Changing irrigation type.

In high saline lands with a permanent source of salts using suitable salt tolerant crops with irrigation system is the best solution to save water. MIP in saline lands is selecting suitable crop with irrigation system according to certain soil type and soil salinity.

Aims of the MIP.

- Reducing the effect of salinity on crop yield,

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- Reducing the cost of preparing land and reclamation,
- Reducing irrigation water using low water consumption crops,
- Dealing with different types of irrigation system,
- Dealing with different types of soil type and
- Comparison between revenues from different crop pattern.

The different cases in MIP are irrigation systems, soil type and crop pattern. Many authors studied feasibility study of irrigation project and Life Cycle Cost (LCC).

[2] studied the effect of soil salinity on yield reduction of poplar. [3] proposed a methodology for the evaluation life-cycle maintenance cost of deteriorating structures by considering uncertainties associated with the application of cyclic maintenance action. [4] presented a general risk-based framework to predict the range of a possible LCC associated with the construction and rehabilitation of infrastructure system. [5] compared and estimated the LCC of different wastewater projects in Greece to determine the most cost-effective alternative. [6] discussed the theoretical assumptions and the practical usefulness of the LCC approach in making environmentally responsible investment decision. [7] explained how the LCC module was provided details of the algorithms, created and used in the module to estimate costs from sizing information.[8] studied the effect of soil salinity on osmotic stress and yield reduction for rice as a sensitive crop. [9] studied the effect of soil salinity on yield reduction of Jatropha. [10] proposed a new outlines for assessing economic LCC of dams considering performance system for sustainability aspect. [11] used LCC analysis for infrastructure strategic planning and settlement in describing current challenges of the water sector in Europe such as climate change or demographic change.

This paper presents an approach to manage the irrigation projects and create a design curve by evaluating three proposed cases with different salt-tolerant crop pattern to overcome salinity problems and select the best scenario for certain soil type with existing soil salinity using four LCC methods.

- ***Evaluation of LCC Methods***

LCC is a methodology for evaluating projects by calculating the total cost of a project from inception to disposal. LCC is the sum of all recurring and non-recurring costs over the whole life time or a specified period of a good, service, structure, or system. It includes purchase price, installation cost, operating costs, maintenance and upgrade costs, and remaining residual at the end of its useful life. There are four economic evaluation methods for LCC. These methods are: I) Net present value (NPV); II) Benefit-cost ratio (B/C); III) Internal rate of return (IRR), and IV) Pay-back period (n).

I. Net Present Value Method (NPV).

NPV is the subtracting present value of cash outflows from the present value of cash inflows. NPV is used mainly in capital budgeting to analyze the profitability of project. Disadvantage of this method is ignoring risk associated with the project. The choice is made on the basis of the highest positive value of NPV for comparing between projects. The following formula is used for calculating NPV [12]:

$$NPV = C_i + R_e - S_r + A_a + M + E \dots (1)$$

Where, Ci :is investment costs; Re is replacement costs; Sr is resale value at the end of study period; Aa is annually recurring operating, maintenance and repair costs (except energy costs); M: non-annually recurring operating, maintenance and repair cost (except energy costs); E is energy costs..

II. The Benefit Cost Ratio (B/C).

Benefit cost ratio is a method for analyzing the desirability of public works projects, or any other project where benefits and costs can be quantified. B/C ratio considered the most used method as it provide ratio of benefit and cost as it measure both quantitative and qualitative factors. Costs are project expenses for construction, operation &maintenance, etc. B/C >1.0 means the project is acceptable, whilst B/C <1.0 means the project is rejected. The choice is made on the basis of the highest value of B/C for comparing between projects. The following formula is used for calculating B/C [12]:

$$B/C = \frac{benefits - disbenefits}{cost} \dots\dots\dots\dots\dots..(2)$$

III. Internal Rate of Return (IRR).

IRR is the rate of return that an investment is expected to achieve during its useful life. IRR analyzes an investment project by comparing the internal rate of return to the Minimum Attractive Rate of Return (MARR) of the company. The minimum required rate of return is set by management with a default value equal to annual bank interest. Most of the time, MARR is the cost of capital of the company. If IRR of an investment is greater than or equal to the MARR, the project is considered acceptable, otherwise the project is rejected. This method is impractical when compare projects of different lengths. The following formula is used for calculating IRR[12]:

IRR = investment required/net annual cash flow.(3)

IV. Pay-back Period (n).

Pay-back Period is the length of time required to recover the cost of an investment. This method ignores the benefits occurs after the payback period and ignores profitability. The following formula is used for calculating PBP [12]:

n = Cost of Project /Annual Cash Inflows……..(4)

2. Methodology.

Managing irrigation project methodology is used to achieve the study objectives. The methodology steps used in the study are:

- Specify the three used cases.
- Estimation cost for each alternative.
- Calculate the revenue from each alternative.
- Using LCC methods to evaluate these cases.
- Create a design curve.

2.1 Specifying the three used cases.

There are three proposed cases to MIP:

- Surface irrigation system with clay soil.
- Trickle irrigation system with sand soil.
- Trickle irrigation system with clay soil.

These three proposed cases are studied with six salt-tolerant crop patterns which are: 1.

- Rotation 1 (sorghum + Sugar beet).
- Rotation 2 (Wheat + Maize).
- Rotation 3 (cotton + Barley).
- Jojuba.
- Jatropha.
- Palm.

2.2 Developing cost estimation for each cases.

The cost estimation will cover initial cost (irrigation network, seedlings and planting) and annual cost (operation, pest resistance and maintenance). All data is collected from ministry of agriculture and the cost of irrigation network and its maintenance from per 1 feddan (4200 m^2) [13],over 30 years " life time of the project" as shown in Table (1)

2.3 Calculating the revenue from each cases.

To use LCC approach methods revenue must be calculated. The net revenue is calculated from the yield of crops which cultivated in sand and clay soil with different soil salinity from 0 ds/m to 15 ds/m.

From Table (2) and crop data collected from ([14]and [15] for R1, R2 and R3 , [16] and [17] for Jojuba.[18] "A case study of Ismailia " and [19]"A case study of Luxor" and [9] for Jatropha and [20] and [21] For Palm it is evident that the benefits decrease according to the increase in salinity resulting in the soil according to the response of each plant to the increase in salinity.

3. Results and discussion.

The cost of each alternative is shown in Table (1) and revenue of each alternative is shown in Table (2), the return from the first alternative (R1) decreases by 12.17% according to the increase in salinity by 1ds/m , the second alternative (R2) decreases by 7.33% according to the increase in salinity by 1ds/m, the third alternative (R3) decreases by 5.97% according to the increase in salinity by 1ds/m, the fourth alternative (Jujoba) decreases by average 7.25% according to the increase in salinity by 1ds/m, the fifth alternative (Jatropha) decreases by average 4.1% according to the increase in salinity by 1ds/m, the sixth alternative (palm) decreases by 3.6% according to the increase in salinity by 1ds/m.

Three MIP cases are compared to each other using the four LCC methods (Equations 1, 2, 3 and 4) as shown in Fig.(1) , Fig.(2), Fig.(3), Fig.(4).

The below figure (1) shows that

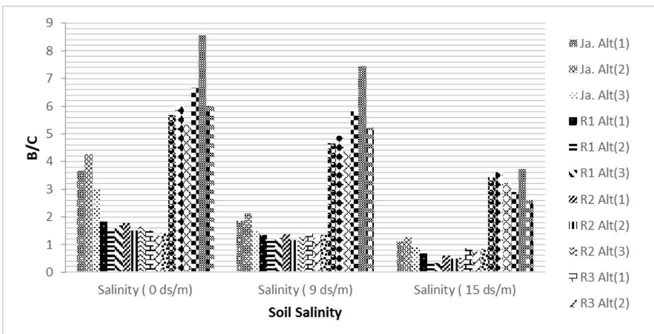

Figure (1) : B/c for three cases

1. At salinity 0ds/m, the maximum B/C ratio is achieved from Jojuba crop with trickle irrigation system and sand soil then Jojuba crop with surface irrigation system and clay soil shown but the minimum B/C is achieved from rotation 3 crop pattern with trickle irrigation system and sand soil.

2. At salinity 9ds/m, the maximum B/C ratio is achieved from Jojuba crop with trickle irrigation system and sand soil then Jojuba crop with surface irrigation system and clay soil but the minimum B/C is achieved from rotation 1 crop pattern with trickle irrigation system and sand soil.

Table (1) Initial and annual cost of each case in Egyptian Pound.

			First Case			
Crop	R1	R2	R3	Jojuba	Jatropha	Palm
initial cost	20000	20000	20000	50987.6	32542.6	130500
M.O	9816.197	9789.311	15427.32	9580	3693.164	13060
			Second Case			
Crop	R1	R2	R3	Jojuba	Jatropha	palm
initial cost	29000	29000	29000	59987.6	41542.6	139500
M.O	10556.2	10529.31	16167.32	10320	4433.164	13800
			Third Case			
Crop	R1	R2	R3	Jojuba	Jatropha	palm
initial cost	29000	29000	29000	59987.6	41542.6	139500
M.O	10556.2	10529.31	16167.32	10320	4433.164	13800

Initial cost is as present value, M.O is maintenance and operating cost as annual cost

Table (2) Annual Revenue of each case in Egyptian Pound.

			First Case			
Crop	R1	R2	R3	Jojuba	Jatropha	palm
Revenue at 0 ds/m salinity	22115.59	21323.4	26522.1	100095	26342.75	152686.5
			Second Case			
Crop	R1	R2	R3	Jojuba	Jatropha	palm
Revenue at 0 ds/m salinity	21261.90	20500.3	25498.4	142993.00	37632.5	172067.96
			Third Case			
Crop	R1	R2	R3	Jojuba	Jatropha	palm
Revenue at 0 ds/m salinity	23110.79	22282.90	27715.60	100095	26342.80	152686.5

3. At salinity 15ds/m, the maximum B/C ratio is achieved from Jojuba crop with trickle irrigation system and sand soil then Palm crop with trickle irrigation system and sand soil but the minimum B/C is achieved from Jatropha crop with surface irrigation system and clay soil.

The below figure (2) shows that

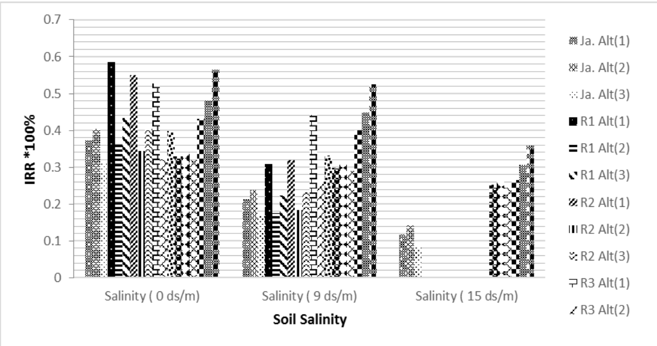

Figure (2) : IRR for three cases

1. At salinity 0 ds/m, the maximum IIR is achieved from rotation1 crop pattern with surface irrigation system and clay soil then Jojuba crop with trickle irrigation system and clay soil but the minimum IRR is achieved from Jatropha crop with trickle irrigation system and clay soil.
2. At salinity 9 ds/m, the maximum IIR is achieved from Jojuba crop with trickle irrigation system and clay soil then Jojuba crop with trickle irrigation system and sand soil but the minimum IRR is achieved from Jatropha crop with trickle irrigation system and clay soil.
3. At salinity 15 ds/m, the maximum IIR is achieved from Jojuba crop with trickle irrigation system and clay soil then Jojuba crop with trickle irrigation system and sand soil but the minimum IRR is achieved from Jatropha crop with trickle irrigation system and clay soil.

The below figure (3) shows that:

1. At salinity 0 ds/m, the minimum n is achieved from Jatropha crop with trickle irrigation system and sand soil then Jatropha crop with surface irrigation system and clay soil but the maximum n is achieved from rotation 3 crop pattern with trickle irrigation system and clay soil.

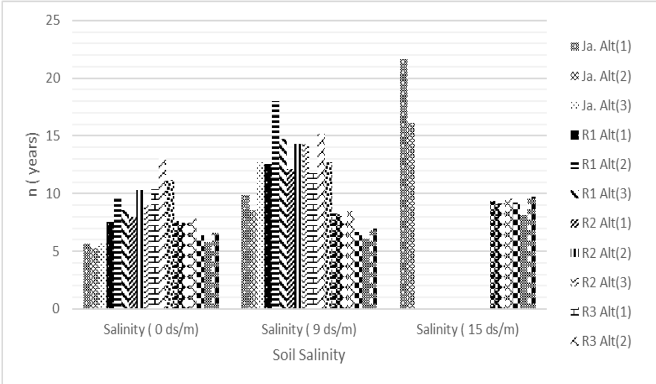

Figure (3) : Payback period for three cases.

2. At salinity 9 ds/m, the minimum n is achieved from Jojuba crop with trickle irrigation system and sand soil then Jojuba crop with surface irrigation system and clay soil but the maximum n is achieved from rotation 1 crop pattern with trickle irrigation system and sand soil.
3. At salinity 15 ds/m, the minimum n is achieved from Jojuba crop with trickle irrigation system and sand soil then Palm crop with trickle irrigation system and sand soil but the maximum n is achieved from Jatropha crop with surface irrigation system and clay soil.

The below figure (4) shows that

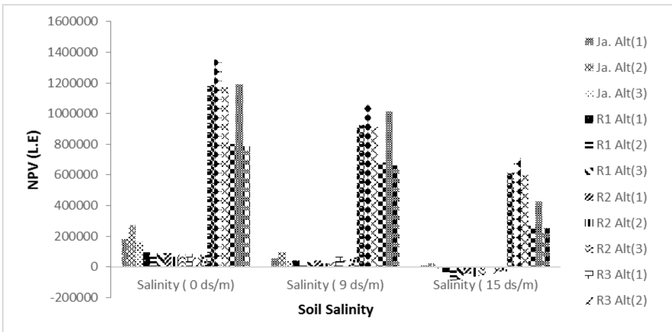

Figure (4) : NPV for three cases

1. At salinity 0 ds/m, the maximum NPV is achieved from Palm crop with trickle irrigation system and sand soil then Jojuba crop with trickle irrigation system and sand soil but the minimum NPV is achieved from rotation 3 crop pattern with trickle irrigation system and sand soil.
2. At salinity 9 ds/m, the maximum NPV is achieved from Palm crop with trickle irrigation system and sand soil then Jojuba crop with trickle irrigation system and sand soil but the minimum NPV is

achieved from rotation crop pattern with trickle irrigation system and sand soil.

3. At salinity 15 ds/m, the maximum NPV is achieved from Palm crop with trickle irrigation system and sand soil then Palm crop with surface irrigation system and clay soil but the minimum NPV is achieved from Jatropha crop with surface irrigation system and clay soil.

4. Design Curve.

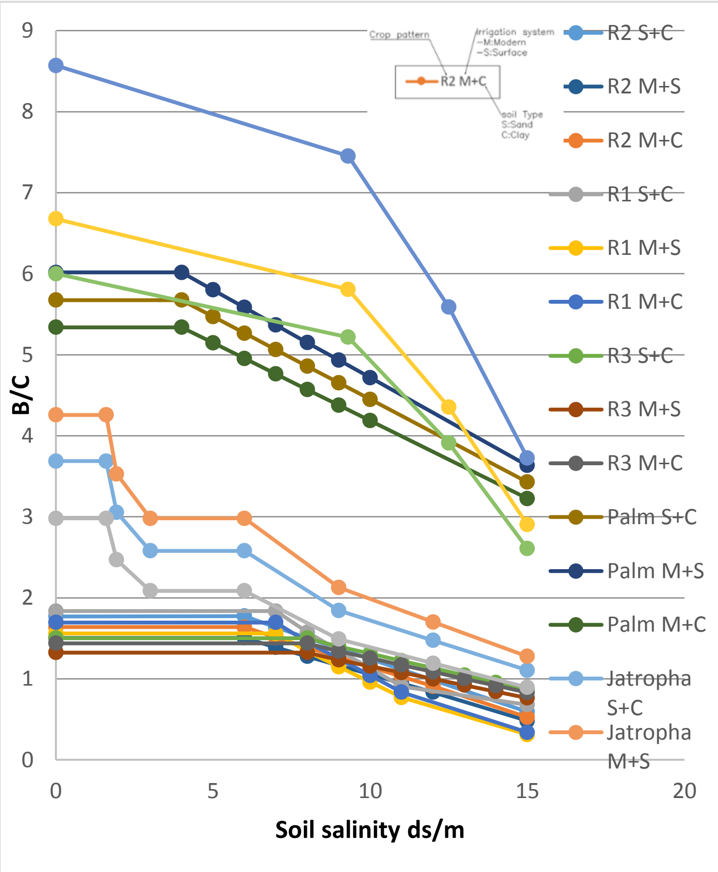

Figure (5) : Design chart for three cases according to B/C.

Design curve is drawn for the three suggested cases with proposed six salt-tolerant crop patterns

at different studied salinity values based on (B/C) ratio method as it is considered the most used method as it provide ratio of benefit and cost as it measure both quantitative and qualitative factors, don't depend on MARR , don't need to be compared with MARR , take total cost into consideration and revenue after pay-back period, shown in Figure (5). Design curve will used for any area of soil clay or sand by identifying soil type and soil salinity from horizontal axis between [0 to 15 ds/m] then choosing from curves irrigation system with crop pattern to get maximum B/C.

The final result of this paper is the creation of a design curve.

5. Conclusion.

There are many factors affecting the crop yield such as soil and water salinity. There are many areas in Egypt suffering from salinization problem, especially at the North which led to less production of crops or non-productive. Due to saline soil with a water deficit situation, crop pattern must be changed to the pattern of salt-tolerant crops, such as non-food crops grown specifically for energy. Jojuba is considered one of the most practical and scientific solutions for saline lands in Egypt, because it needs little quantities of water, great salinity tolerance (up to 3,000 ppm without any impact to the yield). This paper presents an approach to evaluate three proposed cases of MIP using four LCC methods. LCC is a methodology for calculating the total cost of a system from inception to disposal taking into account the money's time value. The motive to conduct this research is to select the best alterative of MIP taking into account costs incurred during the whole life of Irrigation Project, rather than considering only the initial construction cost. Three cases are suggested: I. Surface irrigation system and clay soil, II. Trickle irrigation system and sand soil and III. Trickle irrigation system and clay soil. These cases are studied with six different salt-tolerant crop patterns, these crop patterns are: R1 (sorghum + Sugar-beet), R2 (Wheat + Maize), R3 (cotton + Barley), Jojuba (Energy crop), Jatropha (Energy Crop), Palm trees. Cost estimation is carried out to initial cost (irrigation network, seedlings and planting) and annual cost (operation, pest resistance and maintenance) to compare between different cases using four life cycle cost methods: I. Net present value (NPV), II. Benefit cost ratio (B/C), III. Internal rate of return (IRR) and IV. Pay-back period (n). Design curve is drawn for different studied salinity values for the three proposed cases. The economic analysis led to the following results: I. improving soil properties by using suitable irrigation and drainage system is the most efficient method to increase crop yield but with the current water deficit in Egypt, the best solutions are those that do not need large quantities of water. II. Jojuba with trickle irrigation system and sand soil is the best alternative for different salinity levels (0 to 15 ds/m). III. Jojuba with surface irrigation system and clay soil is the best alternative for salinity from 0 to 14 ds/m then palm. IV. Jojuba with trickle irrigation system and clay soil is the best alternative for salinity from 0 to 13.8 ds/m then palm for salinity from 13.8 to 15 ds/m.

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