Farm-Based Environmental and Economic Impacts of the Drip Irrigation System

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***Abstract*-Drip irrigation has received considerable attention from policy makers, researchers, and economists for its ability to contribute significantly improvements to water resource development, agricultural productivity, economic growth, and environmental sustainability. In this paper, the impact of drip irrigation has been studied on a farming system in terms of environmental and economic conditions using the developed Trickle Irrigation System Design Modeling (TISD). The environmental conditions included soil type, land topography, climate zones, water sources, their quality, and the farm dimensions. The economic conditions comprised of real and nominal interest rates, raw land price, and the energy and labor escalation rates. The study considered only the Benefit-Cost Ratio (BCR) to indicate the impact of environmental and economic parameters on the use of the drip irrigation system. The study used tomato-sesame as a crop rotation (line-source) and citrus as a long-life tree (point-source). Some parameters such as soil type, land topography, and water quality had a significant impact on the BCR.**

Keywords-trickle irrigation; system configuration; economics; environmental changes; citrus; tomato-sesame rotation

I. Introduction

Developing infrastructure for water resources and their management is a common policy agenda in many developing economies, particularly in arid and semi-arid tropical countries like Egypt. A study by the International Water Management Institute (IWMI) has shown that around 50% of the increase in water demand by the year 2025 can be met by improving the efficacy of irrigation [1]. Drip irrigation systems require a general understanding of the economic and environmental site conditions. Lack of consideration of economic conditions could lead to the failure of a system that may environmentally appear to be well designed. Some of the environmental conditions that must be considered are: crops and cultural practices, farm size and shape, topography, soil type, climate, water supply, and water quality [2-11]. Economic efficiency is paramount to the system selection process. The data required for economic analysis fall into two general categories, site-dependent and system-dependent [3]. Site-dependent economic parameters include: interest rate, labor cost, energy cost, energy inflation factor, general inflation factor, property taxes (on equipment), water cost, land value, and the return to irrigation for each crop. Interest rates are categorized as real or nominal. Nominal rate is the current rate of interest charged by the lending institution that will provide the credit and includes an inflationary component and a risk management and profit component. The real rate (inflation-free and ranges from 5 to 7%) is used to determine the annualized cost of capital expenditures that tend to appreciate, such as land values and permanent improvement to the land, like land-leveling. Nominal rate is used to determine the annualized cost of capital expenditures that depreciate or reach technical obsolescence with little or no salvage value. The energy inflation factor is the expected inflation rate for energy over the system's economic life and is important for balancing capital and operating costs. Inflation factors should be included for other input costs, such as for labor and water. System-dependent parameters include: system component costs, system component lifetimes, and labor, energy and maintenance costs. The economic impacts of Drip Method of Irrigation (DMI) had been studied in [12] for sugarcane cultivation. The cost of cultivation was reduced in operations like weeding, intercultural and irrigation cost (both labor and other costs). The benefit-cost ratio varied from 1.98 to 2.02 (without subsidy condition) and from 2.07 to 2.10 (30% subsidy at different discount rates). Further, the net present worth indicated that the entire capital cost was recovered from the income of the very first year itself even without subsidy. The measures of zero sales tax were suggested to bring down the cost of drip set. The effect of planting distance on guava yield, quality and economic return under DMI was conducted experimentally in [13]. The guava had been planted at 6m×6m

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(I) and 5m×5m (II). The results produced 8.31t/ha and 15.0t/ha (I) and 12.0t/ha and 21.60t/ha (II) after the 3rd and 4th year of plantin, respectively. The highest Benefit-Cost Ratio (BCR or B/C) (2.20) was at (II). The effect of salt-affected land production under DMI was reclaimed using a 1-3yr. field experiment in [14] to investigate changes in soil's physical, chemical, and biological properties with cropping maize. The results indicated that the soil physical environment and nutrients status were both improved. Author in [15] used a Subsurface Drip Irrigation (SDI) system to examine the convenient streams of irrigation water in uncovered domains and greenhouses. Authors in [15] examined and analyzed pipeline materials, emitters spacing, and soil texture. The study investigated the impacts of soil sort and climate on consumption of water. Soil moisture was measured by two Enviroscan sensors. In addition, the climate parameters were measured by two weather stations. Software, based on Penman–Monteith approach, was used to estimate the crop evapotranspiration and the amount of irrigation water according to the FAO guidelines as a reference. The outcomes manifested a significant increase in crop productivity by 18% when the proposed SDI system was used over the normal DMI. Authors in [16] studied the effect of DMI of cultivation in terms of cropping pattern, resource use and yield. The DMI has been found to get an important effect on saving resources, cultivation cost, crops yield and farm profitability. Authors in [17] studied the adaptability of the DMI with the aid of solar power. Although the recurring cost for energy was waived due to the use of freely available solar energy, the initial investment for the solar powered drip system is high. Further, the BCR was 2.64 for using solar operated drip rather than the diesel operated system which had BCR equal to 1.30. The study in [18] aimed to assess the techno-economic feasibility of solar and wind based pumping irrigation systems. In the first stage of the study, the irrigation water requirements were determined by using the CROPWAT software to assess two different crop patterns that represent existing feasible alternatives for small farmers. For 1ha, the pumping systems powered by solar, wind and diesel energy were sized based on the crop water requirements. The costs of irrigation due to the three technologies, the two crop patterns and the three methods of irrigation (surface, sprinkler and drip) were estimated and compared. The economic analysis was complemented by a cost-benefit analysis spanning over 20 years. The economic analysis showed that windmills are the most cost effective solution, with solar pumping systems in second place. Diesel pumping systems are the least cost effective. To study the climate effect on the tomato yield under DMI, authors in [19] investigated three different combination levels (100, 75 and 50% of crop water requirement) and two mulches (black polyethylene sheet and paddy straw). The highest yield for each mulch was obtained when the 50% of water requirement was applied. The yield results were 81.12t/ha for polyethylene and 79.49t/ha for straw. With 100% water application, the straw-mulched treatment produced higher yield than polyethylene-mulched treatment. The highest water use efficiency of 592kg/ha/mm was acquired with 50% water application under polyethylene mulch. The highest net return (US$ 7098/ha), incremental net return (US$ 1556/ha), and incremental benefit-cost ratio (7.03) were found for 50% water application with straw mulch. Authors in [20] studied the economic and resource impacts of drip irrigation including its benefit–cost pattern using survey data in okra cultivation. The study results revealed that the drip irrigation usage can reduce about 15% of cultivation cost, save about 47% of water resources and electrical energy, and increase okra productivity by 49% for the same cultivated area under traditional methods of irrigation. Farmers cultivating okra under the usage of drip irrigation acquired an extra farm trade income of RS 72,711 per acre over the non-drip adopters. Author in [21] conducted economic analysis on seven crops and nine vegetables using the Trickle Irrigation System Design (TISD) developed in a hypothetical field in Egypt based on local environmental and economic conditions [22]. Economic B/C analysis and net returns amounts were calculated. The results of the study showed that high values of net return were attained for most crop rotations. Further, most B/C for crop rotations ranged from 1.5 to up to more than 2.0. Authors in [23] used the TISD [22] linked with the measures of the economic analysis in [21] to study the effects of system configuration and lateral directions for long-life fruit trees on the selected economic bases. The study was conducted on eleven long-life fruit trees based on environmental, crop, and economic conditions. The results revealed that the drip irrigation system with configurations and lateral directions has a very small effect on BCR, annual net return, total annual costs, and net cultivated area. The used system has significance on initial capital cost and annual energy cost. Moreover, the drip irrigation system configurations and lateral directions have a considerable effect on annual maintenance cost. The objective of this study was to assess the impact of environmental and economic parameters in drip irrigation systems in farms using the TISD. The considered environmental conditions were: soil type, land topography, climate conditions, and water source conditions. The economic conditions were: real and nominal interest rates, raw land price, and energy and labor escalation rates.

II. MATERIALS AND METHODS

This study used the TISD [22] to design the trickle irrigation system with the economic analysis detailed in [21] to estimate the impacts of farm conditions under drip irrigation system on the BCR. Figure 1 shows the flowchart of the TISD. The conditions considered are the environmental and economic data and suitable crop rotations. The environmental site data are soil type [24-29], land shape and topography [30-31], water source position and type, irrigation water quantity and quality [32-34], and climate zone [35-37]. The economic data include: land price [38], real and nominal interest rates [12, 39], energy source type and fuel cost [40-43], energy inflation factor, labor availability and cost, labor inflation factor, and system components' availability and costs. Crop rotations are either long-life trees or combination of winter and summer field crops or vegetables. The crop rotations should be compatible against soil type, irrigation methods, climate zone, water quality, and agricultural recommendations. After designing the concerned system, TDIS calculates the different system costs and returns to determine the different selection bases. The system costs include: installation, operation, maintenance, land, water (if any), and crop production (land preparation, seeding and planting, fertilization, weeding, pest control, harvesting, and transportation). To analyze this methodology, a farm with certain environmental and economic parameters was proposed as the base farm (base run). This base run will be used in comparison with the following runs. In this study, one crop rotation (tomato-sesame) and one long-life tree (citrus) cultivation were selected. The TISD model runs by using the environmental and economic data of the base run for tomato-sesame and citrus with the drip irrigation system configurations and lateral directions. This step was repeated for different parameter values, by changing one parameter while keeping the others to the value of the base run. Then, the effect of each environmental and economic parameter on the BCR as the only selection basis could be discussed.

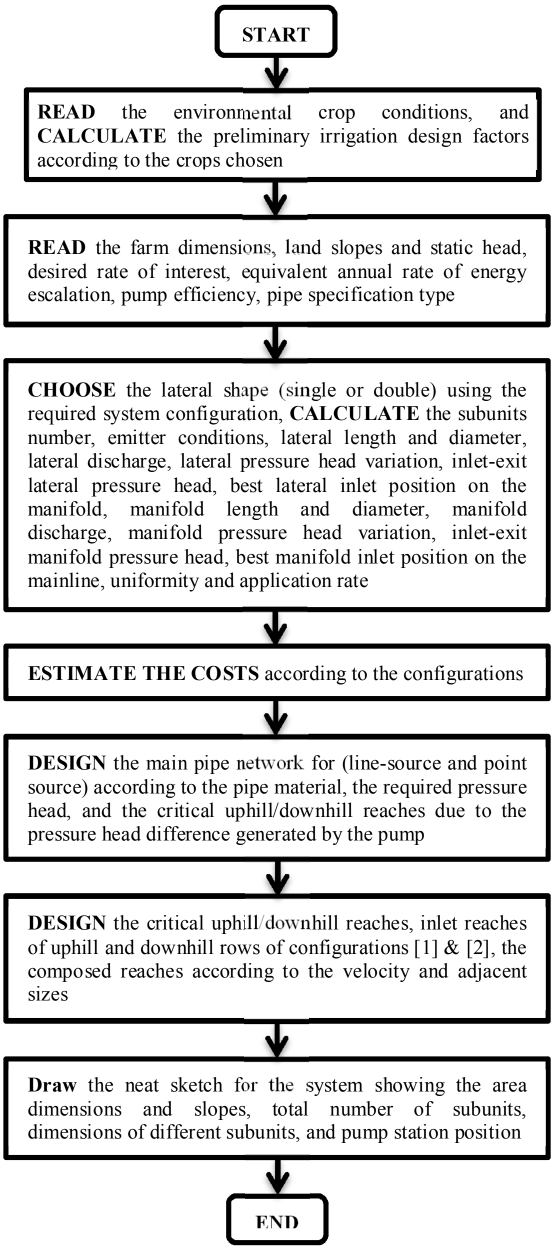

Fig. 1. Flowchart of the TISD program.

A. Proposed Data for Base Farm (Run)

Figure 2 shows the proposed farm's shape and topography. The proposed data to complete the analysis procedures for the base run include environmental and economic conditions (Table I). Further, crop rotations are considering the environmental site data (Table I) and the agricultural statistics in Egypt [44] based on the required information of the concerned crop rotations (tomato-sesame) and long-life fruit trees (citrus) in 2018 (Table II). The TISD model proposes the suitable crop rotations and their average production costs, expected average crop productions, and average crop prices as in [21] and [23].

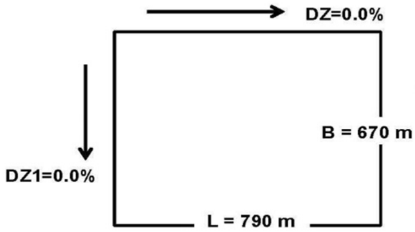

Fig. 2. Farm dimension, slopes, and North direction of the base run.

TABLE I. CASE STUDY'S SITE DATA

Environmental Conditions	
Soil type:	Coarse texture (coarse or fine or loamy sands), Code number=2
Climatic conditions:	Hot climate (Middle Egypt), CLZ (Code No.) = 3 Wind speed (WS)=3.0mph
Farm shape:	Figure 2
Farm topography:	Figure 2
Crop conditions: [24, 45-48]	Plant spacing, plant root depth, shaded area (%), average rate of water use, seasonal water requirements, leaching requirement ratio
Obstructions:	No
Water source:	Surface water Suction head, H_s =6.0m Water quantity = no restriction Frequency = continuous Water quality, Electrical Conductivity, EcW= 640.0ppm=1.0dS/m Water price=0.0US$/m^3
Economic Conditions	
Raw land value:	RAW=1000 US$/ha
Real interest rate:	RIR=6.0%
Nominal interest rate:	NIR=10.0%
Electric energy: [49]	Energy cost=0.10 US$/kWh (2018 prices) Energy escalation rate=27.0% (2018)
Labor: [50]	Available and reliable Labor cost=4.5 US$/man-hr (2018 prices) Labor escalation rate=5.0%. (2018 prices)
Construction elements:	Available for drip irrigation system Available maintenance supports PVC specification = DIN (Germany) PVC price=15US$/kg of PVC (2018) Aluminum and steel pipe [3], outlets' prices [51]

B. Proposed Changes in Base Run's Data

The proposed changes of the base run environmental and economic data are listed in Tables III and IV. To study the effect of farm area and dimensions on system costs and returns, the base farm was divided into two, four, six, and eight equal parts. This partition was made by dividing the farm length and/or width and introduces dimension ratios (L/B) of (1.179, 1.272, 1.696, 1.769, 2.358, 3.39, 4.716, 5.089, 6.785, 7.075, and 9.433). Other farm dimension ratios with constant farm area were also studied. The considered farm dimension ratios with the same farm area are: 1.0, 1.5, 2.0, 2.5, and 3.0. Figure 3 shows the methodology flowchart.

TABLE II. ECONOMIC INFORMATION FOR THE CASE STUDY [44, 2018]

Crop Rotations	Fruit production price (US$/ha)	Average fruit production ton/ha)	Average fruit price US$/ton)*
Tomato	4064.11	40.9689	99.2
Sesame	1183.84	1.2941	914.8
Citrus	3726.2	24.11	154.55

*[44, 2017]

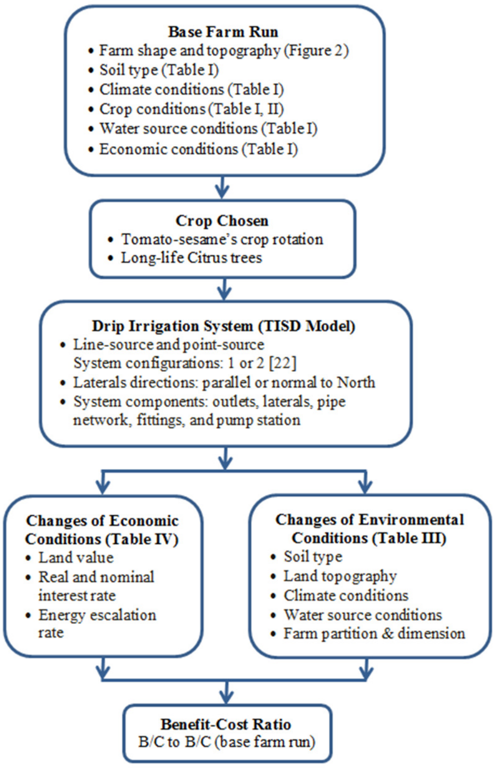

Fig. 3. Flowchart of the methodology analysis.

TABLE III. PROPOSED CHANGES ON BASE RUN ENVIRONMENTAL PARAMETERS

Crop rotation	Environmental conditions						
	Soil texture	Land topography		Climate conditions		Water source	
	(1)	DZ%	DZ1%	(2)	WS mph.	EcW	H_s
Tomato-sesame	4,5	2,4,8,16	1.5,3,6,12	5	3,6,12	2,8	30
Citrus	4,6	2,4,8,16	1.5,3,6,12	2,5	3,6,12	2,4	30

(1) Text code: Code 4: very fine sandy loams, loams, and silt loams, Code 5: clay loams, silty clay loams, and sandy clay loams, Code 6: sandy clays, silty clays, and clays,(2) CLZ Code: Code 2: Moderate climate, Code 5: High desert climate

TABLE IV. PROPOSED CHANGES ON BASE RUN ENVIRONMENTAL PARAMETERS

Crop Rotations	Economic conditions				
	Land value	Real and nominal interest rates		Energy escalation	
	RAW US$/ha	Real %	Nominal %	ESCR %	LASCR %
Tomato-sesame	2000, 4000, 8000	4,8,10	8,12,14	3,5,9	2,6,8
Citrus	2000, 4000, 8000	4,8,10	8,12,14	3,5,9	2,6,8

III. RESULTS AND DISCUSSION

The TISD model was run for the preselected crop rotation (tomato-sesame) and long-life trees (citrus) under the drip irrigation system and configuration by using the environmental and economic data of the base run according to Tables III and IV. For tomato-sesame rotation, the laterals must be perpendicular to the North direction. For citrus trees, the laterals may be arranged parallel or perpendicular to the North. As in [22], if the laterals are parallel to the North direction, the configuration is either #1 (with pump at the farm center [DP1], with pump on the big side [DP11], with pump on the small side [DP12]) or #2 [DP2]. If the laterals are perpendicular on the North direction, the configuration is either #1 (with pump at the farm center [DN1], with pump on the big side [DN11], with pump on the small side [DN12]) or #2 [DN2].

A. Effect of Different Environmental Conditions on the BCR

1) Soil Type

The effects of different soil types on the BCR of tomato-sesame crop rotation and citrus trees are shown in Figure 4. The Figure shows the BCR (stated as B/C) of the base run (coarse texture, Text = 2) with different configurations. Figure 4 shows the changes of the base run BCR due to changes to the soil texture from coarse to medium and moderately fine (Text = 4 and 5, tomato-sesame) and from coarse to medium and fine texture (text = 4 and 6, citrus).

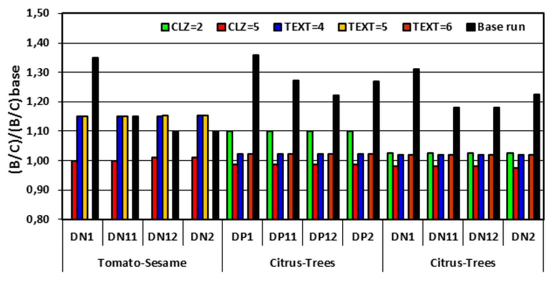

Fig. 4. Effect of soil texture and climate condition on the BCR.

It could be noted that the effect of soil type on the BCR of line-source is considerable (about 15.0%) and for point-source is negligible (within 2.0%). The best B/C is obtained with medium soil. For point-source and line-source drip systems, the soil type has a negligible effect on the selection of system configuration and laterals' direction (less than 0.5%). For line-source drip system, the improvement in the BCR due to the change to the soil texture from coarse to medium is considerable and due to this change the soil texture from coarse to medium to moderately fine is negligible. For the point-source drip system, the improvement in the BCR due to change of the soil texture from coarse to medium or fine is negligible. So, it is preferable to use the point source drip system on the coarser soil textures.

2) Uniform Land Topography

The effects of different uniform land slopes on the BCR of tomato-sesame crop rotation and long-life citrus plantation are shown in Figure 5. This figure shows the B/C of the base run (DZ=DZ1=0.0%) under the drip irrigation system configurations. The Figure shows the resulting changes in the BCR of the base run due to changes in the farm slopes. From Figure 5, it could be noted that the effect of land slope on the BCR depends on the slope value and direction, and the pump position. The negative effect of the land slope on the BCR could be avoided by putting the pump unit on the upper farm side (if possible). Also, for the point-source drip system, it is better to arrange the lateral lines on the small slope direction. Land slopes have a considerable effect on the configuration selection, especially for high slopes. Configuration #1 with the pump on the upper farm side may improve B/C. Configuration #2 improves the B/C due to increase in the land slope up to 2.0%. Therefore, Configuration #1 with the pump station at the farm's center is not always the optimum configuration for inclined lands.

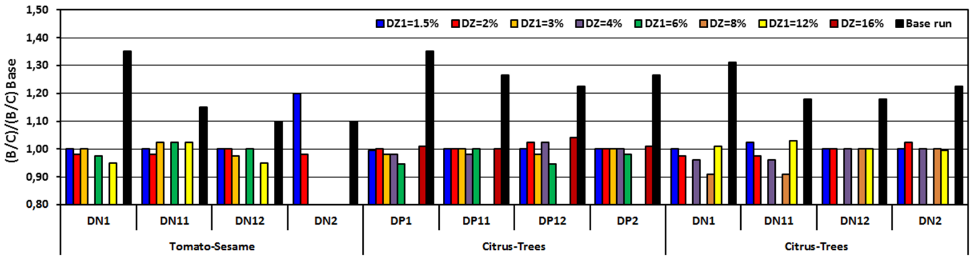

Fig. 5. Effect of land topography on the BCR.

3) Climate and Wind Conditions

The effects of different Climate Zones (CLZ) and Wind Speeds (WS) on the BCR of tomato-sesame crop rotation and long-life citrus trees are shown in Figure 4. It should be noted that there is no effect of WS on the BCR of drip irrigation systems. In addition, the effect of climate on the B/C is negligible for line-source, and small (3.0%) for point-source. Climate has a negligible effect on the configuration's selection. Therefore, it is preferable to use drip systems in hot climate and high wind speeds.

4) Water Source Quality Conditions

The effects of water source quality and type on the BCR of tomato-sesame crop rotation and citrus trees long-life plantation are shown in Figure 6.

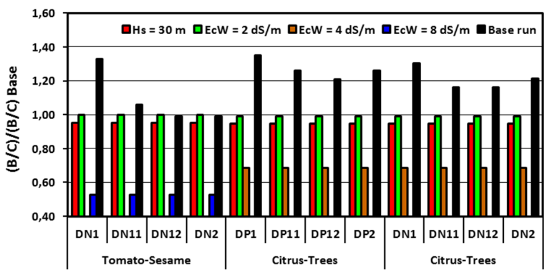

Fig. 6. Effect of water source quality on BCR.

It can be noted that the effect of water quality on the BCR of line-source and point-source drip systems depends on the salt concentration in the irrigation water. This effect is negligible if the salt concentration approaches the lower limit of the crop salt tolerance range, ECe_{min}, (2.5dS/m for tomato and 1.7dS/m for citrus, [52-55]). When the salt concentration increases to approach the upper limit of the crop salt tolerance range, ECe_{max}, (12.5dS/m for tomato and 8.0dS/m for citrus, [52- 55]), the system costs increase and the crop yield decreases [56-59]. The reduction in the BCR may be more than 45% with EcW = 8.0dS/m for tomato-sesame and more than 30% with EcW = 4.0dS/m for citrus trees. The BCR reduces about 5% to 35% due to increase in the suction head from 6.0 (base run) to 30.0m. Water source quality and type have a negligible effect on the selection of system configurations or laterals' direction.

5) Farm's Size and Shape

The effects of different farm areas and dimensions on the B/C of long-life citrus trees are shown in Figure 7. It can be noted that the effects of farm area and dimension ratio on the BCR of point-source drip system are small. The resulting changes in the BCR due to the farm partition are not bigger than 4.0%. The best improvement in the BCR was obtained with L/B ratio within 1.18-1.27 (L/2×B/2 and L/3×B/2) and farm area within 8.82-13.23ha. Further, farm partition has a small effect on the selection of system configurations and laterals' direction. For the same farm dimension ratio, L/B, (L×B/2 and L/2×B/4) and different farm areas (26.46 and 6.615ha, respectively), B/C improves by less than 1.0%. Therefore, the farm area has a negligible effect on the BCR of the point-source drip system. Further, the base run farm area remained constant (52.92ha) and the L/B ratio changed. The used dimension ratios, L/B, are 1, 1.5, 2.0, 2.5, and 3.0. The effects of L/B ratio on the base run B/C of tomato-sesame and citrus are shown in Figure 8. It can be noted that the effect of farm dimension on the BCR is negligible. The BCR changes by less than 2.0%. The best L/B ratio is less or equal to 1.5. Also, the farm dimension ratio has a negligible effect on the selection of system configuration and laterals' direction.

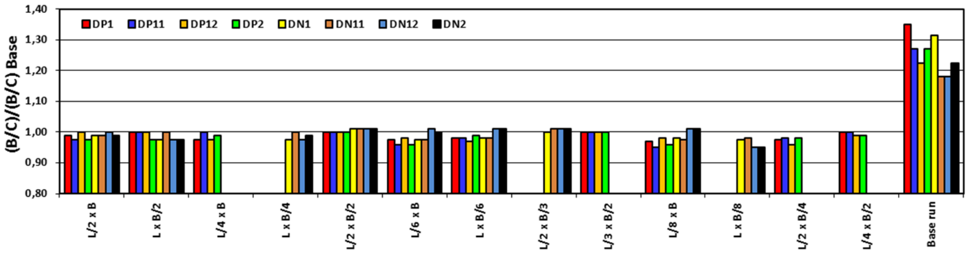

Fig. 7. Effect of farm partitioning on the BCR of long-life citrus trees.

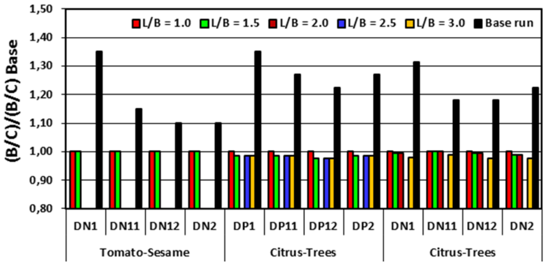

Fig. 8. Effect of farm dimensions on the BCR.

B. Effect of Different Economic Conditions on the BCR

1) Real and Nominal Interest Rates

Interest rates are often categorized as real or nominal. Nominal rates are the current rates of interest charged by the lending institution that will provide credit [60-61]. The rate includes an inflationary component and a risk, management, and profit component. The real rate is inflation-free, therefore, it is less than the nominal by the long-term inflation rate. The real rate is used to determine the annualized cost of capital expenditures such as land value and permanent land improvements (land-leveling). Nominal rate is used to determine the annualized cost of capital expenditures that depreciate or reach technical obsolescence with little or no salvage value. The effects of real and nominal rates on the B/C of tomato-sesame and citrus are shown in Figure 9.

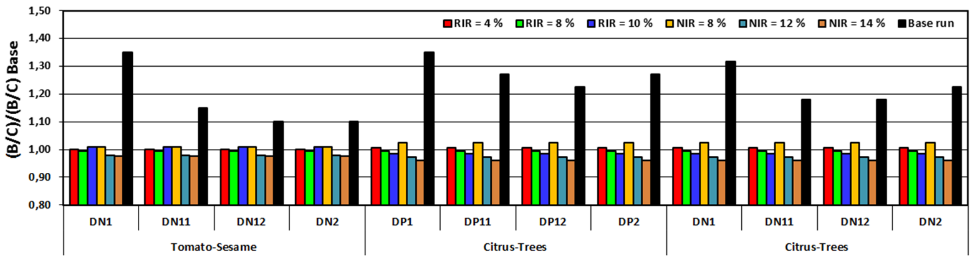

Fig. 9. Effect of real and nominal interest rates on the BCR.

It can be seen that the effects of real and nominal interest rates on the BCR of the drip irrigation system depend on their values. The effects of real and nominal interest rates on the selection of system configuration and laterals' direction are negligible for the drip systems. The BCR increases as the real and nominal interest rates decrease. The nominal interest rate has a higher effect on the BCR than the real rate due to the high values of construction elements compared with the land price.

2) Raw Land Price

The effects of raw land price on the BCR of tomato-sesame crop rotation and long-life citrus trees plantation are shown in Figure 10. It can be noted that the effect of raw land value on the B/C depends on the land price. The BCR increases as the raw land price decreases. There is no effect for raw land price on the selection of system configuration or lateral lines' direction. The effect of raw land price on the BCR of line-source and point-source systems is approximately the same (about 2.6% for every 1000US$/ha increase).

3) Energy and Labor Escalation Rates

The effects of energy and labor inflation factors on the BCR of tomato-sesame crop rotation and long-life citrus trees are shown in Figure 11. It can be seen that the effect of energy and labor inflation rates on the BCR depends on their values. The BCR increases as the inflation rates decrease. There is no effect for the energy and labor inflation rates on the drip system configuration or laterals' direction. There is no effect for labor inflation rate on the BCR of drip systems. The effect of energy inflation rate on the BCR of the line-source and point-source drip systems is small and approximately the same (1.0% for every 1.0% inflation rate).

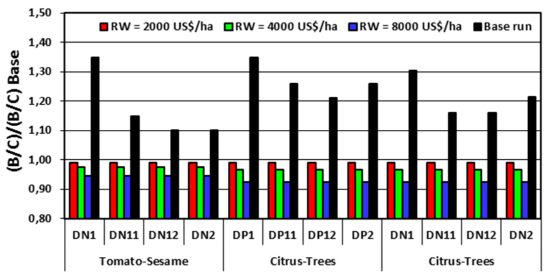

Fig. 10. Effect of raw land value on BCR.

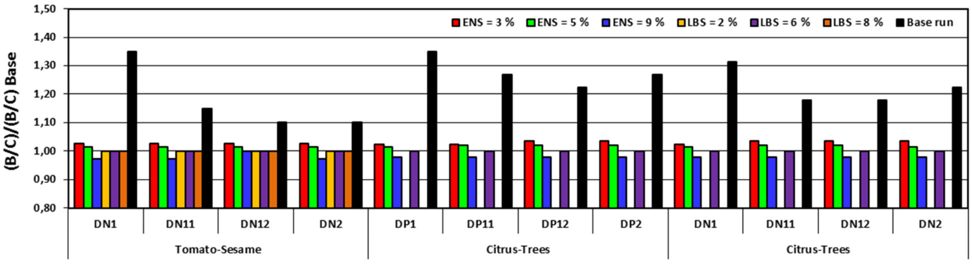

Fig. 11. Effect of energy and labor escalation rates on BCR.

The conducted analyses through the present study for different environmental and economic parameters (Tables III and IV) are summarized in Table V. Environmental and economic analyses were conducted based on the BCR for tomato-sesame crop rotation and long-life citrus trees cultivation.

IV. CONCLUSION

The outcome of this study is based on the environmental and economic parameters of cultivating farms using the TISD software to fulfill the needs of the irrigation agencies and engineers. The TISD model was used to select the drip system's configuration type that could potentially meet the desired economic goal of BCR. The effect of the soil type on the BCR and the configuration selection and laterals' direction are considerable for line-source and negligible for point-source. The soil type has a negligible effect on the selection of system configuration for all drip systems. The effect of land slopes on the BCR depends on the slope direction with laterals and pump position. For the same slopes, it is preferable to arrange the point-source's laterals on the small slope and put the pump on the upper farm side. Also, the land slope has a considerable effect on the configuration's selection of drip systems, especially with high slopes. The effect of high wind speeds on the B/C is negligible for the drip systems. The effect of climate on the BCR and the selection of configuration and lateral's direction is negligible for line-source and small for point-source. The effect of irrigation water on the BCR and configuration' selection of drip systems is negligible up to the lower limit of the crop salt tolerance. The effect of water source type on the BCR and selection of configuration and laterals' direction is small for drip systems. So, it is preferable to use drip systems with groundwater sources. The effect of farm partition on the BCR and configuration selection of the drip systems is very small. The effects of real and nominal interest rates on the BCR and configuration' selection depend on their values. The nominal rate has a higher effect than the real rate on the B/C due to the higher installation cost. Also, the nominal rate has a higher effect on the BCR of drip systems due to their initial installation cost. The effect of raw land value on the BCR depends on the land price. The effect of land value on the B/C of drip is negligible on the selection of system configuration or laterals' direction. The effect of energy and labor inflation rates on the BCR depends on their values. There is no effect for the energy and labor inflation rates on the selection of system configuration or laterals' direction. There is no effect for the labor inflation rate on the BCR of drip systems. The effect of energy inflation rate on the BCR of the line-source and point-source drip systems is small and approximately the same (about 1.0% for every 1.0% inflation rate).

TABLE V. EFFECT OF DIFFERENT ENVIRONMENTAL AND ECONOMIC CONDITIONS ON BCR

No.	Parameters	Drip sys. type	Drip sys. effect	Configuration effect	Lateral direction effect
1	Soil texture	L-source	High	No	-
		P-source	Very small	Negligible	-
2	Land topography	L-source	Small	Small	-
		P-source	High	High	High
3	Climate zone	L-source	Negligible	Negligible	-
		P-source	Small	Negligible	Small
4	Wind speed	L-source	No	No	-
		P-source	No	No	-
5	Water quality	L-source	Very small	No	-
		P-source	Very small	Negligible	Negligible
6	Water source type	L-source	Small	No	No
		P-source	Small	Negligible	Negligible
7	Farm Area	L-source	Very small	Negligible	
		P-source	Small	Very small	Small
8	Farm dimension	L-source	Negligible	Negligible	-
		P-source	Very small	Negligible	Negligible
9	Interest rates	L-source	Small	No	-
		P-source	Considerable	Negligible	Negligible
10	Raw land cost	L-source	Small	No	-
		P-source	Considerable	Negligible	Negligible
11	Energy escalation	L-source	Small	Negligible	-
		P-source	Small	Negligible	Negligible
12	Labor escalation	L-source	Very small	Negligible	-
		P-source	Negligible	Negligible	Negligible

Negligible	0.0 < Effect < 1.0 %	Considerable	5.0 < Effect < 10.0 %
Very small	1.0 < Effect < 2.0 %	High	10.0 < Effect < 20.0 %
Small	2.0 < Effect < 5.0 %	Very high	Effect > 20.0 %

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