Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN NO. 2320-5407

Article DOI:10.21474/IJAR01/17978
DOI URL: http://dx.doi.org/10.21474/IJAR01/17978

RESEARCH ARTICLE

THE IMPACT OF CANALS REHABILITATION AND CONTINUOUS FLOW SYSTEM ON APPLICATION OF MODERN IRRIGATION SYSTEMS IN EGYPT

Magda Salah Mohamed[1], Hoda Kamal Soussa[2], Nagy Ali Ali Hassan[2] and Talaat Tahir El Gamal[1]

1. Water Management Research Institute, National Water Research Center, P.O. Box 13621/5, Delta Barrage, Cairo, Egypt.
2. Department of Hydraulics and Irrigation, Faculty of Engineering, Ain Shams University, Egypt.

……………………………………………………………………………………………………....

Manuscript Info

……………………….

Manuscript History
Received: 10 October 2023
Final Accepted: 14 November 2023
Published: December 2023

Key words: -
Modern Irrigation System, Canal Rehabilitation, Continuous Flow, Water Distribution System

Abstract

………………………………………………………………

With The intent of Ministry of Water Resource and Irrigation in Egypt to apply the modern irrigation system in the old land, it is important to understand the impact of canals rehabilitation and water distribution system on such application. The study investigated such impact through studying two canals, the first canal (Branch # 11) in West Delta, and the second canal (Dakalt canal) in Middle Delta. The study discussed the accurate application of the continuous flow based on the experiences of the developed countries, and it used the simulation model (HEC-RAS) to test the ability of both canals to convey the required water under different water abstraction scenarios. These scenarios were irrigating throughout the whole time, through the whole days of “On”periods. Both systems worked properly for the first two scenarios, while there was aproblem in the third scenario. The discussion highlighted that accurate application of the continuous flow requires enhancing the performance of the irrigation network, besides precise calculation of water requirements. The study conduct that adapting water distribution system before applying modern irrigation system is essential to avoid the failure of such application.

……………………………………………………………………………………………………....

Introduction:-

Irrigation challenges in Egypt

Egypt is one of the countries facing great challenges, due to its aridity and fixed share of limited Nile water. According to (**Radwan G. 2020**) the water resources in Egypt are suffering from water stress due to the limited supplies and the rapidly growing population, which consequently increased water demand for public water supplies. Water share per capita was around 1000 m^3 in 2000 and it is projected to reach 534 m3 by 2030 (**FAO, 2014**). An additional difficulty for Egypt's water resource management is the anticipated effects of climate change on the River Nile Basin and its flows. To face such challenges, it is essential to define the optimal allocation of water resources, to improve water and land productivity and to enhance the overall irrigation efficiency. According to (**Karajeh,etal.2013**) the flood irrigation system, which is the most used system in Egypt, representing 60% of the total irrigated area, and its efficiency ranges between 40 and 50%. They recommended to expand the application of modern irrigation systems as a strategy to achieve the objectives of sustainable development strategy 2030, which aimed to adopt the integrated water resources management approach. The modern irrigation system plays an important role in improving irrigation efficiency and water application uniformity **(Negm, 2019**).

Corresponding Author:- Magda Salah Mohamed
Address**:-** Water Management Research Institute, National Water Research Center, P.O. Box 13621/5, Delta Barrage, Cairo, Egypt.

Based on (**M.A.M. Moursy, et al.2023**) Egypt is suffering from water scarcity, it is of great importance to apply modernirrigation techniques to achieve highest productivity with optimum water consumption and improve the irrigation system efficiency from 40 to 80%.

For these targets, the Ministry of Water Resources & Irrigation (MWRI) has started a Mega project for applying pressurized irrigation systems (modern irrigation) in the old lands. the newly reclaimed land must apply the pressurized irrigation system as it was designed for applying such system.

Modern Irrigation System

Impact of applying modern irrigation systems

To effectively tackle the issue of increasing irrigation water scarcity, farmers need to convert to modern irrigation systems with lower water use while achieving higher yields and profitability (**Dorna Jahangirpour et.al 2022)**. Applications of modern micro-irrigation methods are inevitable for optimum water use due to the limitations imposed by irrigation water resource scarcity (**Mishari A. Elnaim et al 2022).**Modern irrigation systems benefit for individual farmers and also be beneficial for the national economy by increasing the productivity of land units and achieving optimal use of social resources. In addition, it could lead to the efficient use of agricultural water, which is one of the most significant challenges in this time(**Mahmoud A. Ahmed2023)**. Based on a study conducted by **Water Management Research Institute**on different region in Egypt, the following results were obtained.

There was a decrease in water application for different crops. The decrease ratios were between 14% and 32% for the summer crops and between 12% and 25% for winter crops (Table1).

Table 1:- Amount of water (m3/fed) for summer& winter season.

Amount of water (m3/fed) for modern irrigation system & surface irrigation system					
Summer crops			**Winter crops**		
Crop	Modern Irrigation System	Surface Irrigation System	Crop	Modern Irrigation System	Surface Irrigation System
Maize	1520	2230	Wheat	1800	2300
Summer Tomato	3540	4100	Winter tomato	2400	3210
Egg plant	3040	3550	Egg plant	3640	3810
			Onion	2010	2300
			Green bean	1680	1917

There was an increase in the productivity for different crops. The increase ratios were between 19% and 39% for the summer crops and between 19% and 25% for winter crops (Table2).

Table 2:- Productivity (ton/fed) for summer & winter crops.

Productivity (ton/fed) for modern irrigation system & surface irrigation system					
Summer crops			**Winter crops**		
Crop	Modern Irrigation System	Surface Irrigation System	Crop	Modern Irrigation System	Surface Irrigation System
Maize	3.2	2.7	Wheat	3.2	2.57
Summer Tomato	30	19	Winter tomato	37	31
Egg plant	25	18	Egg plant	24	20
			Onion	18	15

There was a decrease in the expenditure with an increase in the net return. Regarding the expenditure, the decrease ratios were between 38% and 57% for summer crops and between 35% and 58% for winter crops. Regarding the net return, the increase ratios were between 6% and 10% for the summer crops and between 11% and 14% for winter crops (Table 3).

Table 3:- Total cost and net return (LE/fed) for summer crops.

Total expenditure & net return for modern irrigation system & surface irrigation system									
Summer crops					**Winter crops**				
Crop	Expenditure (LE/fed.)		Net Return (LE/fed.)		Crop	Expenditure (LE/fed.)		Net Return (LE/fed.)	
	Modern Irrigation System	Surface Irrigation System	Modern Irrigation System	Surface Irrigation System		Modern Irrigation System	Surface Irrigation System	Modern Irrigation System	Surface Irrigation System
Maize	6350	7000	6200	4500	Wheat	7550	8800	7550	5550
Summer Tomato	28000	30000	12500	8200	Winter Tomato	31070	28650	12380	9165
Cucumber	14800	16500	13650	8700	Egg plant	20400	23050	12150	7700

Based on collected information, farmers prefer modern irrigation systems due to their influence on productivity growth and reduction of various agricultural inputs (fertilizer, labor, irrigation cost). The factors also include weed control and improving irrigation efficiency.

Modern irrigation application requirements

To ensure the successful application of modern irrigation systems and to capture the expected benefits of such application, the operation of the irrigation system should be adapted to be suitable for such application. The success of any irrigation system depends on being a demand-based system, which means its ability to deliver water to the user at the appropriate time and with the required amount. Achieving such a target depends on having a rehabilitated irrigation system with a precise operation system. These two items, with the institutional reform, constitute what is called irrigation modernization. Based on (**Plusquellec, 2002)**, irrigation modernization is a process of rehabilitation of irrigation systems during which substantial modifications of the concept and design are made to take into consideration the changes in techniques and technology and to adapt the irrigation systems to the future requirements of operation and maintenance. Delivery of water should be as flexible as possible, with demand irrigation being the ideal solution." Among the previous components of irrigation modernization, operating the system could be the core element. Based on (**Renault D. et al., 2007**) In Asia, the FAO regional irrigation modernization program concerning more than 30 irrigation systems highlighted inadequate attention to canal operation as a major reason for disappointing results and underperformance." The operation should be shifted from supply to service-oriented that want to improve the flexibility and reliability of water supply.

(**Talaat, 2008**) In Egypt, during the implementation of Irrigation Improvement Projects, as a type of irrigation modernization, there was an attempt to change the operation of the irrigation canals from a rotation system to a continuous flow system, as a service-oriented system. However, the application of the system failed as it was associated with no calculations of water requirements or with an arrangement of water abstraction inside the improved canals. Moreover, with the existence of some critical points in the network, such as municipal intakes on the main canal, the irrigation directorates tend to close to the branch canal to satisfy the required water levels at these points. The degradation of the irrigation network was an additional element that diminishes the precise operation of the irrigation system and in consequence, makes it difficult to apply the modern irrigation systems.

International Experience about Operating the Irrigation Systems

The operation of the irrigation systems in most developed countries depends on "service – oriented" concept and the main indicator is the flexibility of providing the irrigation water with the required amount at the required time. Regardless of the differences between the irrigation systems in the developed countries, the common point between them is the precise operation of the system. Considering two examples, which are Japan and the USA, there are many differences including average land tenure size, the lining of the irrigation canals and subsides of the country.

However, in both countries, the systems are operated by elected associations that hire technical staff to operate the systems. In Japan, the water is released to different canals based on collecting the requests for irrigation from different farmers. The technical staff check these requests and the farmer should receive the water on the following day of his request **(M. Satoh and Ishii, 2021)**. The next figure depicts the procedure of water distribution in a typical irrigation district in Japan.

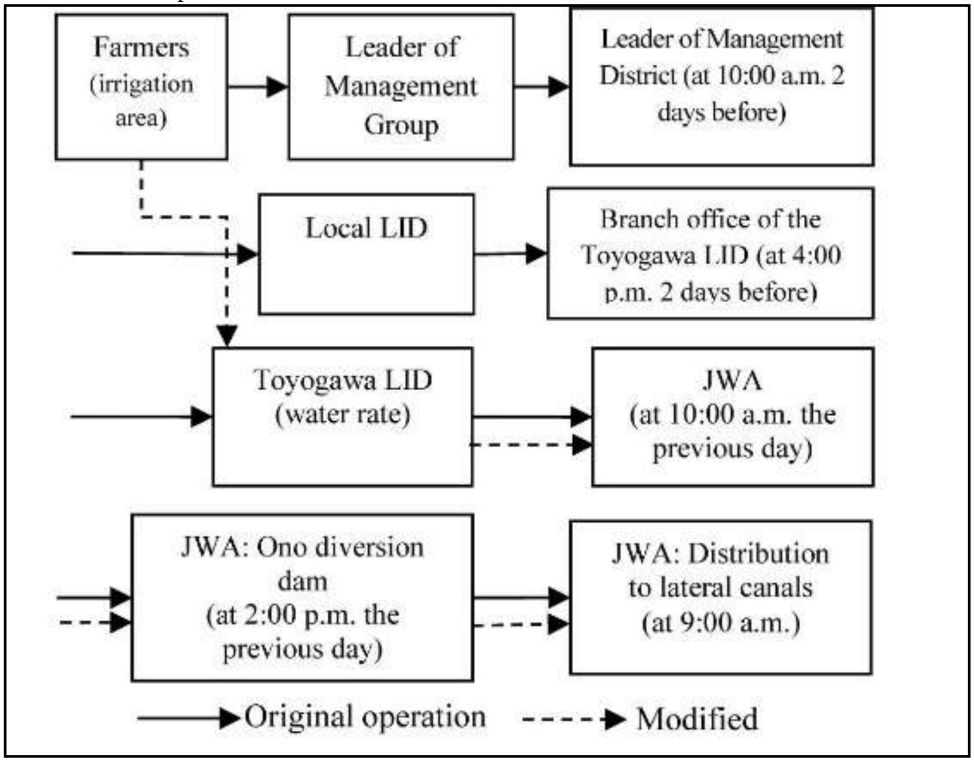

Figure 1: - Mechanism for promoting farmer coordination in irrigation projects.

In the USA, instead of depending on precise regulations, the model focuses on improving measurement devices and monitoring system in order to improve the flexibility and the reliability of water supply. (**Plusquellec, 2002)** stated, "Many of the canal irrigation systems in the United States are far from having been modernized. Farmers, however, enjoy flexibility in flow rates. The flexibility in delivery can be offered because of excellent communications, high mobility of staff, high density of turnouts and judicious use of proper equipment such as weirs, regulating reservoirs and recirculation of excess water through interceptors and numerous applications of remote monitoring through SCADA. There is almost always flow measurement rates at all turnouts."

Study area

The investigated canals include a branch canal in the new land in West Delta (Branch # 11 canal - El-Bostan command area) and a branch canal in the old land in Middle Delta (Dakalt canal – Mit Yazid command area)

Branch #11canal is a part of El-Bostan 1&2 irrigation district, and it is located between 30° 43´ 18.2´ E longitude and 30° 23´ 30.6´ N latitude.

The main canal is El-Bostan canal that off-takes from El-Nobariya canal (km 52.5), and it is total served area is around 125,000 feddan. Branch # 1 Left canal takes off from El-Bostan canal (mm 14.1) behind the third lifting station, and it total served area is around 50,000 feddan. Branch #11 canal is located at the end of Branch # 1 canal. It is 2.20 km long and the total served area is 465 feddan. Around 80% of the cultivated area of Branch # 11 is orchard (citrus & Mango), while common crops constitute a small ratio of the served area. The whole cultivated area of Branch # 1 Left depends on modern irrigation systems. Regarding the operation of the system, Branch # 1 Left is closed two days a week (Saturday and Tuesday). Based on the discussion of the farmers, the water availability is fine at Branch # 11 during most of the year except few periods in summer, although is located at the end of the system. This is likely due to the rehabilitation of the system.

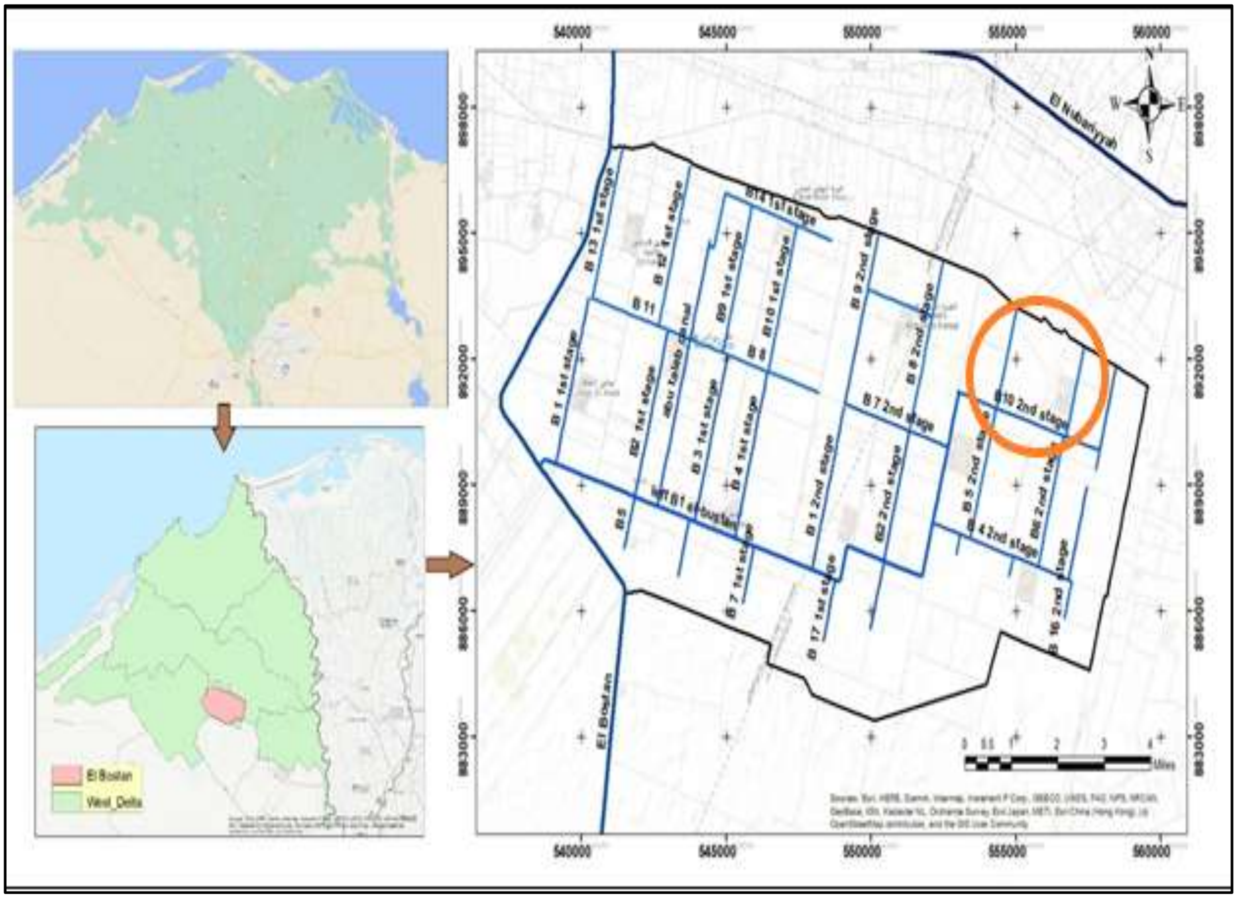

Figure 2: - location map of branch #11 canal.

The design data are shown in the next table.

Location	Bed Width	Top Width		Weir		Bed Level		N			E		
		US	DS	Width	Level	US	DS						
Head	1.00		6.0			14.205	14.185	30	43	18.2	30	23	30.6
First Weir		6.00	6.00	1.20	14.660	14.380	13.390	30	43	42.6	30	23	38.8
Tail End		6.00				11.520		30	44	26.2	30	23	53.3

Dakalt canal off-takes from the right-hand side of Mit Yazid canal (Km 41.070). Mit Yazid canal is 63.0 km long and it serves around 197,000 feddans. Dakalt canal is about 11.4 km long and serves about 5580 feddans. It is served by two drains; No 7 drain on the right-hand side and El-Raghama drain on the left-hand side and it has 19 sub-branches. Figure (3) presents the layout of Dakalt canal. Irrigation improvement project was applied in Dakalt canal, but the canal itself is not rehabilitated and there is an obvious difference between design and actual cross sections in many locations. The main summer crop is rice, which is normally exceed the design quota (50%). During winter, the main crops are sugar beet, wheat and Barseem.

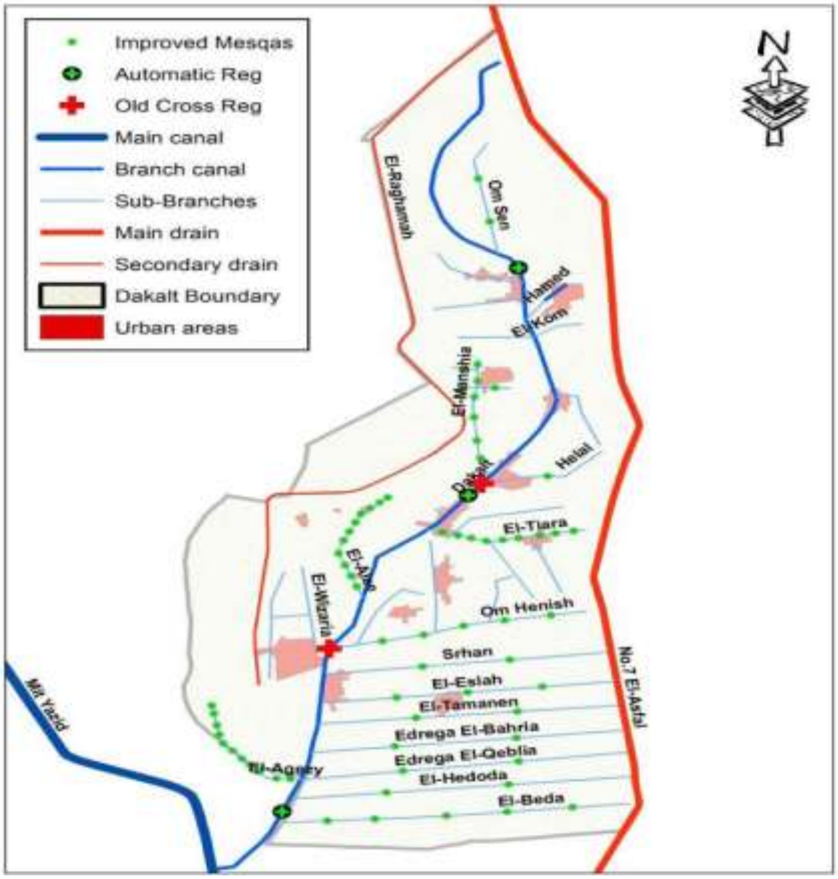

Figure 3: - Dakalt command area.

Regarding the characteristics of both study areas, the impact of applying the continuous flow in Branch # 1 Left and the rotation in Dakalt canal could be observed from the change in daily water supply in both areas.

Figure (4) presents the average daily water supply for Branch # 1 Left. The served area of the canal is around 50,000 feddans. Due to the canal being opened continuously, except two days per week, the daily water supply ranged between 8.0 and 27.0 m^3/fed/day on average. (Saturday and Tuesday). The same trend could be observed at different areas of the irrigation system.

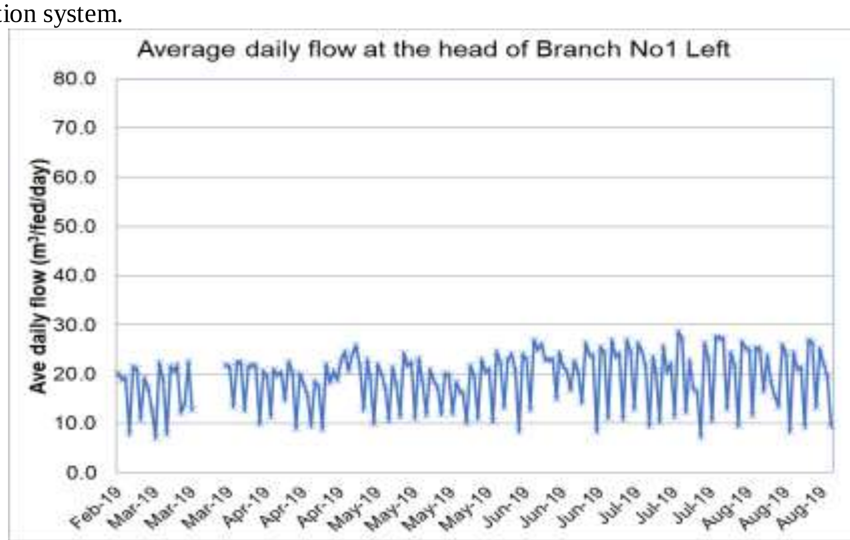

Figure 4: - Average daily flow at the head of Branch No.1 left.

For Dakalt canal, figure (5) presents the average daily water supply in the main canal (DS El-Wasat regulator) and at the head of Dakalt canal. There is a big difference of daily water supply in both canals. The values were almost constant DS El-Wasat regulator during the peak period (~ 40.0 m^3/fed/day) and they gradually decreased at the end of the season. At the head of Dakalt canal, there was a fluctuation with a rotation trend. The highest value was around 70.0 m^3/fed/day. For other periods, the values were fluctuating between 30.0 and 50.0 m^3/fed/day. As the case of the main canal, the values decreased gradually at the end of the season.

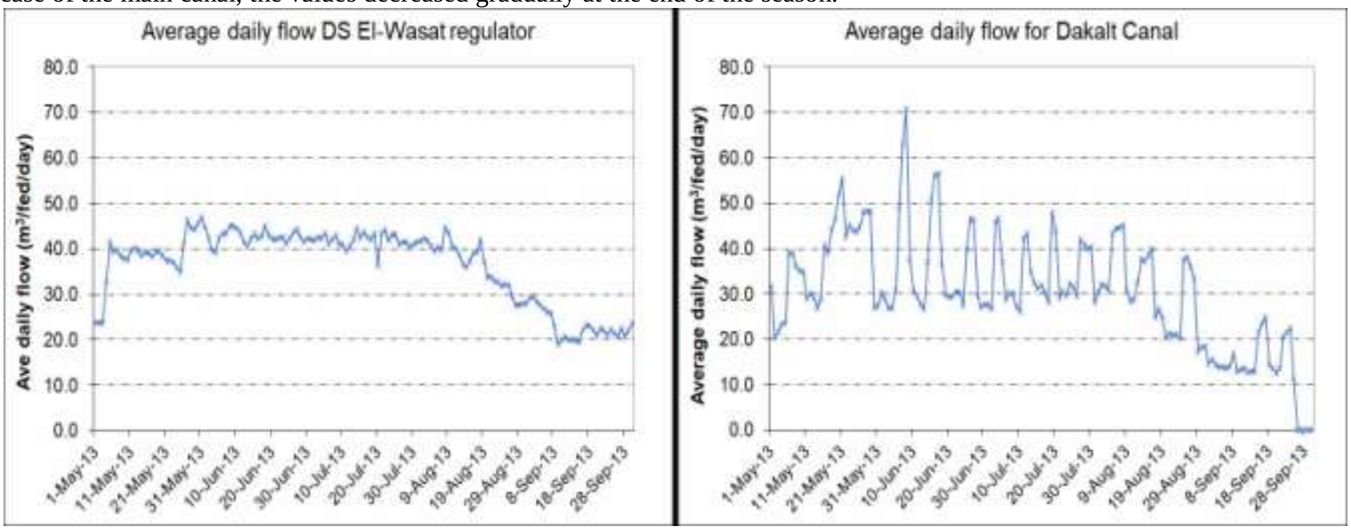

Figure 5: - Average daily flow DS El-Wadat regulator and at the head of Dakalt canal.

Figure (6) presents an example of total water abstraction and the flow at the head of Dakalt canal. Total abstraction values were 0.26 m^3/sec during midnight and 6.7 m^3/sec during afternoon.

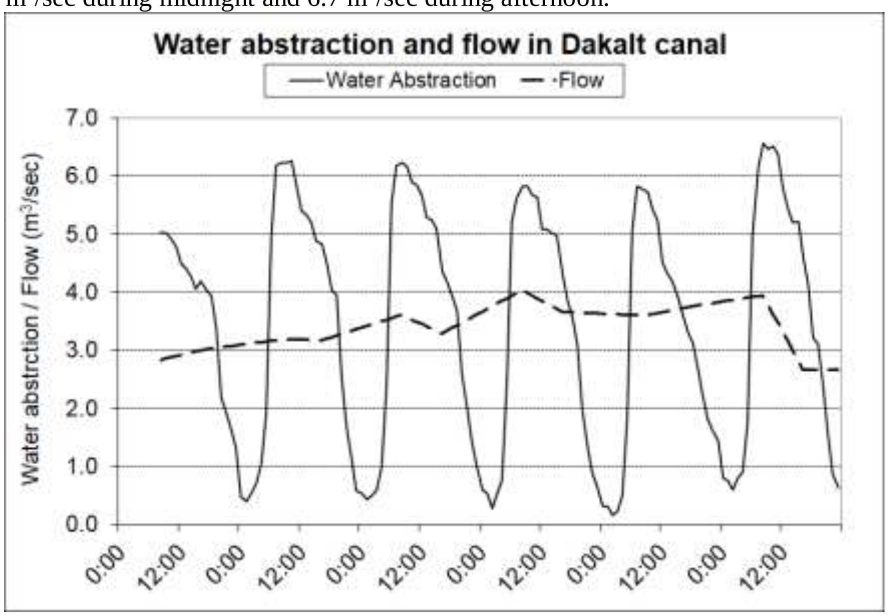

Figure 6: - Water Abstraction and flow in Dakalt canal

Methodology:-

The study aims to investigate the interconnection between canals rehabilitation, modern irrigation system and canals operation system through three steps:

1. In the first step, the operation system of The Branch #11 canal, which is a rehabilitated canal and applying modern irrigation system was investigated and described in detail. The simulation model (HEC-RAS) was used to imitate the system, and after validating the model, it was used to check different scenarios for improving the operation system.

2. The second point is to check the differences between the study area and the regular area in the old lands. The simulation model was used again to imitate the situation in the old lands with its operation strategy and to check the ability to apply a modern irrigation system in such environment.

Simulation Program

River Analysis System (HER-RAS) was developed by the Hydraulic Engineering Center (U.S Army Crops of Engineering). The program performs one-dimensional steady and unsteady flow calculations. Unsteady flow calculation in HEC-RAS is capable of simulating one-dimensional unsteady flow through a full network of open channels. HEC-RAS followed different HEC software programs that began in 1960. Early software packages were HEC-1 (watershed hydrology), HEC-2 (river hydraulics), HEC-3 (reservoir analysis for conservation), and HEC-4 (stochastic stream flow generation program).

For an unsteady flow model, two necessary file types are required:(1) The geometry file contains the necessary physical description of the stream reach including drawing the network, and defining the cross sections, junction and structures (2) The flow file describes all flow inputs and related boundary conditions needed for the unsteady flow analyses.

Geometry data:

Defining the geometry includes drawing the network, and defining the cross sections, junctions and structures as shown in Figures (7&8).

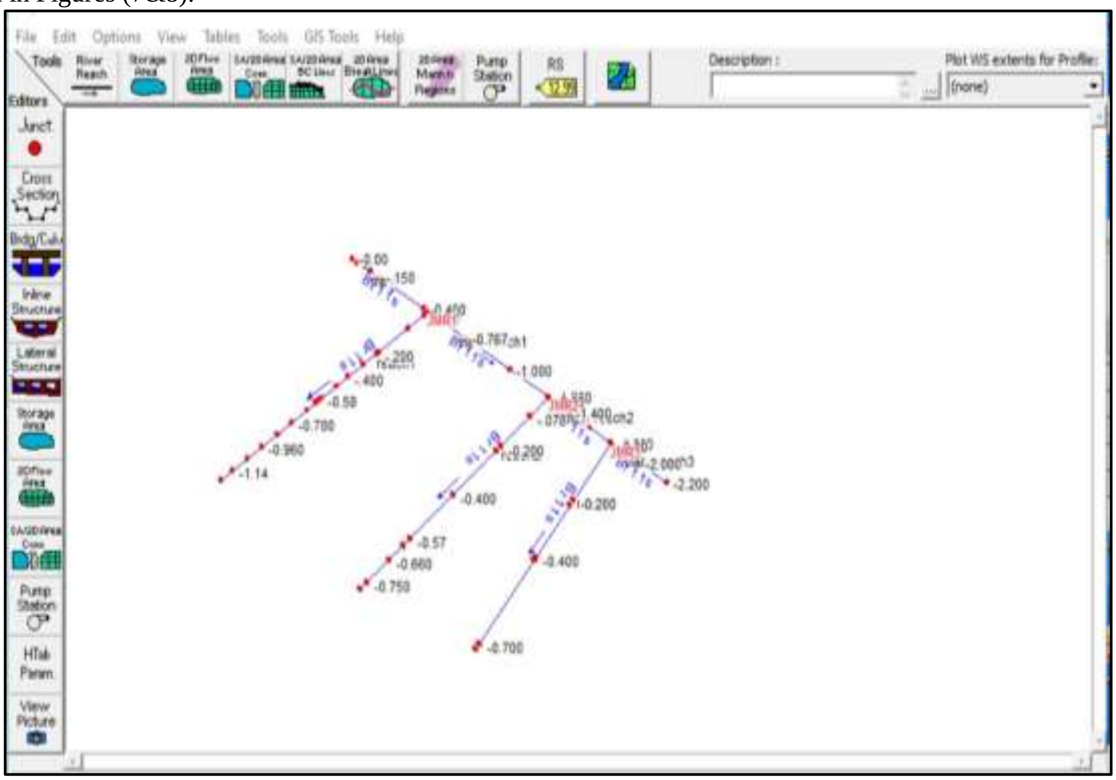

Figure 7: - Schematic drawing of branch #11 and its reaches.

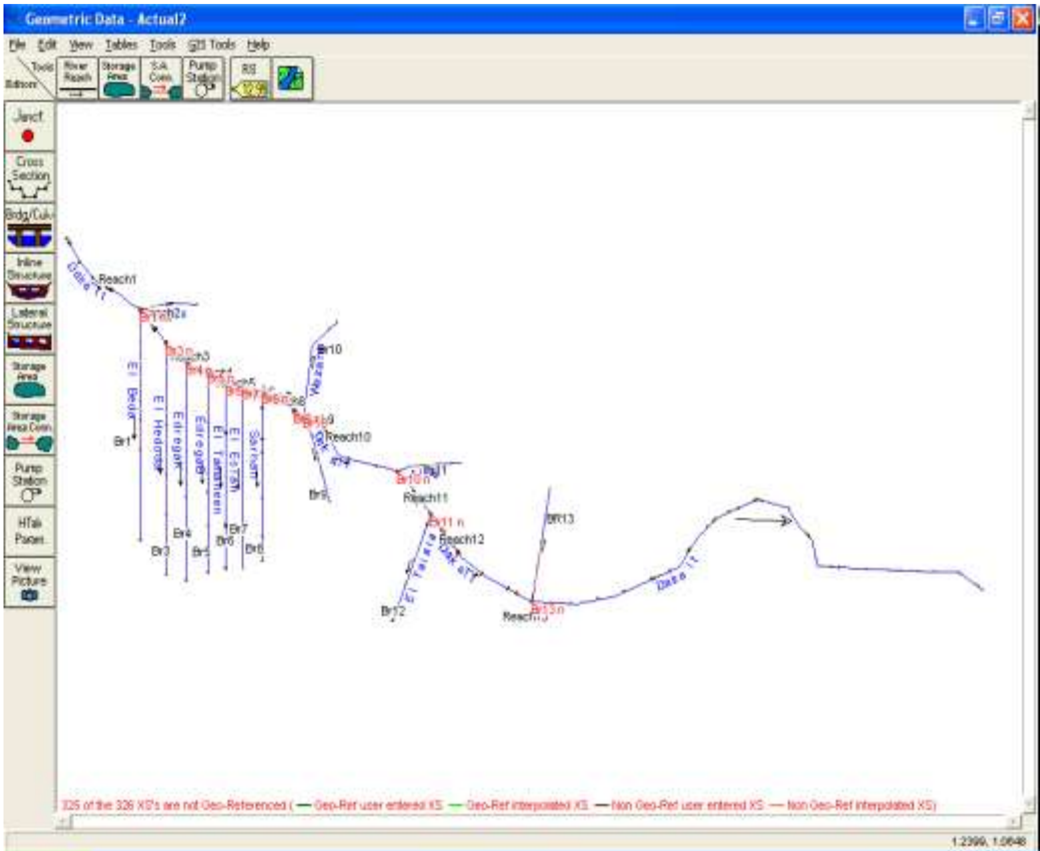

Figure 8: - Schematic drawing of Dakalt canal and its branches.

Boundary conditions and lateral inflow:
In the current study, boundary conditions included upstream boundary at the upstream end and downstream boundary conditions at the downstream end. The consumptions in the canal were defined as lateral inflow boundary condition.

Initial condition:
The default way to define the initial condition in HEC-RAS program is to define the initial discharge at the beginning of each reach. The program uses steady flow calculations to calculate the initial condition (water levels and velocities at different points of the canal).

Calibration the model
Before using the model to check different scenarios for improving the operation system, the model was calibrated to assess the sufficiency/suitability of surveyed cross sections and to define different parameters and coefficients, such as the roughness coefficients for different reaches of the canals. The accuracy of calibration was examined using two performance statistics, which are the Root Mean Square Error (RMSE) and Normalized Objective Function (NOF), as follows:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(p_i - O_i)^2}{N}}$$

$$NOF = \frac{RMSE}{O_{mean}}$$

Where Pi and Oi are the calculated and measured discharge values, respectively; O is the mean of measured values, and N is the number of measurements. Model predictions are acceptable for NOF values in the interval from 0.0 to 1.0 (**Gikas, 2014)**

Results:-

The next figure shows validation results for Branch#11 canal. From the next figure, the correlation coefficient between calculated and measured values was 0.95. RMSE and NOF values were 0.02 and 0.14 respectively.

Date	Measured Discharge (m3/s)	Calculated Discharge (m3/s)
05/08/2023	0.120	0.11
19/08/2023	0.139	0.125
28/08/2023	0.103	0.08
RMSE		**0.02**
NOF		**0.14**

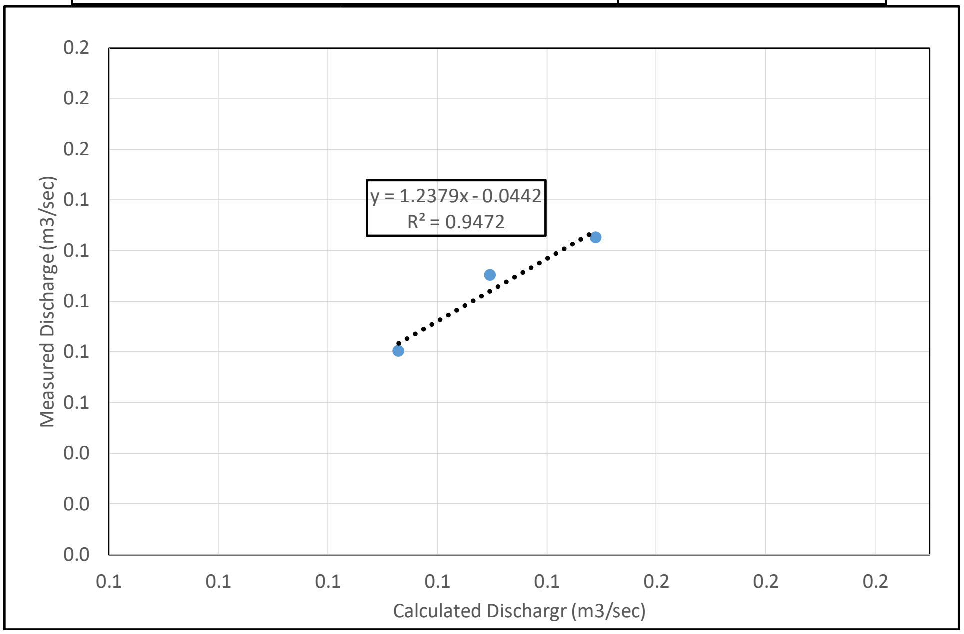

Figure 9:- The regression analysis between the measured and calculated Discharge.

Suggested Scenarios:

Four scenarios were suggested for this study. For the rehabilitated canal, three scenarios were investigated:

1. The first scenario reflects the continuous flow condition. Each lifting point serves four farms, each one is 5.0 feddans. Based on calculated water consumption, each farm requires 5.0 mm/day (84.0 m^3/day - 21.0 m^3/fed/day). The lifting point will rotate between the four farms in four days. Each farm will take a day every four days. As the average capacity of the lifting points is 0.04 m^3/sec. Figure (10) presents the schedule for this scenario, from this figure, each three lifting points will work together for three hours. The twenty-four lifting points will work through the days as in the figure and they will irrigate one-fourth of the study area in each day. The scenario will be repeated for the other three farms on each lifting point in the next three days. The whole area will be irrigated four days.
2. The second scenario reflects the rotation system. A four-day opening and an eight-day closing of the canal are scheduled. The lifting points on the canal will work for twenty-four hours during the day. The schedule will be the same as in the previous scenario, but the abstraction value will be three times the previous value.

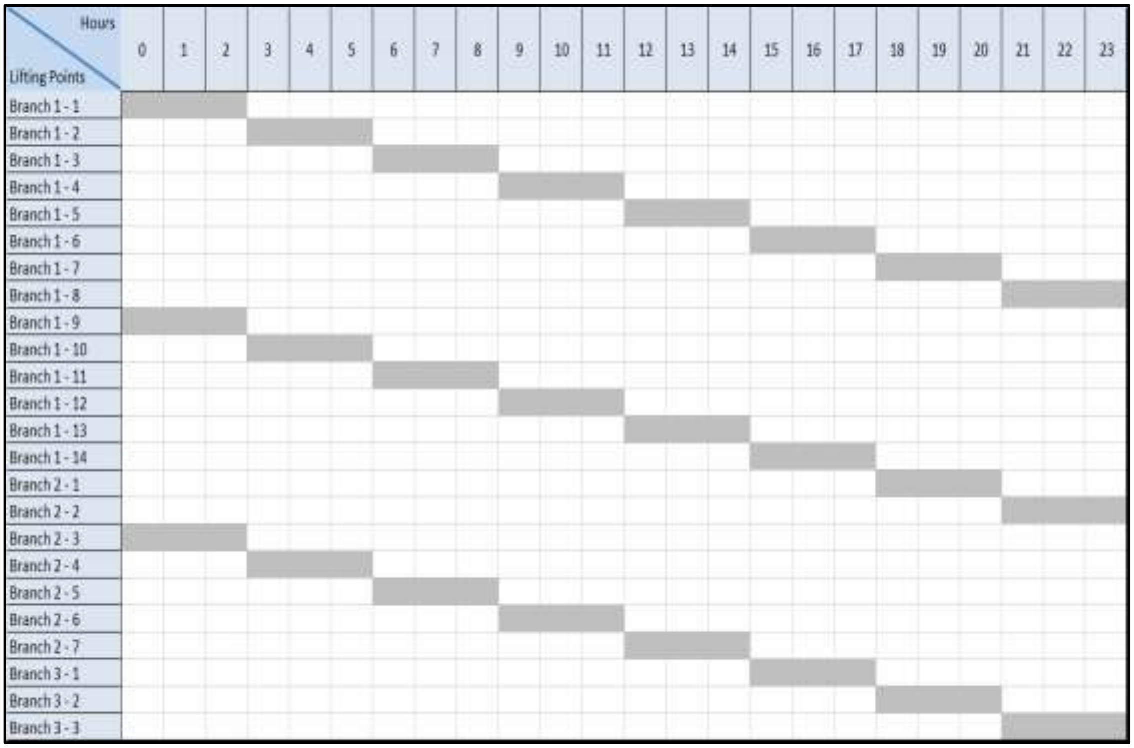

Figure 10: -The schedule for the first scenario.

The third scenario imitates the current conditions in the old lands, where the irrigation activities are concentrated during day hours. The irrigation period in this scenario was between 5:00 AM and 5:00 PM. The concentration of the irrigation was between 8:00 and 11:00 AM. Figure (11) presents the schedule of the irrigation and figure (12) presents total water abstraction through the day.

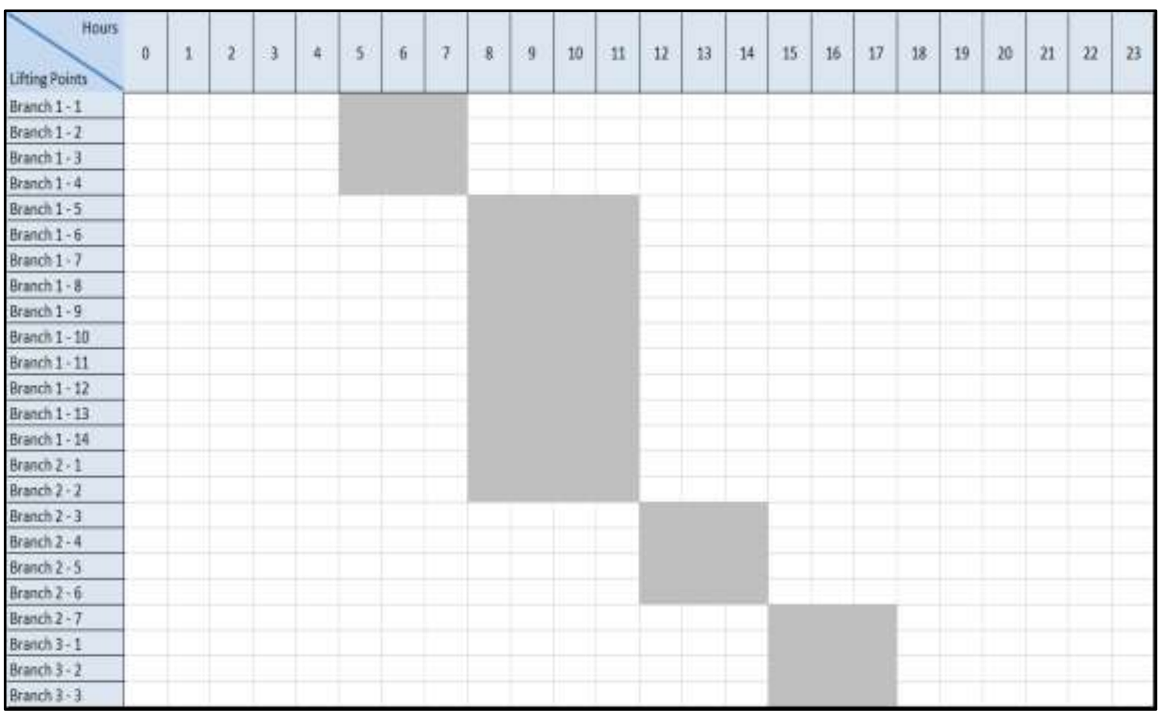

Figure 11: -Schedule for the third scenario for Branch#11 canal.

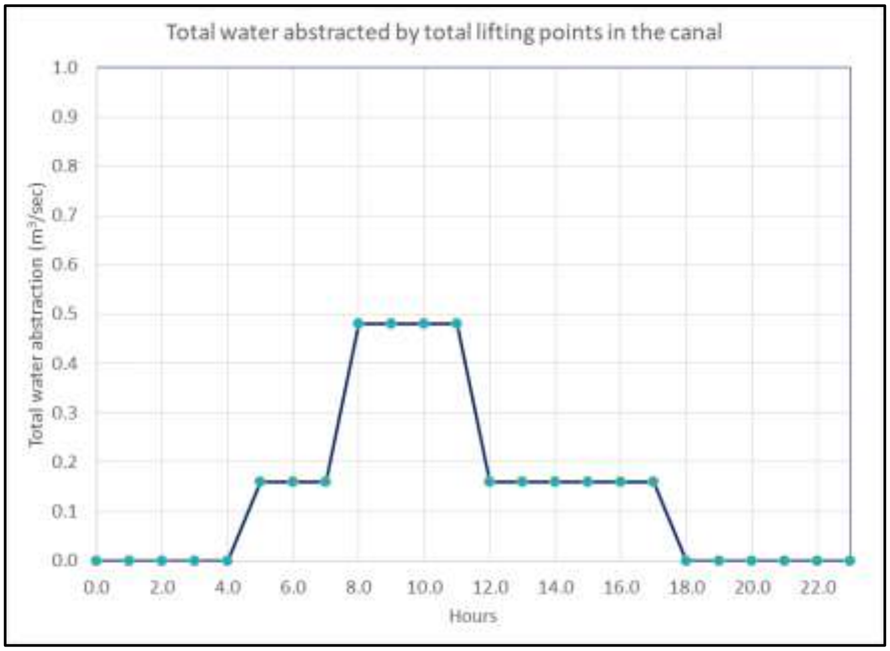

Figure 12: -Total water abstraction for Branch#11.

The fourth scenario reflects the actual conditions in the old lands. The canal is not rehabilitated, the irrigation efficiency is low, which is reflected in higher water requirements, and there is a concentration of irrigation activities during day hours.

First scenario results

Figure (13) presents water levels and flow at the beginning of the first reach (before the first weir) during the simulation period. Neglecting the first period of the simulation, which is affected by the inconsistency between initial values and boundary conditions, water levels are fluctuated between 14.39 and 14.44 m. Flow values were between 0.112 and 0.118 m^3/sec.

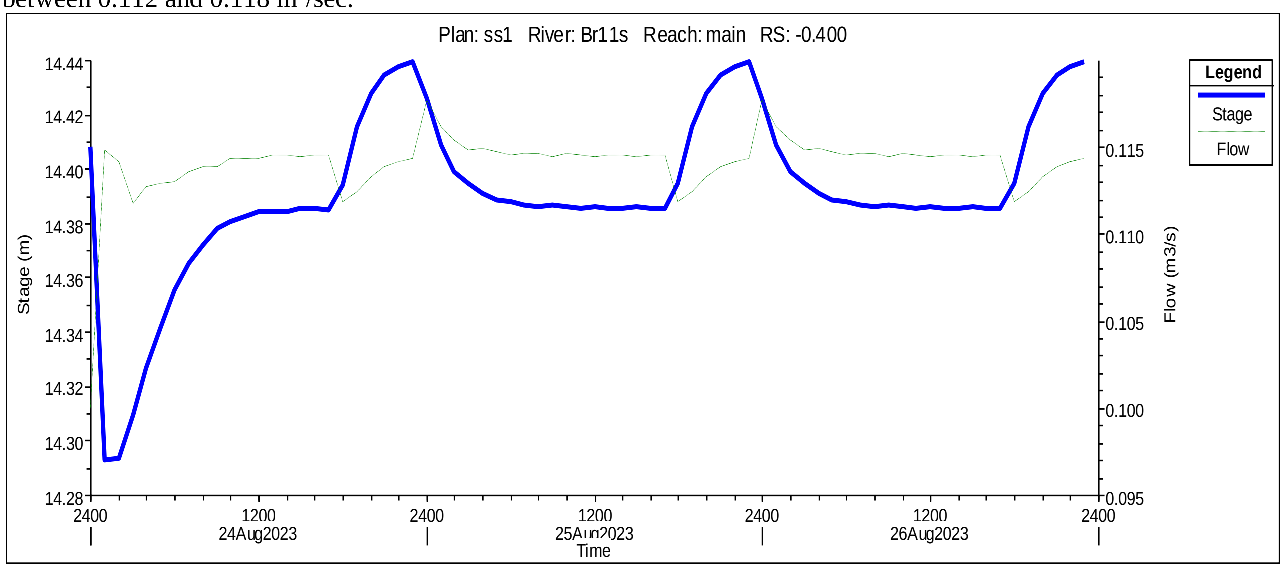

Figure 13: - Water levels and flow at the end of first reach (km 0.4).

At the end of the third reach (before the third reach), and considering the same period of the simulation, water levels were fluctuating between 13.49 and 13.88 m. Flow was fluctuating between 0.0001 (~ 0.0) and 0.029 m^3/sec.

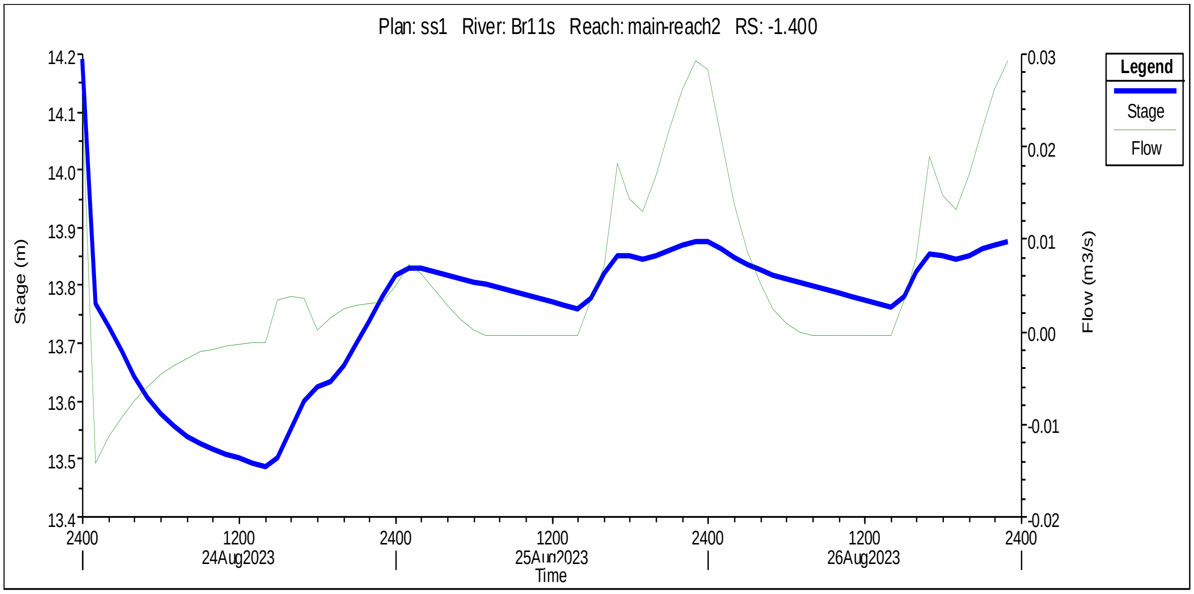

Figure 14: - Water levels and flow at the end of third reach (km 1.4).

Figure (15) presents Water levels through the investigated canal at the end of the first day and at the end of the fourth day. At the end of the fourth day, there is an increase of the levels in the third reach, while there is a significant decrease in the levels in the fourth reach. The levels were almost constant in the first and second reaches.

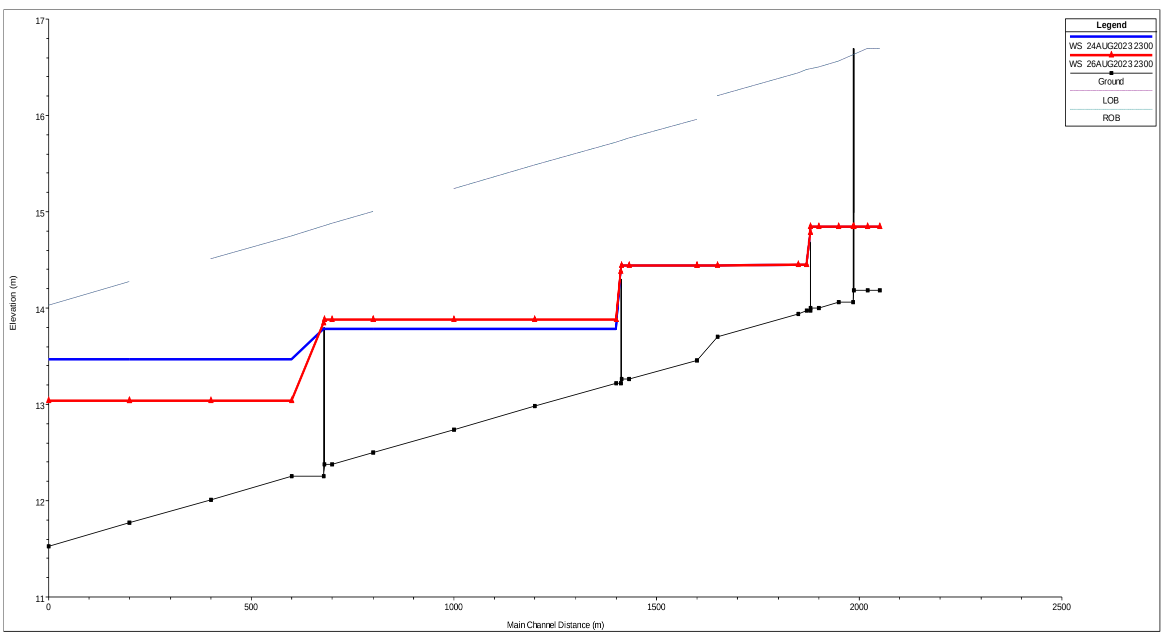

Figure 15: - Water levels through the investigated canal at the end of the first day and at the end of the fourth day.

Second scenario results

The second scenario reflects the rotation period in branch#11. The whole area will be irrigated in four days and the canal will be closed for eight days. Therefore, the daily flow during "on" days was three times the daily flow in the previous scenario. The results showed that the canal can convey the required flow successfully. Considering the same simulation period of the previous scenario, water levels were fluctuating between 14.50 and 14.61 m. Flow values were between 0.36 and 0.37 m^3/sec.

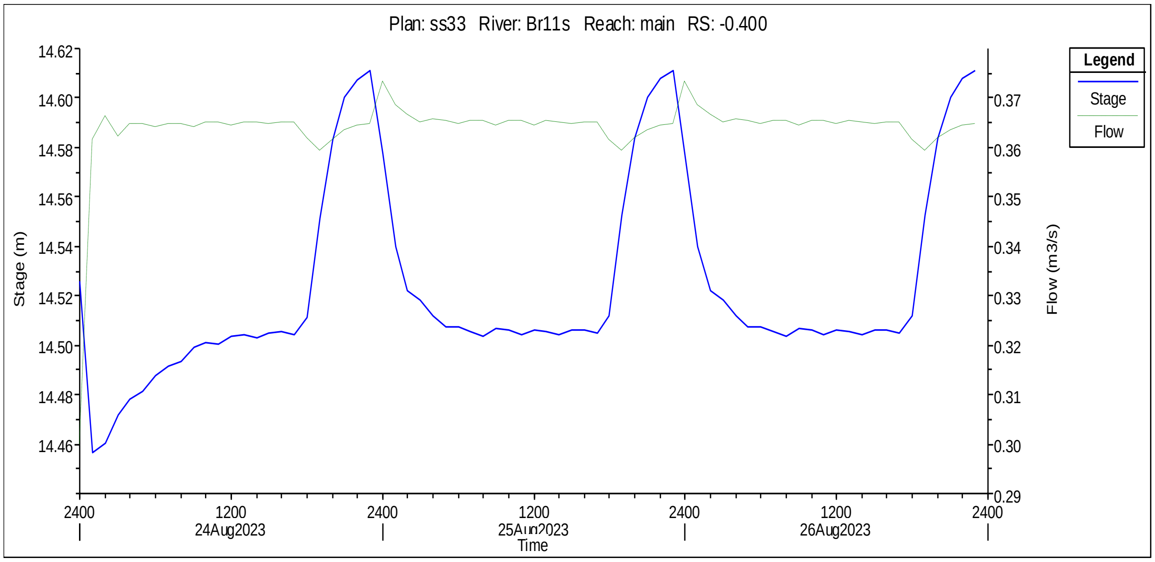

Figure 16: - Water levels and flow at the end of first reach (km 0.4).

At the end of the third reach (before the third reach), and considering the same period of the simulation, water levels were fluctuating between 13.84 and 13.99 m. Flow was fluctuating between 0.0047 (~ 0.0) and 0.12 m^3/sec.

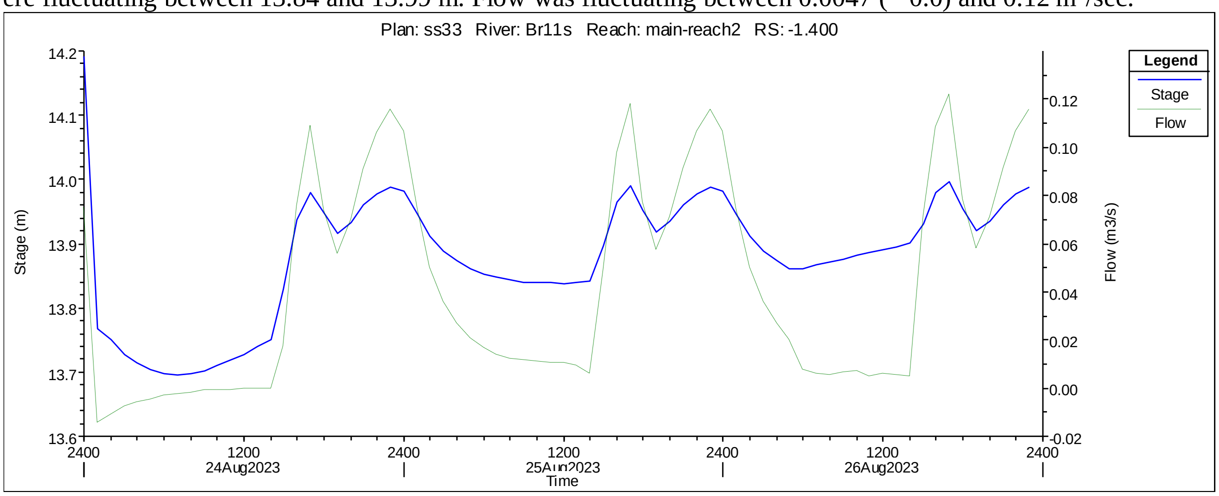

Figure 17: - Water levels and flow at the end of third reach (km 1.4).

Figure (18) presents Water levels through the investigated canal at the end of the first day and at the end of the fourth day. The levels have the same trend of the previous scenario regarding the change from the first day to the fourth day. There is an increase of the levels in the third reach, while there is a significant decrease in the levels in the fourth reach.

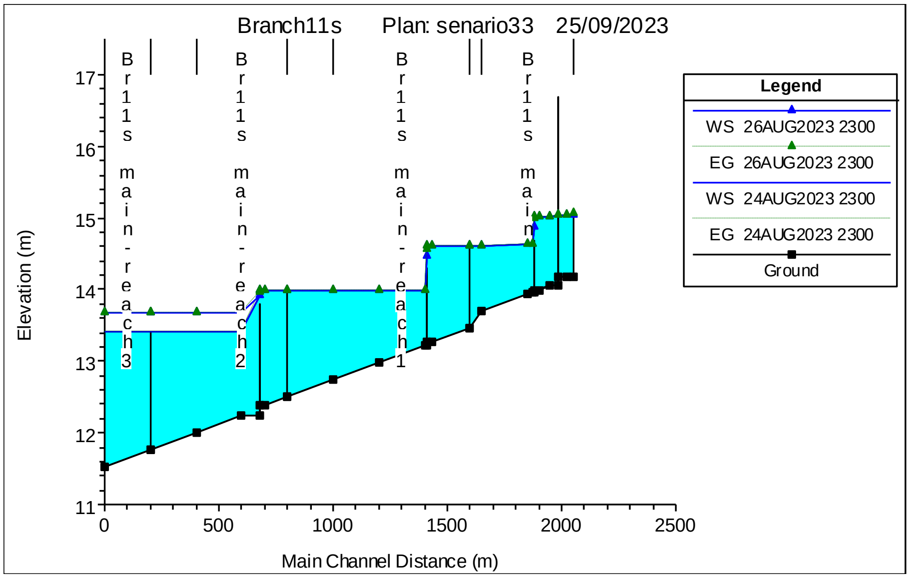

Figure 18: - Water levels through the Branch #11 canal at the end of the first day and at the end of the fourth day.

Third scenario results

The third scenario reflect the case of concentrating the irrigation during day hours in No 11 branch. The canal was not able to convey the required flow and the simulation stopped after the first day.

Fourth scenario results

This scenario depended on the study that was made on Dakalt canal by Water Management Research Institute (WMRI). Figure (19) presents water levels and flow at the beginning of the first reach (before the first weir) during the simulation period. Neglecting the first period, which is affected by the inconsistency between initial values and boundary conditions, water levels were fluctuating between 2.66 and 2.85 m. Flow values were between 4.55 and 5.83 m^3/sec.

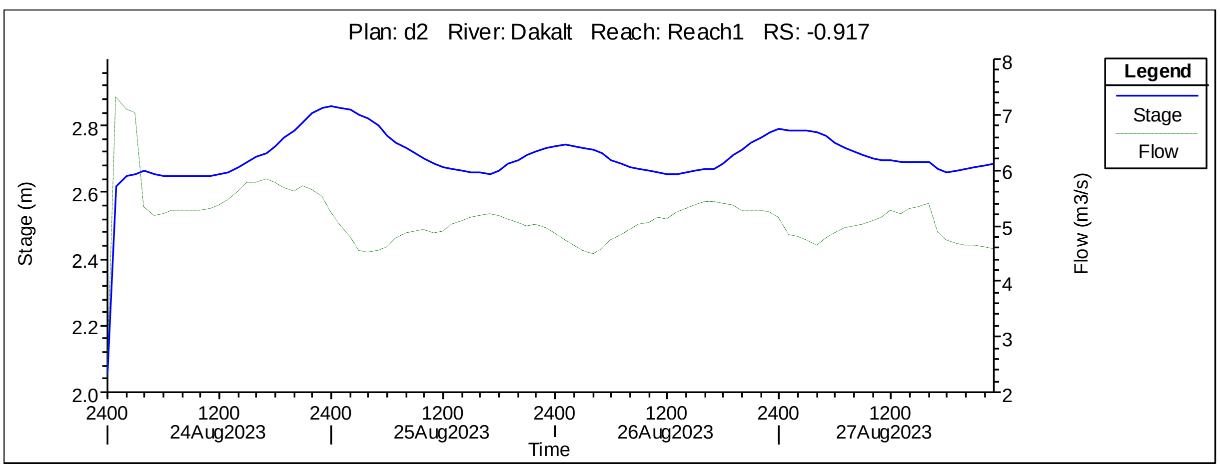

Figure 19: - Water levels and flow at the end of first reach (km 0.917).

At the last reach, and considering the same period, water levels were fluctuating between 1.79 and 1.36 m. Flow was fluctuating between 1.16 and 0.12 m^3/sec

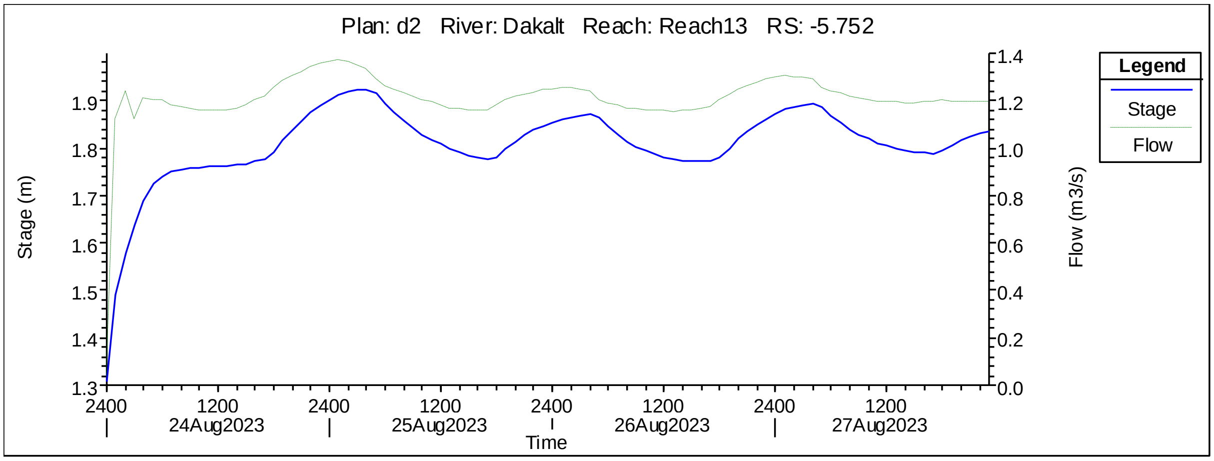

Figure 20: - Water levels and flow at the end of first reach (km 0.917).

Discussion:-

The findings related to the capability of implementing continuous flow in both modern irrigation and surface irrigation systems. While distributing the irrigation throughout the whole day, the cross sections in both cases (El-Bostan & Dakalt) were suitable to convey the required water. This was true in the case of distributing water requirements through the whole period or concentrating them during “on” periods of a rotation system. With the concentration of water abstraction during day hours, the branch canal in El-Bostan region (# 11 canal) was not suitable for conveying the required flow. Likely, the cross-section of the canal was small as the whole area was designed for modern irrigation system.

However, there is an interconnection between using modern irrigation systems, the performance of the irrigation system and the application of the continuous flow. Such interconnection could be explained as follows:
Regarding the relation between the continuous flow and canals rehabilitation, applying the continuous flow, as was illustrated from the international experiences, means providing the required amount of water at the required time (demand-based water distribution system). This required the following elements:

1. Precise calculation of water requirements with their spatial and temporal variations. Using remote sensing-based program to calculate water consumption is a prominent technique in this field. Merging such technique with a software to define the required flow at different points of the irrigation network.
2. The second point is the performance of the irrigation network. Enhancing the performance of the irrigation network requires having suitable geometry, but it does not necessary to line the irrigation canals. As presented in the international experiences, most of the irrigation canals in USA are earthen canals. However, there is a high flexibility in water distribution due to the continuous dependence on monitoring devices to measure the flow at different points of the system.
3. Missing the advanced tools to calculate water consumption and monitor water supply resulted not only in the disability to apply the continuous flow, but even in the falling of proper application of the rotation system. Falling to apply the rotation system probably is also affected by the existence of many municipal points on the irrigation network, with its high priority affect water distribution and enforce the irrigation directorates to change the rotation. This increased the importance of using computer models that connect irrigation requirements with other water use requirements and calculates the required flow at different points.
4. With the precise calculations of water requirements and precise controlling of water supply, the coordination between farmers is another essential element for successful application of the continuous flow. The continuous availability of water supply, without fixed arrangement between them, should encourage farmers to use more water, especially for high consumption crops. Based on **(M. Satohet al., 2017**), the water availability has serious impact in baddy areas. Water abstraction almost doubled with the increase of water availability. For regular crop, the impact of water availability is limited. The problem of arrangement between farmers and in controlling their water abstraction increased with the vast replacement of fixed water wheels (Saqias) by diesel pumps during 1970s and 1980s, which was associated by the change of the abstraction pattern and the concentration of the irrigation during day hours.

Regarding the relation between on-farm irrigation system and the application of the continuous, the required points should be considered:

1. daily water duty is different from modern irrigation system to surface irrigation system, and its frequent irrigations with lower water application in modern irrigation system makes this system more suitable for the application of continuous flow. For instance, maize crop is irrigated each two "on" periods (one irrigation each sixteen days) and water applied for the irrigation is 350 m3/fed. With modern irrigation systems, maize crop should be irrigated each three days, and water applied in each irrigation is around 100.0 m^3/fed.
2. However, with the good arrangement between farmers, the continuous flow could be applied for both systems. It should be noted that the idea of applying the continuous flow was introduced by the end of 1970s during Egyptian Water Use and Management [EWUP] project, and it was introduced for improved surface irrigation system (**M. El-Kady et al., 1981**). The idea started by reshaping the canals and reducing their cross sections as a result of reducing water supply, and due to the difficulty of reshaping all branch canals in Egypt, another concept about night storage was introduced.
3. The evaluation results of IIPs (Irrigation Improvement Project) did not refer to any real application of the continuous flow in the improved areas. The reason was the disability to operate the system as was designed. Water was not distributed between irrigation canals based on volumetric basis and the internal rotation between the improved Mesqas was not applied.

Conclusion and Recommendations:-

The simulation tested the ability of the irrigation systems in old lands and in new reclaimed lands to convey the required water under different scenarios, which are: distributing the requirements through the whole time, distributing the water through the whole days of "on" periods only, and concentrating the irrigation during days' hours during "on" periods only, which is the current trend in the old lands. Both systems worked probably for the first two scenarios. For the third scenario, the canal in the new lands was not able to convey the required water supply.

From the previous discussion, there are other important points to implement modern irrigation system and apply the continuous flow probably. This includes

1. Having a proper way to calculate water requirements for different water use and define the required flow at different point precisely and frequently. Developing a model to calculate the required flow at different points is an important task.
2. Having advanced tools for monitoring water supply at different points of the irrigation network. Water should be distributed on volumetric basis and based on calculated water requirements.
3. Enhancing the coordination between farmers, and controlling their abstraction. This is highly important and it require institutional reform and capacity building of different associations involved in water distribution.

Likely, implementing modern irrigation system in the old lands before considering the previous points will face serious problems. It highly recommended to prepare the irrigation system to be suitable for applying the continuous flow with required flexibility and reliability before such implementation.

References:-

1. Abd El Azim M. Negm, (2019) Conventional Water Resources and Agriculture in Egypt http://www.springer.com/series/698
2. Dorna Jahangirpour and Mansour Zibaei (2022) rrigation Systems Under Risk Condition: Application of Stochastic Efficiency with Respect to a Function Approach. Water Resource Management a section of the journal Frontiers in WaterVolume 4 - 2022 | https://doi.org/10.3389/frwa.2022.931694
3. FAO, (2014) Food and Agriculture Organization of the United Nations (the state of food in secure 2014. Strengthen The Enabling Environment for Food Security and Nutrition in the World (https://www.fao.org/3/a-i4040e.pdf)
4. Gikas, G.D. (2014) Water quality of drainage canals and assessment of nutrient loads using QUAL2Kw. Environ. Process, (1), 369–385.
5. Karajeh, F., Oweis, T., Swelam, A. El-Gindy, A., El-Quosy, D., Khalifa, H., El-Kholy, M. and Abd El-Hafez, S. (2013). Water and agriculture in Egypt. Working Papers 253822, International Center for Agricultural Research in the Dry Areas (ICARDA), Cairo, Egypt.

6. Mahmoud A. Ahmed, (2023) Economic and Productivity Efficiency of Using Modern Irrigation Systems in Egypt (Case Study of Fayoum Governorate). Assiut Journal of Agricultural Sciences 54 (1) (270-283)
7. M.A.M. Moursy, M. ElFetyany, A.M.I. Meleha, Maha A. El-Bialy (2023) Productivity and profitability of modern irrigation methods through the application of on-farm drip irrigation on some crops in the Northern Nile Delta of Egypt.
8. M. El-Kady, J. Wolfe, and H. Wahby, (1982) "The rotation water distribution system vs. The continual flow water distribution system" technical report # 20, EWUP
9. Mishari A, Alnaim, Magdy. s Mohamed, Maged Mohamed and Mohamed Munir (2022) Effects of Automated Irrigation Systems and Water Regimes on Soil Properties, Water Productivity, Yield and Fruit Quality of Date Palm. **Agriculture** 2022, **12**(3), 343; https://doi.org/10.3390/agriculture12030343
10. M.Satoh, T. El Gamal, T. Taniguchi, X. Yuan, A. Ishii&W. H. Abou El Hassan (2017) Water Mangement in the Nile Delta. Irrigated Agriculture in Egypt pp (187–224) SBN 978-3-319-30215-7 ISBN 978-3-319-30216-4 (eBook)
    DOI 10.1007/978-3-319-30216-4.
11. M. Satoh, and Ishii, (2021) Japanese Irrigation Management at the Cross Roads. Journal of water Alternative 14(2):413-434
12. Plusqueelles, (2002) How Design, Management and Policy Affect the Performance of Irrigation Project. Emerging Modernization Procedures and Gesign standards (FAO, ISBN: 9746802151,9787946802154
13. Radwan, G, (2020) Water Resources in Egypt and their challenges lake Nasser case. The Egyptian Journal of Aquatic Research (46) (1) pages 1-12.
14. Renault D. et al., (2007) Modernizing Irrigation Management. The MASSCOTE APPROACH, volume 63(1)
15. Talaat, (2008) Factors Adversely Affecting the Application of Continuous Flow in Improved Canals in Egypt. Egyptian Journal of Applied science, vol 23, 10B
16. Water Management Research Institute (Evaluating Modern Irrigation Systems in Old Lands in Egypt- Joint Study with JICA -June 2021).