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Evaluate The Performance of Water Management By Farmers Practices for Irrigation Water in Nile Delta

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ABSTRACT

Most irrigation systems used in the old Nile Delta are surface irrigation from an open irrigation canals. In addition, dependence on groundwater to complete the shortage exploitation of surface water in some places. Thus, unless precisely managed, it can bring about saltwater interruption and weakening of groundwater and soil quality. This paper presents a thorough investigation for utilizing those current watering system frameworks on suitableness methodologies What's more hones to upgrading crop water profit at the watering system networks levels, with thought the issues of water conveyance execution and efficiencies, disparity of water circulation, water quality crumbling, and helpless water system and poor irrigation management/practices. The research area is on the eastern outskirts of Menia El-Qamh city and the southern outskirts of Sharqia governorate in Egypt's Nile Delta. The paper inferred that water is accessible inadequate amount all through the water system seasons and the ranchers at the top of the water system network in the investigation region utilize more water than their necessities, however, the ranchers in the tail of its organizations use groundwater to cover the water lack in surface water. The outcomes show drainage surface water from the El Alfya canal water system waterway to the groundwater exists, particularly at the tail of the considered arrive at which may happen due to the re-energize from the channel to groundwater at the noticed wells situated along the edges of the trench. The leakage of water from the waterway causes a decline in EC values for groundwater.

Keywords: Water Balance, Groundwater, Surface Water, Irrigation Networks, Conjunctive Use

INTRODUCTION

Some countries have abundant water resources, whereas some others suffer from inadequate water, and even face severe water scarcity problems (Omran E-SE, Negm A, 2020). Water crisis can occur for any countries through two principal factors as follows: actual water emergency, which happens because of deficient accessible regular water assets to supply a district's interest, and monetary water emergency, which happens because of helpless administration of the accessible water assets (Omran E-SE, Negm A, 2020). By the year 2025, Egypt will be positioned among the main ten nations experiencing water lack, somewhat because of fast populace development (Omran E-SE, Negm A (2018)). The situation circumstance in Egypt is influenced by water lack, which is under extreme pressing factor because of Population development, a quick turn of events, intensification of agriculture, and degrading environment in Egypt (Omran ESE (2017a)). On another side, the Ethiopian government started to build a hydroelectric dam called Grand Ethiopian Renaissance Dam (GERD) in 2011. This dam will be believed to affect the water quota in Egypt by decreasing discharge upstream of the High Dam (AHD) (Omran E-SE, Negm A (2018)). The Renaissance Dam will put additional pressure on the Egyptian situation (Omran ESE (2017b)), which, if the Dam completes filling upstream water to 74 billion cubic meters of Nile water, may lead to a change in the water resources map of Egypt. As Egypt's water assets go under expanding pressure, the future vision for assets the executives ought to be changed with the goal that assets are not corrupted or tipping focuses came to, (Omran E-SE, Negm A, 2020). The Nile Delta covers just about 2% of Egypt's space however has about 41% of the nation's populace and includes almost 63% of its farming area (Mabrouk B, *et al*, (2013)). The all-out agrarian land in Egypt adds up to almost 9,000,000 and 270,000 feddans in the year 2014. Around 6,000,000 and 95,000 feddans (1 feddan = 4,200 m2 = 0.42 ha) are represented in the old land and 3,000,000 and 175,000 feddans in the recently recovered region. All water system water comes from the Nile; consequently, over 80% of the Nile water is utilized in horticulture (FAO, 2005). It is among the most thickly populated farming regions on the planet, with 1,360 occupants for each km^2. (El-hag M, *et al*, 2013)

Groundwater is assuming a significant part of the economy of Egypt due to its significance for homegrown, farming, and modern water supply. Nonetheless, numerous alerts and stresses are progressively being voiced on the perils that encompass the groundwater assets (Ragab E., *et al*, 2018). The fundamental components of these concerns are identified with consumption because of over reflection and quality disintegration brought by numerous methods of pollution. Other than the contamination from point and non-point sources like farming, businesses and homegrown squanders, obvious contemplations are offered these days to saline water interruption in the seaside and complex springs of northern Egypt, (FAO, 2005). It is turning into a critical obligation to secure these assets and oversee them in a reasonable way as an

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unquestionable requirement for endurance. Therefore, Egypt has plans to use its limited water resources efficiently and overcome the gap between supply and demand. Furthermore, the majority of irrigation system and agricultural water losses are irreversible, partly due to evapotranspiration and land drainage to the Mediterranean Sea and/or coastal lakes. (Abdel Gawad, *et al*., 2010). In addition, the need to produce more food with less water is urgent due to the exploration of population, while municipal and industry sector take an increment share with the need to keep enough water level for transportation. As a result, water allocation among different sectors is highly competitive with the agricultural sector.

The conjunctive use of surface and groundwater is one of the strategies of water supply management which has to be considered to optimize the water resources development, management and conservation within a basin, and artificial recharge of aquifers is certainly one of the tools to be used for that purpose (FAO, 1993). It can be defined as the management of surface and ground water resources in a coordinated operation to achieve a higher yield of such a system over a period of years that exceeds the sum of the yields of the separate components of the system resulting from an uncoordinated operation. The combined use of groundwater and surface water in many countries is being applied in arid regions to enhance irrigation intensity and often has benefits such as dealing with water saturation and salinity problems in irrigated irrigation areas, water mixing reduces pollution load, etc. (Wai Yang *et al*., 2018). In Egypt, a number of studies have been conducted which conclusively proved its importance and benefits in regards to: solving water logging problems, providing water source when surface water is not available, increasing efficiency of irrigation and mitigate for water scarcity in drought periods. Conjunctive use is being adopted in Egypt on two scales: planned, and random. The government of Egypt has operated the conjunctive use system in many locations in old lands. But on the other hand, random conjunctive use has been used since the eighties by farmers at the canal tails or when the surface water is not sufficient.

Water balance analysis is used in irrigation systems to help manage water supply and predict water shortages (Burt, 1987). As a result, balancing water supply and demand is seen as a critical issue in order to avoid wasting a large amount of water in irrigation by giving more water than is required by the crop. (Chambers, 1988: Moghimi H., 2008). So, the selection of performance assessment concept is essential to successful management of an irrigation system. The ultimate purpose of performance assessment is to achieve efficient and effective irrigation performance by providing related feedback to management at all levels (Hvidt, 1996). This paper provides a thorough examination of how to use current irrigation systems to develop appropriate strategies and practises for increasing crop water productivity at the irrigation network level, taking into account issues such as water delivery performance and efficiencies, inequity in water distribution, water quality degradation, and poor irrigation and drainage management/practices. This study's water balance assessment was divided into two parts: first, an examination of the entire water balance parameters between supply and demand in the study area; and second, the measurement of water availability, adequacy, equity, and irrigation distribution within a day, as proposed by Molden and Gates (1990).

MATERIALS AND METHODS

Study area

The research area's location was chosen to provide a suitable representation of the Nile Delta region, which has two key characteristics. First, surface irrigation is the most common irrigation technology, the soil type is clay, and the cropping patterns include the Nile Delta's principal crops. Second, the farm is quite modest, ranging in size from 1-3 acres. Furthermore, the water balance parameters were properly measured due to the study area's water intake and outflow being controlled. Figure (1) shows the study region, which is located on the east edge of Menia El-Qamh city and the southern limit of Sharqia governorate in the Nile Delta. The study area is the command area of El Alfya canal (9,240 feddans), which is a branch canal from Bahr Abouel-Khdar Canal. The coordinates of the study area are as follows: Latitude:30°29'43.05", Longitude: 31°20'45.06". The direct canal that is supplying the command area, is Al-Alfya canal from Mustafa Afandy at KM 2.00. The total area served by Al-Alfya canal water system is 9,160 fedd. through almost length 8.95 km and number of sub-branches, as shown in Figure (1). The major area of this study that face many problems is Karaqra canal. It is extending for Al-Alfya canal which its length is 6.06 km and serves 2,600 fedd.

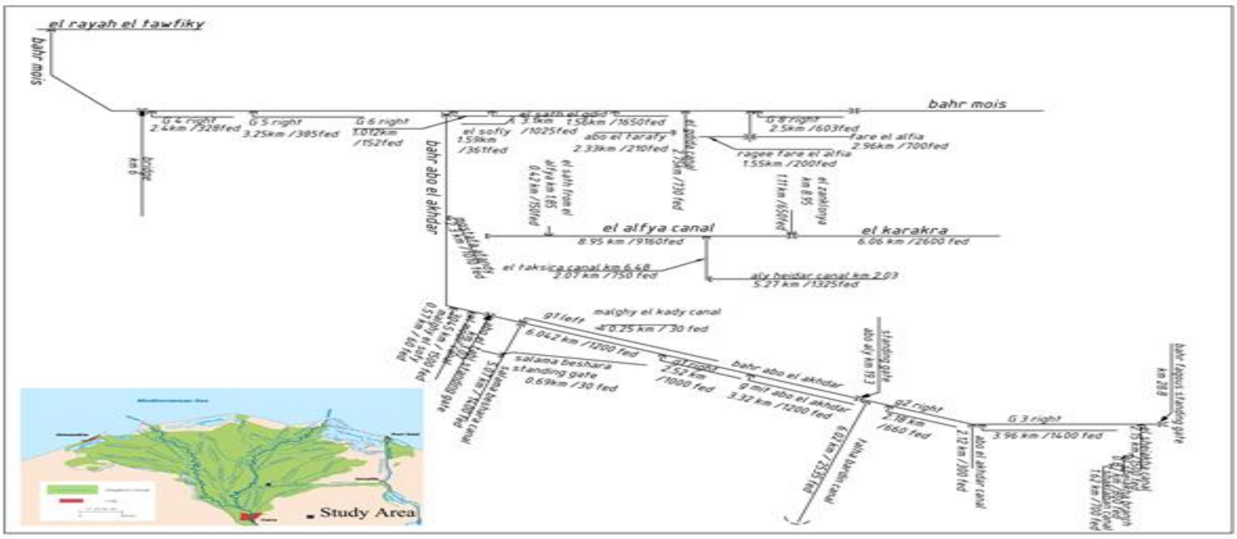


Fig. 1. Study area location

Like most of the old lands in Egypt, Menia El-Qamh areas is characterized by surface (flood) irrigation method which is convenient to the soil type. Basin or Furrow irrigation is prevailing practices in this area based on the crop types i.e., farrow method is suitable for maize and cotton while basin method is fine for rice and berseem. Water delivers from main canals to branch canals by gravity, while farmers used to lift irrigation water to their fields using their own small portable pumps. These pumps are installed at the head of Mesqas to divert water from branch canal to Mesqas, which water flows by gravity to fields through opening along Mesqas by farmers. Private shallow groundwater wells cover significant part of the area especially at the downstream part. The groundwater levels range from 5.5 to 3.0 m throughout the region. The drainage water goes out from the area through Abo Akhdar, Kafr Rabie, Shehata and El Goda Drains. The area drains via a complete network of tail drainage about 20 years ago. The spacing between the laterals is 30 m with total length ranges between 250 to 300 m. the depth of lines start at 1.2 m and end at 1.5 m to keep the water level at about 1.35 m from the land surface. Figure (2) presents the Practices of irrigation system in pilot area.

(a) Using small mobile pump (b) Using private groundwater well

(c) Typical mesqa (d) Intake of sub-branch (c) Typical marwa

Fig. 2. Practical of irrigation activities in study area

The main problems and challenges facing the improvement of on-farm management for irrigation at this location are; (i) lacking of some good implementation for technologies that provided by pervious irrigation improvement in other area in Delta, (ii) seasonal water shortage, and (iii) use of low quality of water (drainage water) in irrigation.

Determination of performance indicators

The assessment of the water balance of this study was conducted in two steps. The first step looks at the water delivery performance by according to indicators of adequacy, equity, efficiency, and dependability that are defined by Molden and Gate (1990). The performance assessment concept is essential to a successful management of an irrigation system, it is also the key factor to improve daily operation, to diagnose problems, and monitor the effect of the interventions to solve these problems. The second step is concerned with the full water balance analysis between water supply and demand in the study area, through the monitoring and evaluation of irrigation operations.

- **Water Balance Parameters**

The water supply performance in the branch canals and selected mesqas was measured using the water use index indicator. The following equation was used to calculate the indicator of water utilised index rate (WUI):

$$WUI = Q_{DTotal} / Q_{RTotal} \quad (1)$$

Q_{RTotal} is the total water requirements for the area covered, and Q_{DTotal} is the total water supply (m^3) into the irrigation network (m^3). If the WUI number is 1.0, it means that enough water is being provided to meet the water demand. Nonetheless, a WUI value greater than 1.0 indicates the presence of a wastewater irrigation network. and the value of WUI is lower than 1.0 indicates that there is shortage water through irrigation network.

- **Evaluation of the performance indicators**

Performance indicators used in this study evaluate irrigation networks in the sample selected branch canals, mesqas, and farmers' practices at the pump level. The evaluated proposed by Molden and Gates (1990) concept that based on the four indicators, i.e., (i) adequacy (P_A) measures the distribution of required amount over the command area served, (ii) efficiency (P_F) measures conservation of water resources in command area served, (iii) equity (P_E) measures the distribution of fair water amount over command area, and (iv) dependability (P_D) measures the uniform distribution of water supply over time in the command area. All indicators are concluded to be effective for assessing distribution system performance.

Adequacy Indicator; $P_A = (1/T)\sum_T \{(1/R)\sum a_i p_{Ai,t}\}$, (2)

Efficiency Indicator; $P_F = (1/T)\sum_T \{(1/R)\sum a_i p_{Fi,t}\}$, (3)

Equity Indicator; $P_E = (1/T)\sum_T CV_R(Q_{Di,t}/Q_{Ri,t})$, (4)

Dependability Indicator, $P_D = (1/R)\sum_{a_i} CV_T(Q_{Di,t}/Q_{Ri,t})$, (5)

Where;

Q_D is water supply in irrigation network, (m^3/sec)
Q_R is water required in irrigation network, (m^3/sec)
R is total area of command, (m^2)
a is area of region, (m^2)
T is time operation, (hr)

$p_{Ai,t} = Q_{Di,t} / Q_{Ri,t}$,

$p_{Fi,t} = Q_{Ri,t} / Q_{Di,t}$,

CV_R is the spatial coefficient of variation of $Q_{Di,t}/Q_{Ri,t}$ over the region R; and
CV_T is the temporal coefficient of variation of $Q_{Di,t}/Q_{Ri,t}$ over time T

For this study, the period of evaluation in the summer season is covered five months (May to September), while in the winter season is covered seven months (October to April). For the total area covered the sample selected branch canals, mesqas, and farmers' practices at the pump level in the region. From the indicators' values, performance was categorized as "good," "fair" or "poor" according to the criteria of Molden and Gates (1990), was listed in Table 1.

Table 1. Evaluation criteria for each indicator (Molden *et al*. 1990)

Measure	Performance Class		
	Good	Fair	Poor
P_A	0.90 - 1.00	0.80 - 0.89	< 0.80
P_F	0.85 - 1.00	0.70 - 0.84	< 0.70
P_E	0.00 - 0.10	0.11 - 0.25	> 0.25
P_D	0.00 - 0.10	0.11 - 0.20	> 0.20

• Determination of crop water requirements and water delivery

RapidEye technical is used in the agricultural field to provide up to date crop information for better production management and monitoring of agricultural areas. The benefits of using RapidEye are cost effective, Daily revisit capability – with 5 satellites in the RapidEye constellation capture is rapid and reliable. Therefore, the coverage of RapidEye images cover the proposed study area would be used in the field of images classification. RapidEye images acquired in 8th March 2017 to estimate winter crops pattern and 25th July 2017 to estimate summer crops pattern. Two topographic maps with scale 1:50,000 was used to geo-referencing the RapidEye satellite images. The parameters of map projection are defined as Universal Transverse Mercator, with Datum: WGS_1984_UTM_Zone_36N, Central Meridian: 33E, False Easting: 500,000 m, and False Northing: 0.0 m. As shown in Figure (3), many crops in winter season such as Wheat, Clover while in summer season such as Rice, Maize others were estimated and its areas was calculated with other soils feature such as urban, bare soils, and canals and drains. The results show in Table (2) that about range between 75.8% to 66.7 % of the studied area was classified as cultivated, and about 14.0% from the studied area was classified as urban areas.

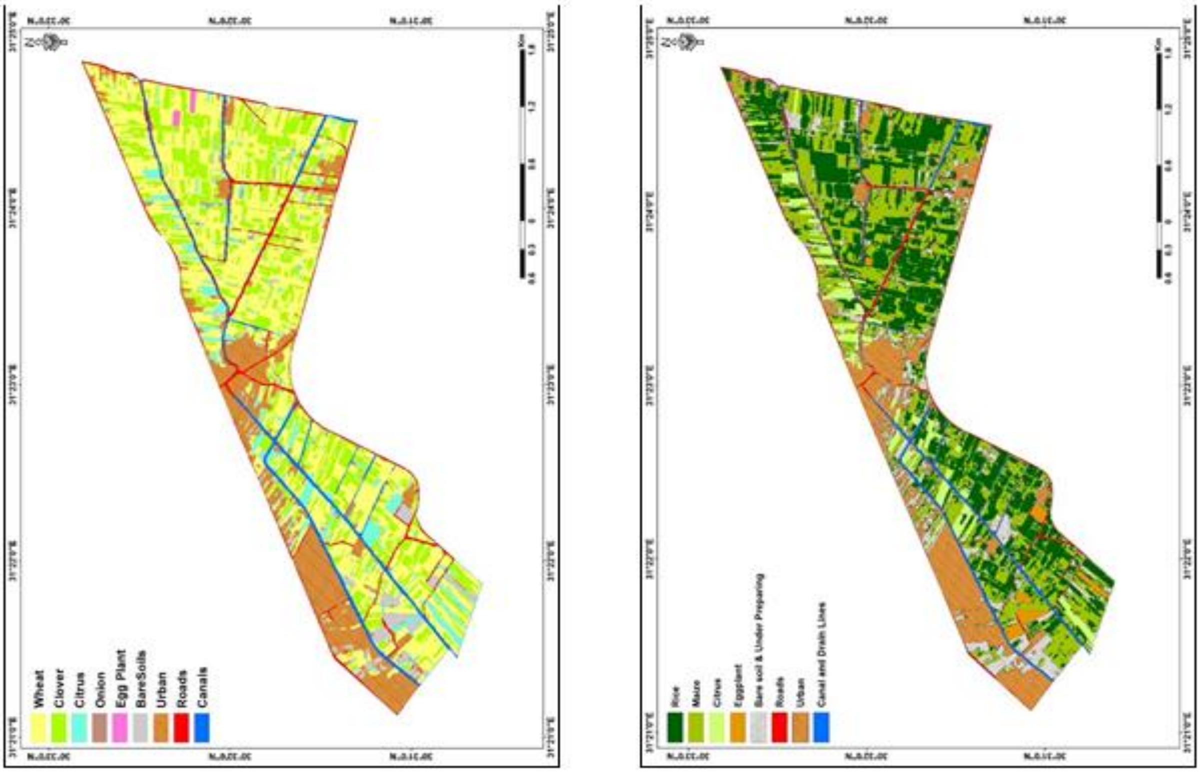


Fig. 3. Classified Image according IMAGINE objective model (Winter 2016-2017) and (Summer 2017)

Table 2. Estimated crop areas according IMAGINE objective model (Winter 2016-2017) and (Summer 2017)

Winter Season	Area			Summer Season	Area		
	Feddan	hectare	%		Feddan	hectare	%
Wheat	898	377	46.1	Rice	598	251	30.7
Clover	435	183	22.4	Maize	580	244	29.8
Citrus	103	43	5.3	Citrus	96	40	4.9
Onion	20	8	1.0				
Egg Plant	19	8	1.0	Eggplant	24	10	1.2
Bare Soils	83	35	4.3	Bare soil	255	107	13.1
Urban	273	115	14.0	Urban	278	117	14.3
Roads	65	27	3.3	Road	65	27	3.3
Irrigation Net.	51	21	2.6	Irrigation Net.	51	21	2.6
Total Area	1947	818	100.0		1947	818	100

Present practices in use of water, soil and crops are traditional, which means that water use is mainly for irrigating crops using the traditional irrigation method. The irrigation rotation there is 5 days on and 10 days off. In this paper, the CROPWAT model was utilised to calculate crop water requirements, with the FAO using Penman-Monteith equations to estimate reference crop evaportranspiration (FAO, 1992). The irrigation manual handbook of the FAO was used to create crop coefficients for the main crops (FAO, 2002). The efficiency of water application is expected to be 65 percent (used by surface irrigation).

- **Water Productivity**

Water productivity at the field level refers to the amount of crop output in physical terms (crop yield in kilogram) divided by the amount of water consumed (evaporated from the soil and transpired by the plant, the evapotranspiration). Productivity may be assessed for the whole system or parts of it. It could account for all or one of the inputs of the production system giving rise to two productivity indicators:

Water productivity (WP) is a partial-factor productivity that measures how the systems convert water into goods and services. Its generic definition can be recognized as:

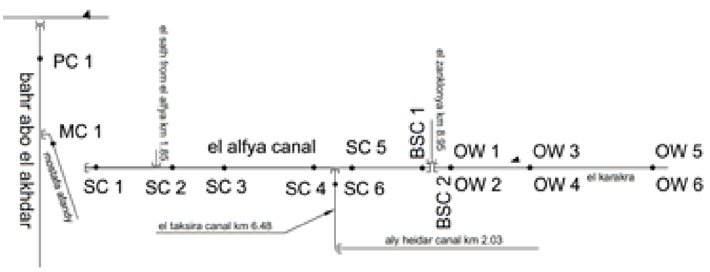
Water Productivity (WP) = Output Derived from Water Use/ Water Input (6)

Water productivity is a very powerful indicator that can be applied at different levels to matching the needs of different users (Hvidt, M. 1996). This indicator is achieved by defining water inputs and outputs in units appropriate to the needs of the stakeholders. The numerator (a product derived from water use) can be achieved in the following ways: (1) Physical output, which can be total biomass or harvestable product; And (2) Economic output (monetary value of output) either total benefits or net benefits.

RESULTS AND DISCUSSION

Inflow Parameters

For evaluated the performance indicators in this study, it required some calculation such as the water delivered to specific reached in selected samples of branch canals. Therefore, water levels were continuously monitored using automatic recorders, so it was necessary to create a relationship between recorded water levels and measured discharges using an individual rating curve for each measurement point at specific locations to inference conversion of water deliveries in the command area. While, routine discharge measurements at selected locations on the sample canals were carried out by an Acoustic Doppler Current Profiler (ADCP). It is a hydroacoustic current meter similar to a sonar, used to measure water current velocities over a depth range using the Doppler effect of sound waves scattered back from particles within the water column. Establishments of the flow calibration through this study depend on data point of discharge measurements on branch canal's length through combined irrigation seasons of summer and winter, as presented in equation. (Y=72.59X - 119.69). The accuracy of calibration is high, which the coefficient of determination is up to 0.97, which Y present discharge (m3/sec) and X present Water level.



Code	Description
PC1	Head of Bar Abo El-Akhdar canal
MC1	Head of Mostafa Afandy canal
BC1	Head of El- Alfya canal
BC2	Before Covering
BC3	After Covering
BC4	Before Divided
BC5	After divided left
BC6	After divided Right
SBC1	Before Head El- Karakra canal
SBC2	After Head El- Karakra canal
OW's	Observed Wells

Fig. 4. Sketch of measurement locations in study area

The figure (5) represents the water flow that calculated from calibration relation of flow. This figure indicates the summer season start at beginning of May month until end of September month with average 5.5 m^3/sec and maximum flow around 6.8 m^3/sec at downstream of head of Bar Abo El-Akhdar canal. For winter season, is starting at beginning of October month until end of April month with average 1.8 m^3/sec and maximum flow around 3

m^3/sec. The water management on Bar Abo El-Akhdar canal is clear and fixation through irrigation seasons. The water flow to Mostafa Afandy canal has equal 5% from the quota of Bar Abo El-Akhdar canal due to its location at head reach main canal. 20% of volume water flow was cultivating the area served in Mostafa Afandy and other is flow to Alfya canal. There is coverage zone (culvert structure) in Alfya canal at residential area for one kilometer. The efficiency of this structure is 95% which there are losses of flow due to accumulate the trash and solid waste at head of structure as shown in figure (6). The water flow in Alfya canal after coverage zone is divided to two paths, 70% of total flow volume go the lift side (El-Zankonlya canal and El-Karakra canal) and 30% of total volume go right side (EL- Tasksira and Aly Heidar). The total volume of flow in lift side was divided into equal values for El-Zankonlya canal and El-Karakra canal which average of flow in El-Karakra canal is 0.96 m^3/sec in summer season and 0.37 m^3/sec in winter season.

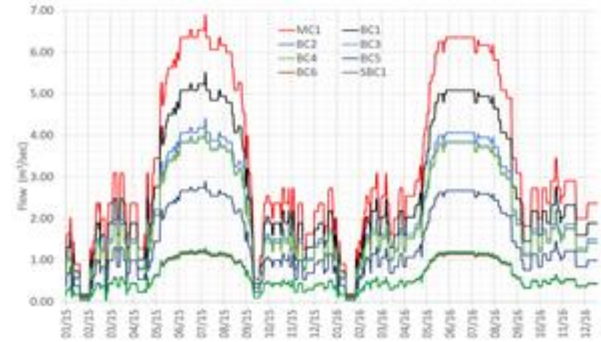


Fig. 5. Water flow through irrigation canal networks

Fig. 6. Accumulate trach and solid waste

Outflow Parameters

In this study, the outflow was estimated at the tail of command area through groundwater level. Groundwater level was measured in six observed wells as present in Fig. (4), to monitoring farmers' practices through irrigation seasons. The study area is a geologically uncomplicated area, as it is considered a part of the old Nile Delta region, where Quaternary sediments are abundant on the surface extending deeply subsurface. On the surface of the study area Quaternary deposits consisting of clay, sand, silt and sandy clay with some rock fragments are found to cover the ground surface, overlying older formations. Observation wells were used to determine the aquifer interaction with surface water as well as, the relation between the groundwater heads and groundwater extraction. Moreover, understand how surface development has impacted the aquifer. The monitoring wells were being recorded for groundwater heads and groundwater samples were collected and chemically analyzed, as presented in Table (3).

Table 3. Average values of water quality parameters in observed wells

Sample Code			OW1	OW2	OW3	OW4	OW5	OW6
					Unit			
PH		mg/l	7.71	7.75	8.56	8.42	7.50	7.46
Carbonate	CO3	mg/l	0	0	38.4	43.9	0	0
Bicarbonate	HCO3	mg/l	585.6	388	519.7	442	292.8	244
Total Alkalinity		mg/l	585.6	388	558.1	485.5	292.8	244
Electrical Conductivity	(EC)	ms/cm	2.13	1.88	1.37	1.39	0.959	0.751
Total Dissolved Solids	(TDS)	mg/l	1361	1207	878	895	614	480
Calcuium	Ca	mg/l	146.92	143.39	81.11	93.41	56.46	50.37
Patassium	k	mg/l	6	5	5	3	5	4
Magnesium	Mg	mg/l	35.1	29.25	24.11	30.83	10.2	10.2
Sodium	Na	mg/l	280	230	178	132	140	103

According to the chemical analysis results, it can be concluded that the pH of the different studied locations ranged between 7.46 to 7.71 for the locations 1, 2, 5 and 6 while the pH values were 8.56 and 8.42 for the locations 3 and 4. The occurrence of CO3 was absent for the locations 1, 2, 5 and 6 while the CO3 occurred in the locations 3 and 4. The occurrence of CO3 in locations 3 and 4 was the reason for being the pH values in those locations higher than 8-2. The total alkalinity values of the groundwater were ranged between 244 and 585.6 mg/L. The values were decreased with the direction of the water flow in the canal. The Ec values of the groundwater decreased with the direction of the water flow at canal where the values ranged at the beginning of the selected reach between 2.13 and 1.887 ds/m while the values were 0.959 and 0.751 ds/m at the end of the studied reach of the canal. The TDS values of the groundwater were coinciding with the values of EC due to the strong significant relation between the EC and TDS. The results of the major cations show that the dominant cation is Na (sodium) followed by Ca (Calcium), Mg (Magnesium) and K for all the studied locations. The results also show that concentrations of those cations were corresponding with the values of TDS and EC.

To follow up and monitor groundwater levels, four regular groundwater level monitoring rounds were conducted through the period of this study because periodic monitoring provides some information to determine trends and develop predictive models. Figure (7) shows the recorded measurements for groundwater levels, for different days. According to the field measurements, the depth of the groundwater levels ranges from 5.3 to 3.0 m throughout the monitoring period. It is clearly shown that every two observation points, which constitute a cross section on the canal, are similar in groundwater levels. After analyzing the groundwater levels for the four rounds and comparing it with the status of surface water availability at Alfya canal; it was noticed that the shallow groundwater levels are highly affected by the extraction rates. As the depths of groundwater is directly proportional with the extraction rates. It is noticed that the local depth of shallow groundwater declines dramatically at the area around the tail of Alfya canal. The reason for this decline is the intensive extraction by rates randomly for groundwater to be used by the farmers for irrigation purposes. The farmers tend to use the groundwater as a sustainable source of irrigation water as the surface water is not available all the time at the ends of the canal. From the previous observations, the following can be concluded that there is seepage action for surface water from the El Alfya canal to the local surrounding groundwater especially at the end of the studied reach. In addition, the seepage water from the canal causes decrease in the EC values at the local surrounding groundwater especially at the last two wells.

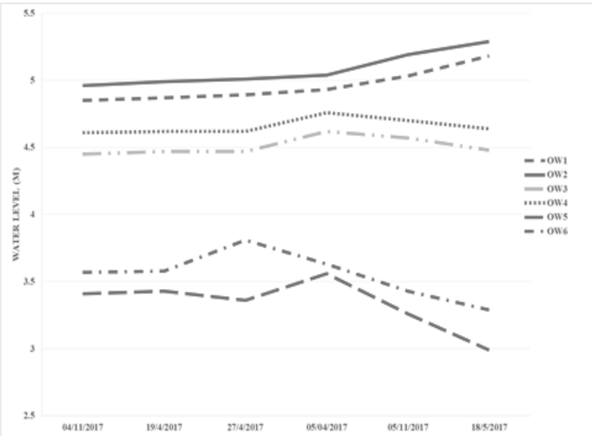


Fig. 7. Groundwater levels for observation

Equity of Water Distribution

The WUIs evaluated at the heads of the monitored branch canals (Mostafa Afandy canal (MC), El- Alfya canal (BC), and El- Karakra canal (SBC)) in study area. The following notes could be made related from Figure (8). The values of WUI for all branch canals in irrigation season are similar performance that indicate the water management in study area. Some WUIs are larger than 1.0 that does not necessarily indicate over supply; water delivered at the head of a branch canal is typically larger than actual crop water and soil leaching requirements in order to account for conveyance and field application losses. On the other hand, a WUI that is well below 1.0 indicates severe water shortage. The WUI values for Mostafa Afandy canal were over than 1.0 through irrigation seasons which indicates over irrigation. For Summer season, the values were closed to 2.0, while in winter season, the values were closed to 3.0 except the period of winter closure. The performance of Alfya canal through irrigation seasons as summer and winter was almost stable and fixed which it is closed to value 1.0. while the El-Karakra canal's values were lower than 1.0 through irrigation season. So, the famers in these areas was using alternative methods for irrigation as shallow well for groundwater to cover the water shortage.

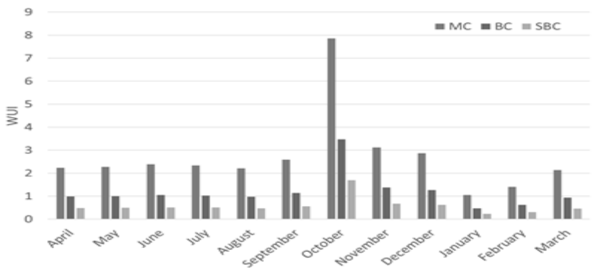


Fig. 8. Monthly WUI at head branch canal level

Performance of the Delivery System

This section analyzes monthly water delivery performance in 2017 among irrigation canals as a spatial function and the difference between irrigation canals of irrigation system through the irrigation systems as a temporal function.

- **Spatial Values of Performance Indicators**

The adequacy values for the spatial function in months are given in Figure (9). The PA values were closed to 0.8 in all months of studying in summer season, while the values were varying through winter season. While, the spatial values of efficiency PF were similar to PA in summer season and variable in all months and not stable in winter season that indicated a reflection of the extreme water delivery for the irrigation systems than available water consuming main crops as rice paddy in summer and wheat crop in winter seasons. This mean the head regulators of branch canals are out of control for water deliver into system and there are high losses of water and impact on the irrigation system in end of reach of main canal. According to performance standard, adequacy performance during summer seasons was evaluated as "fair" and during winter seasons was "poor" in middle season, while it was "fair" in the first months of this season. According to performance standard, efficiency performance during summer season was evaluated as "fair" during irrigation seasons. These results mean that water use is not efficient due to large amounts being supplied without being used. Values of the equity indicator PE for irrigation months, presented in Figure (9), were almost uniformly poor, higher than 0.2 through irrigation seasons summer and winter. This performance confirms the water delivery among branch canals equitable that were lack through irrigation seasons due to abuse of the rotation principle, moreover, damage to head regulators of the system that allowed leakage. According to performance standard, equity performance throughout the irrigation seasons was evaluated as "poor".

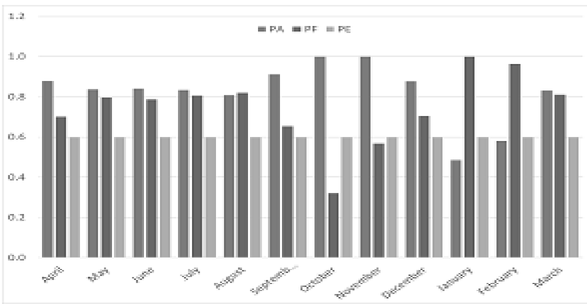


Fig.9. Spatial Performance indicator values at branch canal level wells

- **Temporal Values of Performance Indicators**

The temporal value of PA for Afandy canal was closed to 1.0 Figure (10). While, the value of El- Karakra canal was closed to 0.6. This indicates the irrigation canals that feed from Afandy canal was face water shortage. According to performance standard, adequacy performance for both irrigation canals was evaluated as “fair”. The temporal value of PF for Karakra canal was better than Afandy canal which PF of first was 0.95 and 0.5 for second. This indicates the losses of water through Karakra canal was 50% through irrigation months in summer and winter. According to performance standard, efficiency performance for both irrigation systems was evaluated as “poor”. The dependability indicator PD was generally poor (over 0.2). It means that the farmers in any irrigation district could plan for a dependable delivery of water, even of an inadequate supply, by growing different crop.

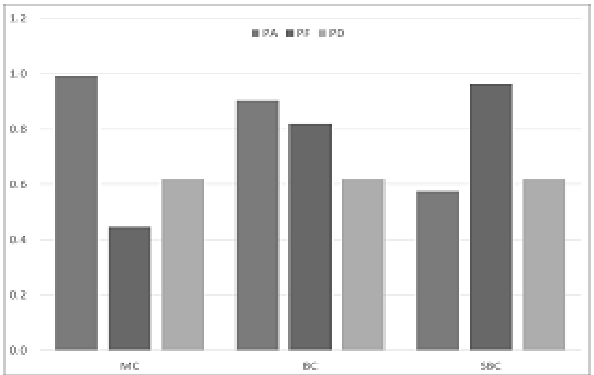


Fig. 10. Temporal Performance indicator values at branch canal level wells

Water Productivity of the Delivery System

Revenues earned from plant production activities in the study area during the winter and summer seasons have been calculated. Results indicate that, during the winter season, farmers near the head of "Mesqa" produce 79.1 and 2.8 tons of long clover and wheat worth LE 7538 and LE 13847, respectively, compared to 75.1 and 1.7 tons worth LE 7088 and LE 7762 for farmers near the tail of "Mesqa", respectively. For the summer season, farmers near the head of "Mesqa" produce 2.1and 4.1 tons of rice and maize worth LE 6605 and LE 12009, respectively, compared to 2 and 2.4 tons worth LE 6603 and LE 7109 for farmers near the tail of "Mesqa", respectively. Cost of production inputs for crops grown by farmers with holdings near the head/tail of "Mesqa" during the winter and summer seasons are presented in Table (6). It is clear that the cost of production for long clover at the head of “Mesqa” is higher compared to the tail (LE 2495 versus LE 2777) while conversely in the case of wheat. The cost of wheat is LE 3482 versus LE 3426 at the head and tail of “Mesqa” respectively. Of course, there are eggplants, onions and green beans grown at head of “Mesqa” in winter season. At the summer season, there are also eggplants and cabbage grown at head of “Mesqa” because of regular water availability to satisfy their needs. However, costs of crops differ at the two sites (Head and Tail) not only because of water availability but also the quantity of inputs and their related prices.

CONCLUSION

Water balance analysis is used in irrigation to help manage water supply and identify water shortages. As a result, balancing water supply and demand is regarded as a critical issue in order to avoid significant water losses in irrigation as a result of giving more water than is required by the crop. Delivering the right amount of water at the right time saves water and boosts crop water productivity, which could lead to more water being available to other farmers and a boost in total income. The major difficulty in achieving both food and environmental security is the goal of growing more crops per drop. The following were the study's conclusions:

- The top soil layers are predominantly composed of clay. Soils are generally deep and relatively free drained;
- Water is available in sufficient quantity throughout the irrigation seasons (adequacy was fulfilled);
- The farmers in this area use more water than their needs because they located at the head of the branch canal;
- The irrigation rotation is irregular due to the manipulation of the people in-charge in open and closing the gates or farmers at the head of the canals because the operation time during the off rotation is just only a few hours to irrigate the areas adjacent to the intakes.
- There is seepage action for surface water from the El Alfya canal to the local surrounding groundwater especially at the end of the studied reach.
- The seepage water from the canal causes decrease in the EC values at the local surrounding groundwater especially at the last two wells.

The study should be replicated on a larger scale to include the entire command area in order to assess the water balance over this area by monitoring and evaluating water availability, adequacy, equity distribution among various mesqas, night irrigation, and the reuse of drainage water in irrigation. Furthermore, the impact of the water delivery system on farmer behaviour should be assessed at the head of branch canals as well as other points inside the main canal.

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تقييم أداء إدارة المياه من قبل ممارسات المزارعين في ري في دلتا النيل

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بلغت أزمة المياه العالمية ذروتها وازدادت حدة بسبب ضغوط التدهور البيئي وتزايد عدد السكان بالطلب على الغذاء في جميع أنحاء العالم. وقد أثرت هذه الأزمة سلبا على الموارد المائية المتاحة، مما يمثل أعباء قوية على جميع الدول في إدارة تحسين الموارد المائية. مصر تعتبر واحدة من الدول القاحلة التي يمكن أن تكون عرضة لضغوط المياه في ظل التغيرات المناخية في المستقبل. هناك مجموعة متنوعة من المخاطر الحقيقية الناجمة عن التغير البيئي في مصر، ومن المحتمل أن تكون القضية الرئيسية هي ارتفاع مستوى سطح البحر الذي يمكن أن يؤثر على منطقة الشمالية بدلتا النيل. معظم أنظمة الري المستخدمة في دلتا النيل القديمة هي الري السطحي من قنوات الري المفتوحة. وبالإضافة إلى ذلك، فإن الاعتماد على المياه الجوفية لاستكمال استغلال نقص المياه السطحية في بعض الأماكن. لذا، ما لم تتم إدارته بعناية، يمكن أن يؤدي إلى تسرب المياه المالحة وتدهور نوعية المياه الجوفية والتربة. ويمكن أن يؤدي لتسرب المياه الملوثة من مصارف الري إلى تلويث طبقات المياه الجوفية. ولذلك تقدم هذه الورقة تحليلا شاملا لاستخدام نظم الري الحالية لوضع استراتيجيات وممارسات مناسبة لتعزيز إنتاجية مياه المحاصيل على مستويات شبكات الري، مع التفكير في مشاكل أداء وكفاءة توصيل المياه، وعدم المساواة في توزيع المياه، وتدهور نوعية المياه، وسوء إدارة / ممارسات الري والصرف الزراعى. الاتزان المائى المطبق فى هذه الدراسة يتم على محورين: أولا، تحليل معايير الاتزان المائى بأكملها بين إمدادات المياه والطلب عليها في مجال الدراسة؛ ثانيا، قياس توافر المياه وكفايتها وإنصافها وتوزيع مواسم الري. تقع منطقة الدراسة على الأطراف الشرقية لمدينة المنيا القمح والاطراف الجنوبية لمحافظة الشرقية في دلتا النيل بمصر. استدلت الدراسة إلى أن المياه متوفرة بكميات كافية طوال مواسم الري وأن المزارعين فى بداية شبكة الري في منطقة الدراسة يستخدمون مياه أكثر من احتياجاتهم، لكن المزارعين في نهايتها يستخدمون المياه الجوفية لتغطية نقص المياه في المياه السطحية. وتظهر النتائج تسرب المياه السطحية من ترعة الالفية إلى المياه الجوفية، خاصة عند نهاية الترعة الذي قد يحدث بسبب التغذية من الترعة إلى المياه الجوفية في آبار الملاحظة الواقعة على جانبي القناة. تتسبب مياه التسرب من القناة في انخفاض قيم EC الملوحه للمياه الجوفية. وتنخفض المياه الجوفية الضحلة في المناطق المحيطة بنهاية ترعة الالفية نتيجة لمعدلات الاستخدام العشوائي المكثف للمياه الجوفية التي يستخدمها المزارعون لأغراض الري والسماح لأعماق المياه الجوفية الضحلة بأن تكون متناسبة بشكل مباشر مع معدلات الاستخراج في نهاية الشبكة.