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Assessment of Irrigation Practices at Main Irrigation Network in the Nile Delta

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***Abstract*—**The improvement of irrigation systems in the Nile Delta is one of the most important attempts in Egypt to implement more effective irrigation technology by improving the existing irrigation networks. Demand delivery system in the existing irrigation network is using of mechanical gates structures to automatically divert water from one portion of an agricultural field to another in the desired amount and sequence. This paper discusses evaluating main irrigation networks system under the government managed before and after improvement systems in the Nile Delta. The overall results indicate that policy of using the demand delivery concept through irrigation networks is successful by improving water delivery performance among them than the rotation delivery concept that used before. It is provided fair share of water delivery among irrigation districts and available water in the end of irrigation network, although this system located in an end of irrigation networks in the Nile Delta.

***Keywords*—**Automation system, Irrigation district, Rotation system, Water delivery performance

I. Introduction

THE Global water crisis is reaching a peak and increasing intensity due to the pressure of environmental degradation and high demand for food by increasing population in all over the world. This crisis affect negatively on the available water resources, which represent the mantle heavily on the countries of the world in the management of water resources' development. Egypt is one of the African countries that could be vulnerable to water stress under climate changes in the future. An array of serious threats resulting from climate change in Egypt, the most important is the rise in sea level that could affect the Nile Delta area. Therefore, the Egypt's policy has permitted cultivation of paddy fields in Delta's area to annexation and compressor having the largest fresh water as possible to stop the overlap of sea water, which these particular areas characterise with a low-level contour. At present, rice is cultivated in Mediterranean areas on submerged land on coastal plains, on the total of about 1,200,000-1,300,000 ha. The most important rice-producing countries in this region are Egypt (660,000 ha) [1]. Even so, these areas consume around 25% of Egypt's quota from Nile flow [2]. But, there is another phenomenon affecting uncertainty of impacts on precipitation and flows in the Nile Basin. The precipitation was predicted to decrease slightly over a sub-catchment of Blue Nile (-5%) [3]. Although, the Blue Nile that constitutes around 10% of the entire Nile Basin area, but contributes about 60% of its total mean annual flow measured at High Aswan Dam in Egypt ($\approx 55.5 \times 10^9$ m^3).

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These changes may have a high impact on trans-boundary Nile River basin, and especially the downstream countries as Sudan and Egypt. So, the water management in the Nile Delta, the scarcity of water irrigation, and high-profit paddy field cultivation considered the major challenge the form crops map of the Egypt, especially in the Nile Delta's areas. So, the operation water distribution in the Nile Delta should be the process of regulatory to maintain the available water resources and good use by deliver it to the sites used in the quantities and the appropriate water levels in a timely manner without an increase or decrease threatened flawed. This process is the main task of the Egyptian government by Ministry of Water Resources and Irrigation (MWRI). The improvement of irrigation systems in the Nile Delta is one of the most important attempts in Egypt to implement more effective irrigation technology by improving the existing irrigation networks. One of the objectives of irrigation system improvement is to increase the reliability of irrigation water supply to meet the water demand more efficiency and effectively. One of the major forms of development is to apply the demand delivery concept in the main irrigation system by installing automation gates in branch canals' level. The conveyance efficiency is higher for canals operated under a demand delivery in downstream than those under a rotation system. The difference of efficiencies is due to the seepage losses, as any branch canal will lack much more when it has been allowed to dry and then refilled. While, continuous supply requires stable water levels in the branch canals. Depending on the rotation system, the gate hoisting mechanism on the canal control structures are operated manually by head keeper. This causes difficulties to adjust gate opening in response to rapidly changing demand. As a result, there was often too much or as well as little flow in the branch canal. Fluctuation of water levels in the branch canal would promote bank instability and unreliable supply to the branch canals. MWRI initiated certain programs to introduce the automated operation of water structures. Improvement of irrigation system performance is not only achieved by technical interventions, but more important, by reform in the institutional framework that enhances the effectiveness and efficiency of system management, operation, and maintenance.

Such development and change will have impacts on the decisions of water management and use. Therefore, performance of water delivery systems needs to be defined and assessed under these conditions before and after improvement. This paper highlights the water management in the Nile Delta zone in Egypt and presents the operation criteria and mechanisms in operation of the irrigation system by using performance evaluation tools through irrigation season (2004) before improvement system and irrigation season (2007) after improvement system in command area in the Nile Delta of Egypt.

Performance evaluation is carried out for such proposes as improving irrigation management, determining the overall state of the system, determining the elements which cause trouble to system, comparing performance from one year to another, or comparing one system with another [4]. Accordingly, this study presents the evaluation objectives of an irrigation system in old land, its impact on water delivery performance by irrigation districts of government's practices to improve water management in the Nile Delta by using the performance indicators proposed by Molden and Gates [5].

II. Materials and Methods

A. Study Area

The Wasat command area, within the Kafr El-Shakh governorate, is located on the northern edge of the middle Nile Delta and extends from the outskirts of Kafr El-Shakh city to the shores of Lake Burullus (31°07' N, 30°56' E). The climate of the northern delta is categorized as typically Mediterranean, with dry, mild summers and cool, wet winters [6]. The command area is fed from the tail reaches of the main canal, Mit Yazeed, which in turn is supplied from the principal canal, Bahr Shebin (Fig. 1). Owing to its location at the tail of the feeder canal system, the Wasat command area suffers from inadequate water supplies. This problem is exacerbated by the tendency of farmers to plant more paddy rice area than they are licensed to. Nevertheless, this area is famous for its rice production, which contributes 40% of Egypt's one [7].

B. Distribution of Irrigation Network in Nile Delta

Water flows from Nile River to the main users' fields through a network of waterways that consist of a principal canal, main canals, branch canals, tertiary canals called "*Meska*", and final field ditch called "*Marwa*" (Fig. 2). Government bodies manage the large canals above the level of tertiary canals, which the General Directorate for Water Distribution allocates the water to the Irrigation Directories, and the latter distributes it to the Irrigation Districts [8]. The irrigation water is diverted from the Nile by barrages, and from there through a system of main canals. This is the primary irrigation system, and it works continuously. The discharge in the main irrigation canal system is essentially regulated by head-control structures, generally equipped with lifting gates.

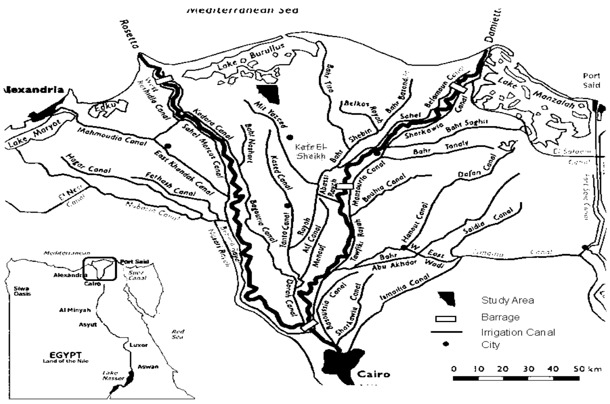

Fig. 1 layout of irrigation networks in The Nile Delta's area

Between the main regulators, one finds cross-regulators at the boundaries between the irrigation directories. From the main system, the irrigation water is admitted to the secondary systems, consisting of branch canals by means of lifting gates operated with rotation system under supervision of district engineers. The problem in here, the gates is opened so as to maintain the target downstream water levels. Adjacent, however, the discharges are not routinely controlled. The water in the branch canals is distributed over the tertiary canals (meskas), which are on a two, or three-turn rotation. After lifting water from meska, a farmer is free to distribute it over his fields by his own methods.

C. Characteristics of Irrigation Districts

In this study, was measured performance of irrigation networks through three selected irrigation districts that share in Mit Yazeed canal at downstream El-Wasat regulator (34.7 km on main canal), (Fig. 3). Each irrigation district was selected irrigation system (branch canal) to represent behavior of operation. The data of selected irrigation districts are summarized in the following Table I.

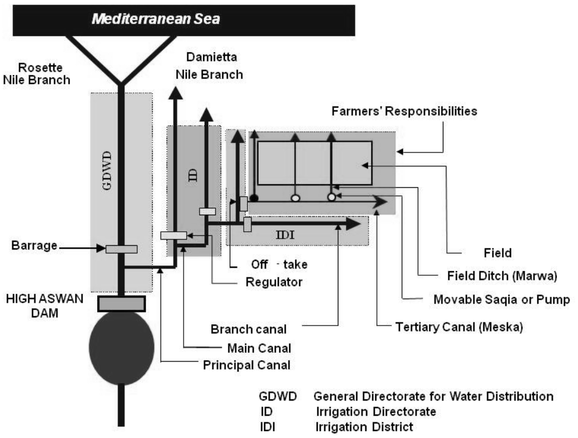

Fig. 2 schematic layout of irrigation systems in Nile Delta Egypt

TABLE I
LIST OF SUMMARIZED DATA OF SELECTED IRRIGATION DISTRICT AND ITS IRRIGATION SYSTEMS

No.	Irrigation District	Location	Area Serviced (ha)	Irrigation System	New Tools	Notes
1	Kafr El-Shakh	Head	42,600	Dakalt	Downstream control gates (AVIS)[a]	This system is divided into three reaches by these gates. (Fig. 4 a)
2	El-Reyad	Middle	38,000	Baseis		
3	Sidi Salim	Tail	68,200	Shalma	Automation system	The head regulator of canal was operated under automation system. (Fig. 4 b)

[a] AVIS is a French acronym for an automatic downstream hydro-mechanical gate working in an open channel

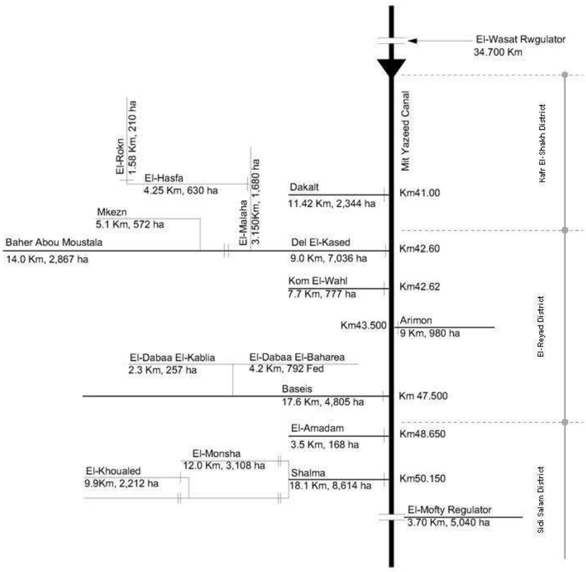

Fig. 3 schematic outlines of the water delivery canals in the study

Before improving the system in the study area, the branch and distributaries canals system were operated according to agricultural rotation principal. There are two systems of rotation; two-turn rotation and three-turn rotation. Under the two-turn rotation, the canal system is divided into two groups. Each group is opened for 7 days and closed for another 7 days resulting in a length of irrigation interval of 14 days. The rotation system for rice is usually two-turn rotation with 4 days on and 4 days off. Under the three-turn rotation, the canal system is divided into three groups. Each group is opened for 5 days and closed for another 10 days giving an irrigation interval of 15 days. The demand delivery system is applied after improved the system.

The basis is downstream control of irrigation network, although downstream control does not necessarily mean demand scheduling. The discharge is controlled by the end user from downstream end of the system. The advantages of demand delivery are that water can be supplied to crop at the optimum time and when farmer finds it most convenient. This offers the chances of increased crop yield, a reduction in water wastage and a consequent reduction in problems of salinity and drainage. It means a free choice of crops as long as water is available, but also an increased capacity of the downstream end of the system [9]. Table II presents comparison of type's delivery concepts.

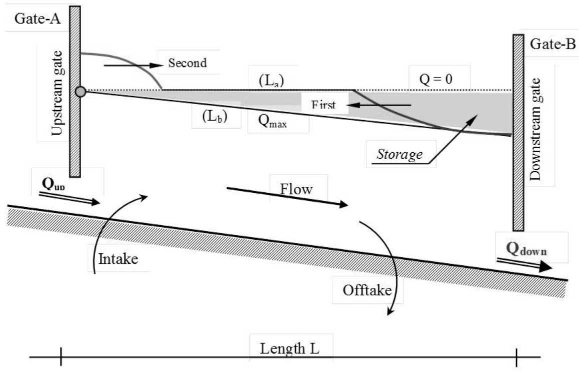

Fig. 4 (a) automatic downstream controls gates

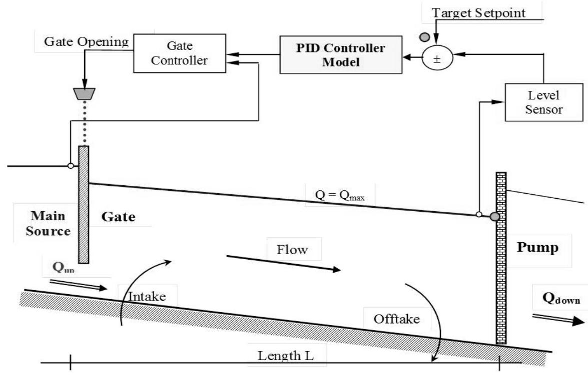

Fig. 4 (b) using telemetry control technology

D.Determination of Performance Indicators

Water Delivery Performance: Water delivery performance through irrigation networks level of irrigation district was determined according to the indicators of adequacy, efficiency, equity, and dependability [5].

TABLE II
COMPARISON OF TYPES DELIVERY CONCEPTS [10]

Consideration	Rotation	Demand
User convenience	Poor	Excellent
Irrigation flexibility	Poor	Excellent
Water use efficiency	Low	High
Ease of canal operation	Easy	Difficult
Complexity of control system	Simple	Complex
Design capacity of canal	~ 40%	~ 80%

Adequacy Indicator: Distribution of required amount (P_A); the objective of adequacy states the desire to deliver the required amount of water over the command area served by the system.

$$P_A = 1/T\sum_{T=1}^{T}\left(1/R\sum_{R=1}^{R} p_A\right), \text{ where } p_A = Q_D/Q_R, \quad \text{if } PA > 1 \; PA=1 \text{ or if } PA < 1 \quad PA \tag{1}$$

Efficiency Indicator: Conservation of water resources (P_F); the objective of water distribution efficiency embodies the desire to conserve water matching water deliveries with water requirement.

$$P_F = 1/T\sum_{T=1}^{T}\left(1/R\sum_{R=1}^{R} p_F\right), \text{ where } p_F = Q_R/Q_D, \quad \text{if } PF > 1 \; PF=1 \text{ or if } PF < 1 \quad PF \tag{2}$$

Equity Indicator: Distribution of fair amount (P_E); if equity were interpreted as spatial uniformity of the relative amount of water distributed, then an appropriate measure of performance relative equity would be the average relative spatial variability of the ratio of the amount distributed to the amount required over the time-period of interest.

$$P_E = 1/T\sum_{T=1}^{T}\mathrm{CV}_R\left(Q_D/Q_R\right), \text{ where } CV_R = \text{Spatial coefficient of variation of ratio } Q_D/Q_R \text{ over the region } R \tag{3}$$

Dependability Indicator: Uniform distribution over time (P_D); an indicator of the degree of dependability of water distribution is the degree of temporal variability in the ratio of amount distributed to amount required that occurs over a region.

$$P_D = 1/R\sum_{R=1}^{R}\mathrm{CV}_T\left(Q_D/Q_R\right), \text{ where } CV_T = \text{Temporal coefficient of variation of ratio } Q_D/Q_R \text{ over the time } T \tag{4}$$

The lower values of variation coefficient (CV) give the higher indicators values. So, the ratio of Q_D to Q_R in these indicators will be unity when the water delivery will be over than demand. Equity and dependability indicators will recalculate depended on this changing in (5) and (6), respectively.

$$P'_E = 1/T\sum_{T=1}^{T}\mathrm{CV}_R P' \tag{5}$$

$$P'_D = 1/R\sum_{R=1}^{R}\mathrm{CV}_T P' \tag{6}$$

where $p' = Q_D/Q_R$, if P' > 1 P'=1 or if P' < 1 P'

The indicators compare the volume of water delivery (Q_D) with water required (Q_R) of a certain region (R) during a certain time (T). Spatial averages are weighted against the surface of the irrigation network through branch canals in order to take into account their relative importance. For this study, the region (R) consists of the total area covered by the selected samples and the period (T) covers seven months of winter season (October-April) and also covers five months of summer season (May-September). Therefore, water delivery and requirement were calculated overall interval of two weeks for branch canals. From the computed values, performance was classified as "good", "fair", or "poor" according to Molden and Gates.

TABLE III
EVALUATION CRITERIA FOR EACH INDICATOR [5]

Measure	Performance Classes		
	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

E. Determination of Crop Water Requirements and Water Delivery

We estimated crop water requirements with the CROPWAT model of the UN's Food and Agriculture Organization (FAO), which uses Penman–Monteith methods to calculate reference crop evapotranspiration [11]. Crop coefficients for the major crops were developed from FAO's Irrigation Manual [12] and water application efficiency (by surface irrigation) was assumed to be 70% [13], while conveyance efficiency was assumed equal to 80% for main canal. The calculations were based on 15-day time steps that related to the cropping pattern.

But, the performance indicators used in this study require the calculation of the water volumes that were delivered to certain reaches of the sample branch canals. Such calculations were not possible unless continuous discharge records were available. Since the water levels were continuously monitored using automatic water level recorders (OTT Thalimedes, Hydromet-Germeny) at upstream and downstream of head regulator for selected branch canals, and then, it was important to establish a relationship between the water levels and the discharges such that the continuous records of water levels can be converted to continuous records of discharges as precisely as possible. These flow heights were converted into discharge using individual rating curves of each point. The rating curves of these canals, constructed to standard geometric shapes. These curves were checked at each measurement point by using the flow velocities measured by current meter, and the area of flow cross section as present in Table IV.

TABLE IV
HEAD DISCHARGE RELATIONS FOR HEAD REGULATORS[a]

No.	Canal	Status	Relation	R^2
1	Dakalt	Submerged	$Q/H^{0.5} = 5.65 \times GO - 0.05$	0.84
2	Basies	Submerged	$Q/H^{0.5} = 9.09 \times GO - 0.84$	0.87
3	Shalma	Submerged	$Q/H^{0.5} = 12.63 \times GO - 0.22$	0.92
		Free	$Q = 0.07 \times WL^{6.67}$	0.77

[a] R^2 = Correlation Coefficient; Q = Discharge (m^3/sec); WL = Water Level (m); H = Head Level (m); and GO = Gate Opening (m)

III. RESULTS AND DISCUSSION

A. Cropping Pattern and Values of Q_D and Q_R

Table V depicts as percentage of the cropping patterns for Wasat command area at the sample branch canals during two irrigation seasons consecutive (2004 and 2007). The major crops for summer season are rice, cotton, and maize, while for winter season are alfalfa, wheat, and sugar beet in the study area, and the areas of the secondary crops' lumps summed together as "others". The maximum legal rice quota is 50% of a branch canal's command area [2], while the rice areas in head location accounted for over 55% of the area during before improvement, and increased to 63% in 2007.

In other side, the crop rate in middle and tail locations was fixed through irrigation season. For cotton crop, the increasing of crop was luck for Dakalt canal, which its area of cotton was increased to 30% after improved against maize crop. Alfalfa is the most favorable winter crop to many farmers since it can either be used as fodder or sold for cash, especially in middle and tail locations. While in head location, this crop was decreased after improved systems. Wheat occupied between from 28% to 44% of cropping before improved and after that it was decreased through all locations. Sugar beet is the third main winter crop due to its cash value as it is sold to the sugar factories there. Its rate was almost fixed.

TABLE V
IRRIGATED CROP PATTERNS OF BRANCH CANALS IN 2004 AND 2007

Crops	Branch Canals					
	Head		Middle		Tail	
	(Dakalt)		(Baseis)		(Shalma)	
(%)	2004	2007	2004	2007	2004	2007
Rice	57	63	44	41	52	52
Cotton	19	30	14	18	32	38
Maize	13	3	17	4	8	3
Citrus	0	0	2	2	0	0
Other (Sum)	11	4	23	35	8	7
Total	100	100	100	100	100	100
Alfalfa	37	27	22	29	26	36
Wheat	40	28	28	20	44	36
Sugar Beet	16	15	18	18	24	15
Citrus	0	0	2	2	0	0
Other (Win)	7	30	30	31	6	13
Total	100	100	100	100	100	100

Q_D and Q_R for the selected branch canals are given in Table VI. The water delivery in summer season was higher than winter season due to control for operation in regulators according to less water demand for winter crops. While in summer season, the gates were opened continuous owing to the greater demand by large proportion of paddy field. The water supply was increased after improved system at downstream main canal and that impact positively on middle and tail locations of branch canals. It is noticeable that the water delivery for the branch canals after the development was equal of values among themselves, which indicated that the automation system through a network of irrigation water is distributed evenly among the districts of irrigation in the same time. While the system before development, the rotation system shifts are given in the head of irrigation district provided its full without taking into account; there are other districts of irrigation. Overall, the water requirement was higher than the water supply before and after improvement owing to the location area at the end of the irrigation system in the Nile Delta and a consistent water shortage.

TABLE VI
Q_D AND Q_R VALUES BY BRANCH CANALS IN 2004 AND 2007

Season	Month	Branch Canals					
		Head		Middle		Tail	
		m^3 / ha					
		Q_D	Q_R	Q_D	Q_R	Q_D	Q_R
Sum 04	May	1,235	1,680	1,016	1,571	1,017	1,768
	Jun	1,947	1,968	1,080	1,777	1,481	2,074
	Jul	2,066	2,243	939	2,133	1,231	2,269
	Aug	1,783	2,092	948	2,070	1,366	2,030
	Sep	621	1,118	792	1,069	734	1,048
Win 04/05	Oct	941	267	393	394	446	241
	Nov	700	461	544	490	439	445
	Dec	841	338	622	360	284	331
	Jan	313	407	274	413	261	418
	Feb	942	521	597	434	328	567
	Mar	856	834	488	763	525	978
	Apr	693	804	700	817	517	949
Sum 07	May	1,088	1,859	1,047	1,760	993	1,852
	Jun	1,725	2,183	1,315	1,866	1,307	2,160
	Jul	1,707	2,322	1,493	2,127	1,137	2,293
	Aug	1,474	2,053	1,653	2,037	1,332	2,003
	Sep	691	1,108	736	1,037	599	1,026
Win 07/08	Oct	904	393	725	432	655	304
	Nov	879	495	414	494	640	472
	Dec	615	362	325	369	449	345
	Jan	339	412	754	412	510	407
	Feb	368	390	628	421	389	477
	Mar	1,012	658	1,131	763	724	808
	Apr	759	681	1,123	937	1,835	873

B. Water Delivery Performance of the System

This section analyzes the water delivery performance by Molden's indicators at the delivery systems in 2004's months before improved, and 2007's months after improved as spatial function that presented as line chart. While, the difference from head to tail of irrigation systems is analyzed as temporal function that is presented as column chart in Fig. 5.

1. Spatial Values of Performance Indicators

The adequacy values for spatial function are given in Fig. 5 (a, b). The highest *P*A values before improvement were found in June month at summer season around 0.8, and between October to December months at winter season around 0.9 to 1.0. For after improved system, the values of *P*A were almost fixed to range from 0.6 to 0.7 through summer months and 0.9 to 1.0 through winter months. According to these values, the performance of water delivery among irrigation districts to water demand are fixed after improved its system in both irrigation seasons. Although, the values of *P*A are poor degree at summer season that is a normal case because this area locates in end of irrigation waterway in Nile Delta and faces water shortage during all the time due to cultivate paddy rice.

However, the automation systems succeed to keep the ratio of available water delivery to water demand among irrigation districts through the months of seasons, while rotation system gave good degree at beginning of each season and after that changed to poor degree through season. The reason is water demand for any crop in mid and/or ends its season that is higher than its season beginning.

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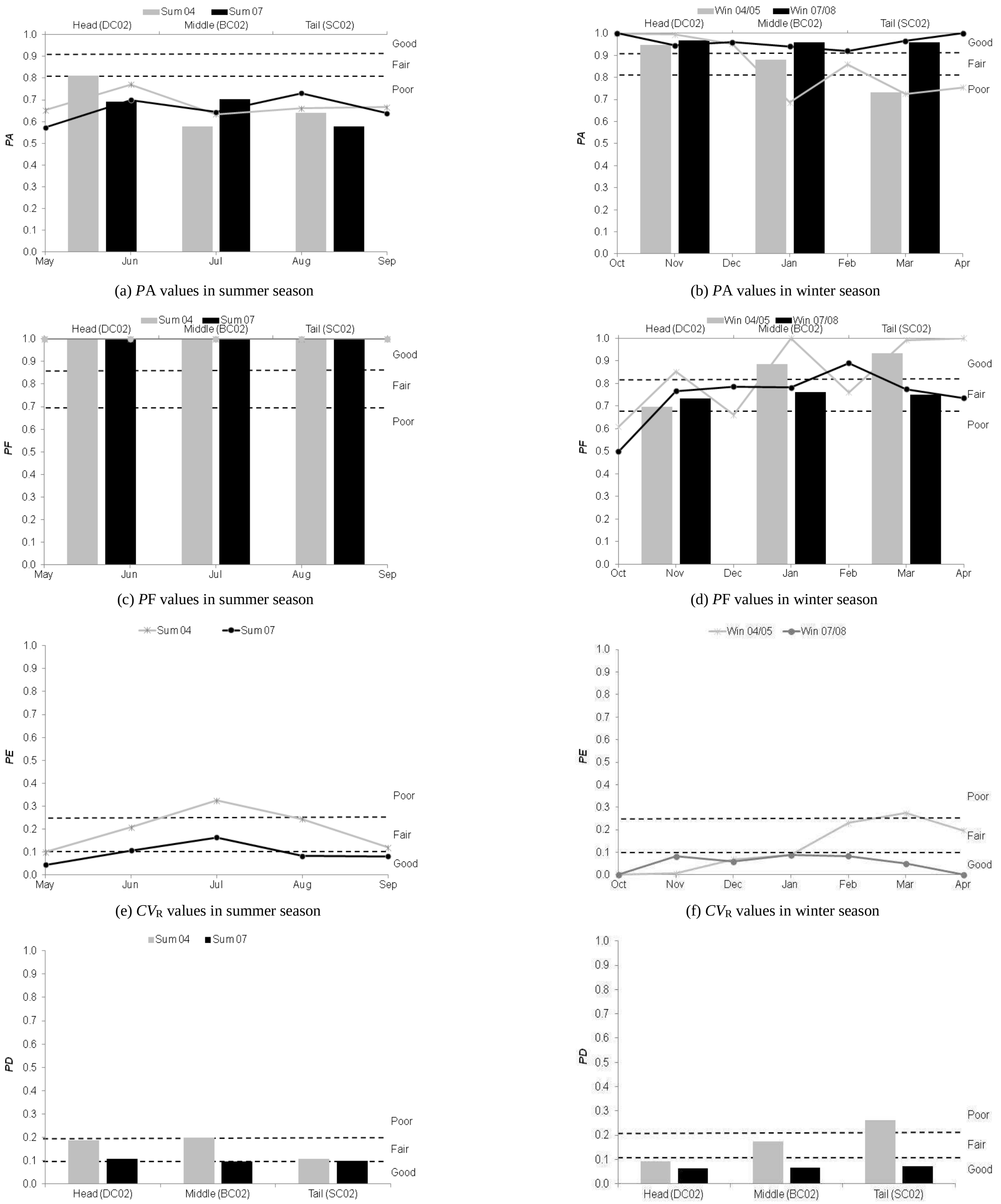

(a) *P*A values in summer season

(b) *P*A values in winter season

(c) *P*F values in summer season

(d) *P*F values in winter season

(e) CV_R values in summer season

(f) CV_R values in winter season

(g) CV_T values in summer season

(h) CV_T values in winter season

Fig. 5 spatial and temporal values of *P*A, *P*F, CV_R, and CV_T for irrigation seasons 2004 and 2007

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Spatial values of *P*F closed to 1.0 through all months in all summer seasons that indicated not good efficient water but water shortage and cultivate intensive paddy crop in Fig.5 (c). For the system before improved in winter season, the values were fluctuated through months for season in Fig.5 (d). This, the lowest value of *P*F was 0.6 in October month, and the highest value was 1.0 in end of winter season. This rate is between good and fair degrees due to operate according to agricultural rotation principle among delivery canals, and there are not control points to distribute water among them and the most important elements of current control between irrigation district and next under the dependence of water level. While after improved, the rate is fair through all months due to equal efficiency of automation gates of irrigation system at all time, and all irrigation systems were irrigated in same days.

For the system after improved, the values of CV_R of Q_D/Q_R were good degree through irrigation season as presented Fig. 5 (e, f), which, the values were lower 0.1 through months of irrigation seasons. This result indicates the water delivery of a fair share to irrigation systems throughout irrigation districts due to active functions of new gates to operate under right to use a specified amount depend on the demand downstream. As for system before unimproved, the values of CV_R of Q_D/Q_R were between fair in summer seasons and fair or poor in winter seasons due to not apply fair share water that based on a legal right for water by is done in many rotational delivery schemes.

2. Temporal Values of Performance Indicators

For the system before improved, the temporal values of *P*A in summer or winter seasons for head location were higher than other locations, as shown in Fig. 5 (a, b). This is a natural fact for available water in the head irrigation district at the main canal by using a rotation system among other irrigation systems. The grade of *P*A for head location in summer season was fair and other locations were poor, while for winter season, it was good, fair, and poor for locations arranged, respectively. For the system after improved, the values of *P*A at different locations through irrigation seasons were fixed, except tail location in summer season. It indicates success of the operating automation gates under capacity of water required in downstream through irrigation systems and the chance of irrigation among irrigation district become the same, especially the tail location. The grade of *P*A for all locations in summer season was poor due to absence crop planning among them, and was good in winter season due to available water deliver.

From Fig. 5 (c), the temporal values of *P*F in summer season for the system before and after improved were good degree not because of more efficient water use by operation irrigation systems, but because of water shortages during this season. For winter season as shown in Fig. 5 (d), the values of *P*F for the system before improved for head location were 0.7 that indicate to deliver more the water to irrigation system than required, in contrast, to other locations were facing water shortage.

There is no cooperation or participation clear among irrigation districts in the operation. For the system after improved, the values of PF were fixed around 0.73 among irrigation systems. Although, the values of PF are fair degree at winter season that indicated the application efficiency through automation gates was high and effective.

CV_T temporal average values were closed to 0.2 for the system before improved (Fig. 5g and h), the dependability performance of all three irrigation systems is poor. While for system after improved, the values of CV_T were closed to 0.1 in summer season and 0.08 in winter season, and in addition, there were same values among them through irrigation season. So, the dependability performance is good for all irrigation systems. The reason is the successes of applying continuous flow through a main canal than a rotation system that applied before. That mean, the farmers in a different irrigation system can plan for a dependable delivery of an inadequate supply of water by growing different crops at any time.

3. Average Values of the Performance Indicators

Average values of four performance indicators are presented for system before and after improved in Table VII. *P*A was below 0.8 in summer seasons, and closed 0.85 before improved and over 0.9 after improved in winter season. *P*F was 1.00 in summer seasons, and closed to 0.84 before improved and 0.75 after improved in winter season. For values of *P*E and *P*D for system after improved were better than before improved, which *P*E was below 0.1 for improved system in summer and winter seasons. *P*D was below 0.1 for improved system and over 0.15 for system before improved. According to the performance standard, the water delivery performance of the system before improved to adequacy, equity, and dependability were fair and poor, and the performance relative to efficiency was good. While for the system after improved to adequacy was poor in summer season and good in winter season, and the efficiency, equity, and dependability were good through summer and winter seasons. The average values of four performance indicators indicate a systemic water delivery problem before improved.

TABLE VII
WATER DELIVERY PERFORMANCE OF IRRIGATION BEFORE IMPROVED 2004 AND AFTER IMPROVED 2007

	Irrigation System			
	Sum 04	Sum 07	Win 04/05	Win 07/08
*P*A	0.68	0.66	0.85	0.96
*P*F	1.00	1.00	0.84	0.75
*P*E	0.20	0.10	0.12	0.05
*P*D	0.16	0.10	0.18	0.07

The reasons are these irregularities in the use of a rotation system among irrigation districts due to the presence of a human in the operating and problems in operation of head regulators as damage or rickety and need to routine maintenance. However, for the system after improved, the using automation operation for water delivery among irrigation systems was improved water delivery performance by improved fair share among irrigation districts through irrigation periods and performed in a consistent manner may be considered dependable.

Nevertheless, there is a complete absence in the crop composition among the districts of irrigation before and after improved system, even after the development and lack of commitment by government limits.

IV. Conclusion

In this study, the water delivery performance among irrigation districts at downstream of El-Wasat regulator was evaluated by comparison irrigation networks by before and after improved systems according to the indicators of adequacy, efficiency, equity, and dependability that proposed by Molden and Gate (1990). Spatial and temporal distributions of delivered and required water were to calculate these indicators. Based on the evaluation of indicators in this study, it can be concluded that the increase in the number of irrigation districts in one main irrigation network system is difficult to continuous monitoring of the water management and distribution among them by using rotation delivery system because there are not control points to distribute water among them and the most important elements of current control between irrigation district and next for equitable distribution under the dependence of water level. As a result, the water delivery performance for irrigation system in tail locations of main canal level was worse than in head location. So, the operation of irrigation system by rotation system was unsuitable for irrigation districts that located in end of large irrigation network in Nile Delta. The main reasons for this result are water shortage in study area during irrigation seasons and absence of crop production planning among different locations of main canal, especially rice cultivation in summer seasons. In addition, there is no cooperation or participation clear among irrigation districts in the operation and coordination in the distribution of water delivery among them and proof of that irrigation district in head location, take its full and up, while the rest district are faced with the inability constant of water throughout the seasons of irrigation if the summer or winter. But applying demand delivery flow through irrigation networks by using automation systems, it is improved water delivery performance to equal share water among them during irrigation periods. As a result of cancellation of the human element in controlling the distribution of water among them according to water needs in downstream, despite the occurrence of the region at the ends of the irrigation networks. Nevertheless, there is a complete absence in the crop composition among the districts of irrigation before and after improved system, even after the development and lack of commitment by government limits.

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