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# Examining an Egyptian Irrigation Network Using MASSCOTE Approach

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## ABSTRACT

Improving the irrigation system, and in consequence the irrigation efficiency became an essential issue with the limitation of water resources, and defining the optimal strategy to improve the irrigation system depend on the accurate investigation of this system. The objective of this study is to investigate different components of the Egyptian irrigation system. A typical command area at the north of the Middle Delta (Mit Yazid command area) was selected to represent the Egyptian irrigation network, and MASSCOTE approach was used as an assessment tool. Mapping System and Services for Canal Operation Techniques (MASSCOTE), which was developed by FAO, is a pre-improvement evaluation approach. The approach provides a systematic way to evaluate any irrigation system, which gives a chance to compare this system with other irrigation systems. The approach consists of ten steps in two categories. The first category investigates the irrigation system, and the second category introduces the modernization suggestions based on the results of the first part. The current study applied the first category, which contained applying Rapid Appraisal Procedure (RAP), checking the capacity of the irrigation system, and assessing the sensitivity and perturbation at different control structures.The assessment defined the specific weakness of the irrigation system and it showed that irrigation performance decrease significantly at the lowest level of the system. The reasons for such decrease and the effect of Irrigation Improvement Project on improving the performance were discussed.

**Keywords:** MASSCOTE, Water Management, Irrigation Improvement Projects

## INTRODUCTION

With limited, and even threatened, water resources, and rapidly increased water demand, Egypt is expected to face severe water shortage problem. According to Mostafa and Fujimoto (2015), "The total water used from various sources in Egypt is about 76.5 billion m$^3$. The Nile River supplies 73% of this demand directly, while the remainder mostly comes indirectly from the Nile (the reuse)." The feasible solution to decrease the gap between water supply and water demand is the enhancement of water utilization, which requires the improvement of the irrigation system. In a vast irrigation system, such as the Egyptian irrigation system, it is important to precisely define the weaknesses of the system, to be able to improve the system with limited budget and time. Most of pre-improvement studies or evaluation programme focused on specific intervention, such as the improvement of tertiary level (Mesqa improvement), or the establishment of Water Users Associations.

Having a systematic way to assess the irrigation systems precisely and in comparable way with other irrigation systems is a useful tool to define the weaknesses of these irrigation systems and the optimal way to tackle these weaknesses. Mapping System and Services for Canal Operation Techniques (MASSCOTE) approach provides such tool. MASSCOTE approach has been developed on the basis of extensive experience with irrigation modernization programmes in Asia between 1998 and 2006. The approach aims to organize the development of modernization programmes through a systematic methodology that includes mapping various system characteristics, delimiting institutionally and spatially manageable subunits, defining the strategy for service and operation for each subunit, and then aggregating and consolidating the canal operation strategy at the main system level.

The approach, which was applied for many irrigation networks in different countries, has specific indicators that could set the investigated irrigation network in the general perspective compared to other irrigation networks in the world, which could help defining the required interventions during the improvement of this irrigation network.

In 2009, FAO activities has conducted on irrigation modernization in the Near East region (Syria, Egypt and Jordan). The activities started by investigating Mounshaat-Al-Asad irrigation scheme in Syria using MASSCOTE approach by some FAO members and with the contribution of some members from the three countries. The plan contained applying the approach in irrigation schemes in Egypt and Jordan (FAO, 2009). In Egypt, the investigated irrigation networks by MASSCOTE approach was Mit Yazid command area, which was investigated by some experts from FAO with some researchers and engineers from Egypt in 2010. Mit Yazid is currently improved irrigation network. Irrigation improvement has started in this command area since the middle of 1990s, and by the time of applying MASSCOTE approach, the second phase was started. The investigation referred to the old system.

The investigation was performed through visiting many sites of the irrigation network, collecting required information from workers, techniques, and farmers in these sites, and analysing the historical data of Mit Yazid command area. Collected information was discussed with administrators at different districts and irrigation directorates.

The current study presented the results of the first few steps of MASSCOTE approach. Other steps will be covered in other studies.

## MATERIALS AND METHODS

The methodology of the current study followed MASSCOTE approach as it was presented in FAO literature (Renault *et al*., 2007). The first and main step of the approach was applying Rapid Appraisal Procedure (RAP). RAP has specific indicators to evaluate the performance of the irrigation system. The value of each indicator is defined based on some specific items. Each item has a weight (importance factor), and a value that is selected based on the situation regarding this item. For example, the indicator that refers to "Actual water delivery service at the most downstream point in the system operated by a paid employee" depends on five items. The weight of first item, which is "Number of fields downstream of this point", is 1.0. The weights of the other items, which are measurements of volume, flexibility, reliability, and apparent equity, are 4.0. The value of the first item (Number of fields downstream of this point) is selected from five cases, each case have a value from zero to 4.0.

The lowest value (0.0) refers to ten fields or more, downstream this point. The highest value (4.0) refers to only one field downstream this point. The procedure is performed for all items. Multiplying the value of each item by its weight and dividing the result by the summation of the weights bring the average value of this indicator. For capacity, sensitivity and perturbation, the collected information is analyzed as will be described later while discussing these steps.

**Study Area**

The current study was performed in Mit Yazid command area at the north of the Egyptian irrigation network (Figure 1). The canal is 63.0 km long and it serves around 82,740 ha. Mit Yazid canal serves three irrigation directorates, El-Gharbiya irrigation directorate at the upstream and East Kafr El-Sheikh irrigation directorate and West Kafr El-Sheikh irrigation directorate at downstream. The official border is Beltag regulator (km 21.600). Based on previous studies (WMRI 2008 & WMRI 2014), the main characteristics of Mit Yazid canal is the inability of the system to convey the required water supply during summer season due to some infrastructure problems downstream Beltag regulator, besides the increase of rice ratio compared to its design ratio. Therefore, there is a high dependence on the drainage water at tail end region. In addition, and based on Molle, *et al*., (2013), the other characteristics include the high ratio of direct irrigation, against the expected in the carrier canals, and the considerably small ratio of municipal water consumption (3~5% of total water supply).

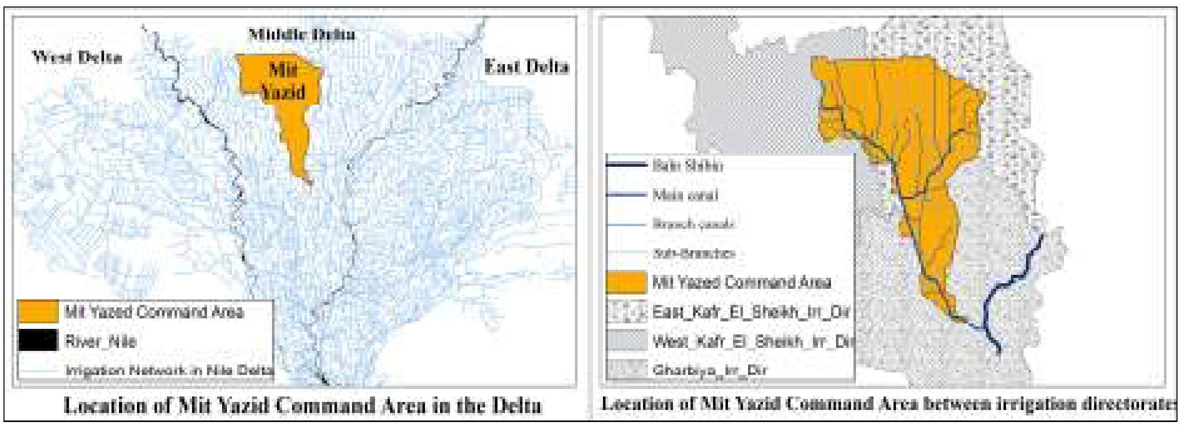


**Fig. 1. Location of Mit Yazid in the Delta and between the irrigation directorates**

**Applying MASSCOTE approach**

**First step (Applying RAP)**

RAP (Rapid Appraisal Procedure) is a quick and focused examination of irrigation systems and projects. RAP consists of external and internal indicators. External indicators express the efficiency and the production. Internal indicators assess operational procedures, water management and institutional setup.

Regarding the external indicators, figure (2) presents land productivity for 56 irrigation networks including Mit Yazid command area (Wahaj, R., 2013).

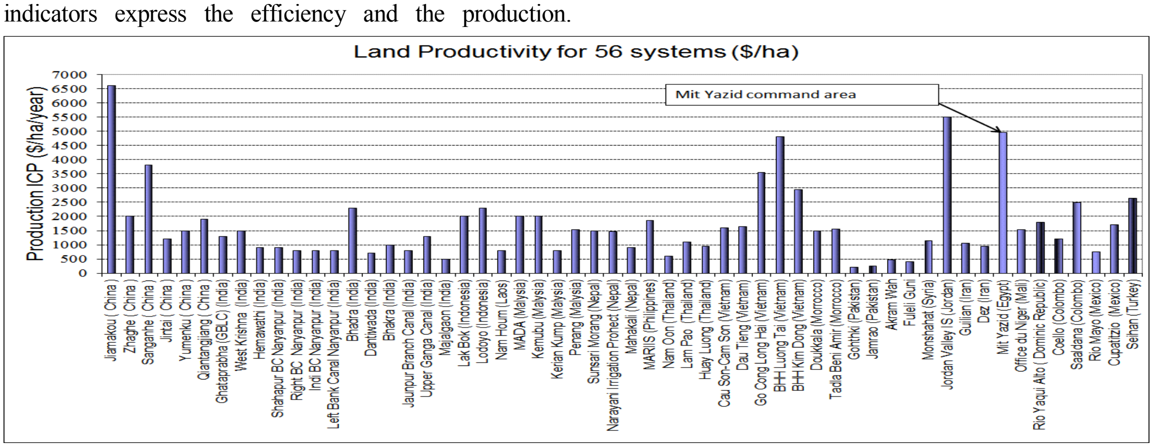


**Fig. 2. Land productivity for 56 irrigation system including Mit Yazid (After Wahaj, R., 2013)**

Internal indicators investigate the performance of the irrigation system. Tables (1 to 4) present the main results of the internal indicators for Mit Yazid command area and the corresponding values for comparative irrigation networks. The values for comparative irrigation networks was collected from Facton, T., (2006).

Table (1) presents indicators values for water delivery service for three levels, and Table (2) presents the items that were used to calculate the average value of each indicator. The concern of this part is to assess the adequacy, reliability and timeliness of receiving water for different levels of the irrigation network and for water users in particular. From Table (1), the values of Mit Yazid were lower than the average values of comparative irrigation networks, especially for lower levels.

**Table 1. Indicators for water delivery service in Mit Yazid and comparative irrigation networks**

| Variable | Other Irrigation Networks | | | Mit Yazid (Egypt) |
|---|---|---|---|---|
| | Max | Min | Average | |
| Actual water delivery to individual ownership | 3.10 | 0.50 | 1.87 | 1.10 |
| Actual water delivery to most downstream point operated by paid employees | 3.10 | 0.40 | 1.63 | 0.80 |
| Actual water delivery from main canal to second-level canals | 3.10 | 0.40 | 2.22 | 1.70 |

**Table 2.Values and weights for different items that used to asses water delivery service**

| Actual water delivery to individual ownership | | | Actual water delivery to most downstream point operated by paid employees | | | Actual water delivery from main canal to second-level canals | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Value | Weight | Variable | Value | Weight | Variable | Value | Weight |
| Measurement of volumes | 0.00 | 1.0 | Number of fields downstream of this point | 0.00 | 1.0 | Flexibility | 1.50 | 1.0 |
| Flexibility | 1.00 | 2.0 | Measurement of volumes | 0.00 | 4.0 | Reliability | 2.00 | 1.0 |
| Reliability | 1.50 | 4.0 | Flexibility | 1.00 | 4.0 | Equity | 1.00 | 1.0 |
| Apparent equity | 1.00 | 4.0 | Reliability | 1.50 | 4.0 | Control of flow rates to the submain as stated | 2.00 | 1.5 |
| | | | Apparent equity | 1.00 | 4.0 | | | |

From Table (2), the performance of the first indicator (Actual water delivery service to individual ownership) depended on four items, which were volume measurements, flexibility, reliability, and apparent equity, and the weight (importance) for each point was different. The most important items were reliability and apparent equity, and the lowest was measuring water volume. Second indicator (Water delivery to most downstream point operated by paid employment), which considered the Mesqas (small ditches with average served area of 20 ha) in this study, included additional item, which was the number of fields downstream this point. The weight of this item (1.0) was lower than the weights of other items (4.0).

In the RAP, defining the value for each item depends on selecting between given cases as explained in the methodology. For the system flexibility, the closest case was "Rotation deliveries, but on a somewhat uncertain schedule" as water was not reaching some parts during the rotation period. This case has the value of (1.0). For reliability, the closest case was "Volume is unknown, and deliveries are fairly unreliable - but less than 50% of the time", which has the value (1.0) as there was no calculation for water volumes at this level and water was not reaching the fields or the end of the Mesqas at required time for less than 50% of the time. The indicator of water delivery service from main canal to second-level canals was considerably higher than the indicators for the other two levels. The weak item was the equity as there is a considerable difference between water supply at head and tail end regions.

The second part after water delivery service, was describing the performance of different levels of irrigation system. RAP has three levels of the canals, and in the current study, these three levels were used for main canal, branch canals, and Mesqas. Table (3) presents the values for different indicators. Indicators values decreased significantly in the third level (sub-branches and Mesqas) than the main and second-level canals. This was the case in Mit Yazid canal as it was the case in comparative irrigation networks.

However, the values of Mit Yazid network for this level were considerably lower than the corresponding values in comparative irrigation networks. For the main and second-level canals, the values of Mit Yazid were lower than the corresponding values of comparative irrigation networks for some indicators, and higher in other indicators.

Table (4) presents the values of different items that were used to calculate these indicators. For instance, the cross regulators indicator contains four items, which are ease of operation, level of maintenance, lake of water levels fluctuation and travel time of flow rate change through the canal. For ease of operation, as an example, the cross regulators of the main canals had the value (3.0), which refers to the condition "Easy and quick to physically operate, but requires many manual interventions per structure per day to meet target." The cross regulators of the second-level canals had the value (2.0), which refers to the condition "Cumbersome to operate, but physically possible." For the last component of the cross regulators (Travel time of a flow rate change throughout this canal level), the value of second-level canals was higher than the value for the main canals as it takes less time for the change of the flow rates by the cross regulators to reach the last point of the canal.

**Table 3. Indicators for the performance of different levels of irrigation canals in Mit Yazid and comparative irrigation networks**

| Variable | | Other Irrigation Networks Max | Other Irrigation Networks Min | Other Irrigation Networks Average | Mit Yazid (Egypt) |
|---|---|---|---|---|---|
| Main Canal | Cross regulators | 3.60 | 0.70 | 2.10 | 2.10 |
| | Communications | 3.80 | 1.20 | 2.39 | 2.50 |
| | General conditions | 3.40 | 1.00 | 2.46 | 1.80 |
| | Operations | 4.00 | 0.10 | 2.22 | 2.30 |
| Second-Level Canal | Cross regulators | 3.90 | 0.60 | 2.00 | 1.40 |
| | Communications | 3.30 | 0.50 | 2.07 | 2.10 |
| | General conditions | 3.40 | 1.00 | 2.30 | 1.40 |
| | Operations | 4.00 | 0.30 | 2.44 | 1.90 |
| Third-Level canal | Cross regulators | 2.50 | 0.00 | 1.14 | |
| | Communications | 3.20 | 0.00 | 1.22 | 0.50 |
| | General conditions | 3.30 | 0.00 | 1.36 | 0.80 |
| | Operations | 3.50 | 0.00 | 1.25 | |

**Table 4. Values and weights for different items that used to assess the performance of different levels of irrigation canals**

| Cross regulators | | | | | | |
|---|---|---|---|---|---|---|
| Variable | Main Canals | | Branch Canals | | Third Level | |
| | Vale | Weight | Vale | Weight | Vale | Weight |
| Ease of cross regulator operation under the current target operation | 3.0 | 1.0 | 2.0 | 1.0 | | |
| Level of maintenance of the cross regulators | 2.0 | 1.0 | 2.0 | 1.0 | | |
| Lack of water level fluctuation | 2.0 | 3.0 | 0.0 | 3.0 | | |
| Travel time of a flow rate change throughout this canal level | 2.0 | 2.0 | 3.0 | 2.0 | | |

| Communications | | | | | | |
|---|---|---|---|---|---|---|
| Variable | Main Canals | | Branch Canals | | Third Level | |
| | Vale | Weight | Vale | Weight | Vale | Weight |
| Frequency of communications with the next higher level? (hr) | 2.0 | 2.0 | 2.0 | 2.0 | 1.0 | 2.0 |
| Frequency of communications by operators or supervisors with their customers | 3.0 | 1.0 | 3.0 | 1.0 | 1.0 | 2.0 |
| Dependability of voice communications by phone or radio | 2.0 | 1.0 | 2.0 | 1.0 | 0.0 | 3.0 |
| Frequency of visits by upper level supervisors to the field | 3.0 | 1.0 | 3.0 | 1.0 | 1.0 | 1.0 |

| General conditions | | | | | | |
|---|---|---|---|---|---|---|
| Variable | Main Canals | | Branch Canals | | Third Level | |
| | Vale | Weight | Vale | Weight | Vale | Weight |
| General level of maintenance of the canal floor and canal banks | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| General lack of undesired seepage (note: if deliberate conjunctive use is practiced, some seepage may be desired) | 2.0 | 1.0 | 2.0 | 1.0 | 1.0 | 1.0 |
| Availability of proper equipment and staff to adequately maintain this canal | 2.0 | 2.0 | 2.0 | 2.0 | 1.0 | 2.0 |
| Travel time from the maintenance yard to the most distant point along this canal (for crews and maintenance equipment) | 1.0 | 1.0 | 0.0 | 1.0 | FALSE | 1.0 |

| Operation | | | | | | |
|---|---|---|---|---|---|---|
| Variable | Main Canals | | Branch Canals | | Third Level | |
| | Vale | Weight | Vale | Weight | Vale | Weight |
| How frequently does the head works respond to realistic real time feedback from the operators/observers of this canal level? | 2.7 | 2.0 | 2.7 | 2.0 | | |
| Existence and effectiveness of water ordering/delivery procedures to match actual demands | 2.7 | 1.0 | 1.3 | 1.0 | | |
| Clarity and correctness of instructions to operators | 3.35 | 1.0 | 2.7 | 1.0 | | |
| How frequently is the whole length of this canal checked for problems and reported to the office? | 0.0 | 1.0 | 0.0 | 1.0 | | |

For communication, there are two additional items besides the presented items in Table (4). The first item is "Existence and frequency of remote monitoring", and it had zero value for both main and second-level canals. The second is "Availability of roads", and it had the value (4.0) for main canals, and the value (2.0) for second-level canals.

For general conditions, the weak point was "Travel time from the maintenance yard to the most distant point". For second-level canals, the value for "General level of maintenance" was low as well.

For operation, the weak point for main and second-level canals was "How frequently is the whole length of this canal checked for problems?"

**Second step (Assessing the capacity of the system)**

In MASSCOTE, assessing the capacity of an irrigation system includes investigating eight items, which are storage, conveyance, diversion, distribution, control, measurement, safety and transmission of the data. The investigation results for the eight items could be summarized as follows:

- Low storage capacity is one of the characteristics of the Egyptian irrigation network, which negatively affect the reliability and the flexibility of water supply. No internal reservoirs are connected to the irrigation network, and average capacity of the irrigation canals does not exceed the flow of these canals for few days during high consumption period.
- Regarding the conveyance, conveyance efficiency is normally high in the old lands in Egypt. The main problem in Mit Yazid command area was the increase of water requirements than the design values due to the increase of rice areas. With the same infrastructures, the system cannot convey the required water supply to the tail end regions, which depend partly on the agriculture drainage water to satisfy their requirements.
- There is no diversion in Mit Yazid irrigation network. All branches are controlled by sluice gates.
- In Egypt, water is distributed volumetrically between irrigation directorates (at main canals level). To fulfill such obligation and other obligations, such as municipal requirements, irrigation directorates have to manipulate in the operation of the branch canals, where there is no volumetric distribution of the water. This resulted in fluctuated distribution of water. Downstream the head regulators of branch canals, water is controlled mainly be water use.
- The common structures to control the flow in Mit Yazid command area are the sluice gates. There were maintenance problems in many of them, and these problems increase at lower levels. The new introduced structures during the improvement project (automatic downstream control gates) were out of service.
- In the Egyptian irrigation network, water volume is measured at the borders of irrigation directorates. In Mit Yazid command area, water volume is measured downstream the head regulator and downstream Beltag regulator to define the share of different irrigation directorates. Water is distributed between branch canals by maintaining water levels downstream the head regulator without calculating the volume.
- Regarding the safety, all branch canals in Mit Yazid command area have tail escapes. Some Mesqas have dead tail end.
- The normal way to transfer the data in the Egyptian irrigation network is the phones. Gatekeepers should record water levels twice a day (at the morning and in sunset), and transfer these levels to their irrigation districts. The accuracy decreased from main canal to branch canals. Moving towards modern technology has started since 1980's with the beginning of the telemetry project, and lastly with the installation of some ultrasonic flow meters. Most of these sites were facing problems.

**Third step (Sensitivity)**

The sensitivity measures the magnitude of change in the flow due to the unit change in the level. Based on Renault (2008) "The ability to identify the locations of the sensitive points or sensitive parts of the system is of specific importance for the managers. For these points, precise operation and regular checking are recommended to minimize possible deviations." To avoid the difficulty of assessing the sensitivity, MASSCOTE suggests using the following equations:

$$S_{offtake} \approx \frac{\alpha}{Head} \qquad S_{regulator} \approx \frac{Head}{\alpha}$$

**Where:**

**$\alpha$ equals 0.5 in under structures such as sluice gates while it equals 1.5 in overshot structures such as weirs (Renault *et al*, 2007 & Renault 2008). The previous equation indicated that the sensitivity in the cross regulators decrease with the decrease of the head around the regulator. In the off-takes, the sensitivity increase with the decrease of the head.**

Figure (3) presents average sensitivity results for three cross regulators and two branches on Mit Yazid canal by analyzing the recorded water levels at these sites. The sensitivity was low at the main canal level (< 0.5), and medium (between 0.5 and 1.5) for the intakes of the branch canals. The last regulator on the main canal (El-Mofty) was considered as a head of a branch canal as the served area downstream it is about 5,040 ha. In general, there was no serious sensitivity problem in operating Mit Yazid irrigation network.

**Fourth step (Perturbations)**

Based on Renault *et al*., (2007), "Perturbation is a significant change in the flows occurring along a canal network because of external variations in inflows or outflows, changes or adjustments in the settings of structures, or transient flow during distribution changes." Renault added, "If perturbations are unavoidable, the only option for managers is to have a reliable knowledge of their origins, and to know how to detect and manage them."

In Mit Yazid irrigation network, the perturbation could be connected to the operation strategies. During high consumption period, the perturbation around the cross regulators of the main canals is small as they are open free continuously. At the head regulators of branch canals, and due to the manipulation in the operation of these canals, as explained before, the perturbation is high. The perturbation at the tail ends increases due to the changes at the head regulators besides the inability to control water use. During winter season, and as a northern area that might face instability in the weather conditions, the perturbation could increase at different levels.

Figure (4) presents water levels at the cross regulator on the main canal (Beltag cross regulator), downstream the head regulator of a branch canal (Dakalt canal), and at the tail end of this branch canal. The variance in water levels was 10 cm at Beltag regulator, 60 cm downstream the head regulator of the branch canal, and 120 cm at the tail end of the branch canal. The fluctuation of water levels could reflect the perturbation of the flow at these locations, and the results confirmed that perturbation was connected to the operation strategy as explained in the previous paragraph.

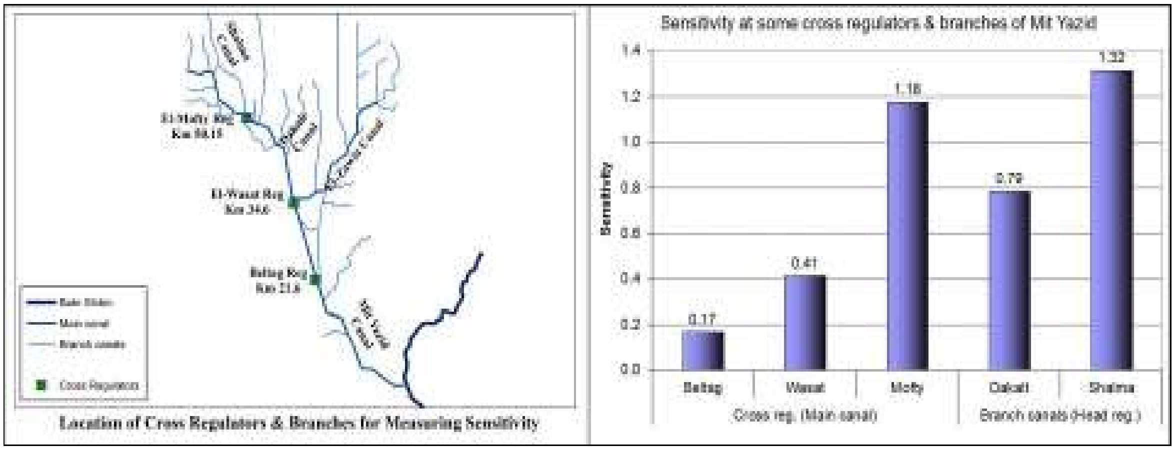


**Fig. 3. Average sensitivity values at the cross regulators of Mit Yazid canal and at the head regulators of two branch canals**

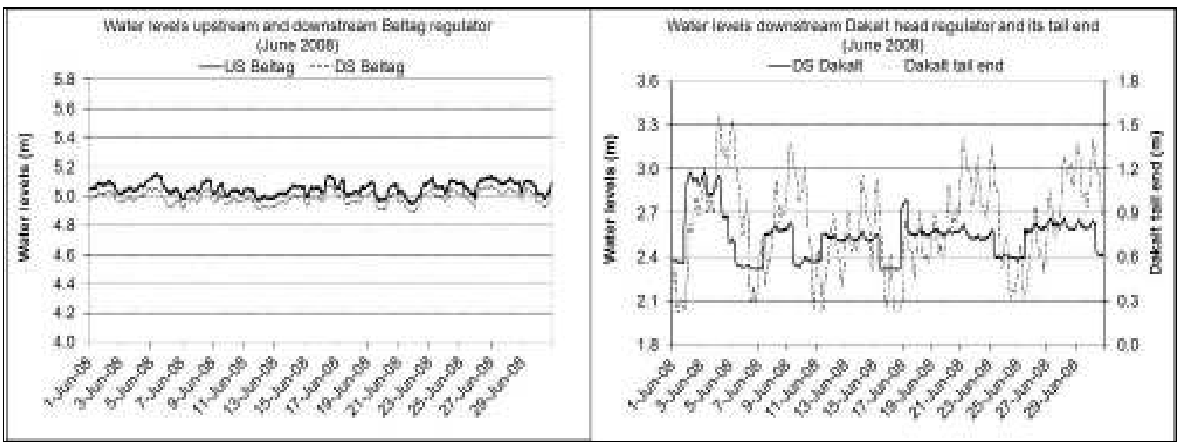


**Fig. 4. Recorded water levels at a cross regulator of Mit Yazid canal and at the head and the tail end of a branch canal during high consumption period**

## DISCUSSION

The assessment of Mit Yazid command area illustrated which elements of the irrigation system were performing well and which elements were not performing as required. Land productivity in Mit Yazid irrigation network was among the highest in the comparative investigated networks. Water productivity was less in rank than land productivity, although it is still higher than many other irrigation networks. Water productivity was the result of high conveyance efficiency, and considerably low on-farm irrigation efficiency. The performance of water delivery service at fields and Mesqas levels was considerably lower than the corresponding performance in the comparative irrigation networks, and the conditions of lower-level canals (sub-branches & Mesqas) were lower than the corresponding conditions in the comparative irrigation networks. For higher levels of the irrigation canals, the conditions were close to the conditions of comparative irrigation networks. The assessment recorded some problems regarding water distribution, control structures and flow measurements. These problems escalated in lower levels of the irrigation system. Using modern technology in water management was facing many problems as well. There was no sensitivity problem in operating the system and perturbation increased in branch canals and especially at their tail ends. In general, the performance decreased in the lower level of the irrigation network regarding different aspects.

To understand the significant reduction in the performance of lower-level canals, the characteristic of the investigated irrigation networks should be considered. Land fragmentation with the high density of the irrigation network made it very difficult to control water supply to each field, and even to each Mesqa. The old system of lifting water by animal-driven wheels (Saqias) with their limited capacities and fixed locations played this role (Plusquellec 2002). Based on Plusquellec, lifting water by Saqias "ensured a high level of equity of water allocation between head- and tail-enders and avoided over-watering of the cultivated lands." This water lifting system, with firm application of the rotation system ensured the reliability of water supply. This was the case few decades ago. The problem started with the introduction of mobile diesel pumps that was not associated with any suitable regulations for this new system. Plusquellec stated, “The situation changed dramatically with rapid replacement of traditional pumps by individually owned diesel pumps or electric pumps since the 1970s, creating large inequities of water extraction along Mesqas.” The change in water lifting technique and other changes, such as the increase of the disposal matter with the change in life standard, affected the performance of the irrigation network at different levels (El-Gamal, *et al*., 2011). As the ends of the irrigation network, and as the private canals owned by farmers and do not have regular maintenance, lower-level canals suffered more from these changes. To improve the situation at these lower-level canals (Mesqas), the continuous support and supervision is required for WUAs in the improved system, regardless the improved Mesqas were already handed over. Such support and supervision should be extended to the unimproved Mesqas and WUAs in these Mesqas after their establishment (El-Gamal, *et al*, 2014). Subsidizing is an efficient tool, and in other countries, such as Japan, the ratio of government subsidy in national irrigation and drainage projects is almost 90 % of total construction cost. Some authors believed that it is a must for success in achieving the goal of government (Satoh *et al*, 2013 & Satoh *et al*, 2014).

Since 1980’s, the government has conducted Irrigation Improvement Project (IIP) to improve these conditions, and the main activity was the replacement of open Mesqas by new lifting points with buried pipelines (improved Mesqas). Irrigation improvement project had its positive effect on Mesqa level, and it could improve irrigation performance through the Mesqa whenever water is available in the canals. However, the effect of IIP on higher levels of the irrigation network was not obvious (WMRI, 2014). IIP could not affect the higher levels of the irrigation network because the problem that was existed during the change from Saqias to diesel pumps was still existed during the change from open Mesqas to improved Mesqas, which was the disability to control water use by farmers. The movement to mobile diesel pump since 1970’s was not associated with any regulations for the adaptation with the new system, as there were no licenses that define water withdraw locations and maximum permissible values for such withdraw.

The improved system was theoretically associated with specific roles for new water organizations, which should be responsible for arranging the irrigation between farmers at Mesqas and branch canal levels. However, there was no actual implementation for these roles (El-Gamal, *et al*., 2014). Therefore, the project could not change the coordination among farmers or enhance water distribution practices, and its effect was limited to improving infrastructure and environmental conditions of the Mesqas (El-Gamal *et al*, 2014 & WMRI 2014).

Conclusions and Recommendations for future studies

The current study assessed the Egyptian irrigation system through applying MASSCOTE approach in Mit Yazid command area, as an example for the irrigation networks in Egypt. The approach, which was developed by FAO, provided a systematic way to check the performance of any irrigation system. The performance of Mit Yazid command area was assessed based on specific indicators, which were compared with corresponding values in comparative irrigation networks. The assessment highlighted the weakness for different items including water delivery service, and the performance of the irrigation canals at different levels. Assessing the capacity of Mit Yazid command area highlighted some weakness as well. In all points, the performance was worse in lower-level canals of Mit Yazid than in higher levels. Specifying the weakness of the performance for different items and at different levels is helpful to define the required interventions for improving the conditions of the irrigation network.

The reasons for the decrease in the performance of lower-level canals were discussed and it was connected to the characteristics of the irrigation system, and to the changes that affected that irrigation system during last decades. The discussion covered the effect of irrigation improvement project, as the current intervention, on enhancing the performance. The discussion showed that Irrigation Improvement Project had positive impact at Mesqa level after enhancing its infrastructure and environmental condition. However, the disability to change the irrigation practices or to adapt the arrangement / coordination between farmers restricted the effect of the improvement project on the complete system. The successful intervention should have a serious change in water distribution practices and operation strategies, by having better control on water use and by imposing volumetric distribution of water supply at branch canals level. Imposing the volumetric distribution of water supply requires fixing the problems of the operation system and the rehabilitation of the irrigation network (El-Gamal 2008 & Salah 2017).

As a future work, the results related to other steps of MASSCOTE approach should be presented for better understanding of Mit Yazid irrigation network. In addition, the approach should be applied for other irrigation networks that have different characteristics.

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## دراسة شبكة الري المصرية باستخدام أسلوب MASSCOTE

**طلعت طاهر الجمل**

**معهد بحوث إدارة المياه – المركز القومي لبحوث المياه**

الهدف من هذه الدراسة هو تقييم وتحليل المكونات المختلفة لنظام الري في مصر. وقد تم اختيار أحد الترع الرئيسية في شمال الدلتا (ترعة ميت يزيد بإدارتي الغربية وكفر الشيخ) كنموذج لشبكة الري في مصر، وتم اختيار طريقه MASSCOTE كأسلوب للتقييم. وطريقة MASSCOTE والتي هي اختصار لـ Mapping Systems & Services for Canals Operation Techniques أو (تعيين الأنظمة والخدمات لتقنيات إدارة الترع) والذي تم وضعة بواسطة منظمة الأغذية والزراعة FAO هو عبارة عن أسلوب لتقييم شبكات الري قبل تطويرها. وهذا الأسلوب هو طريقة منهجية لتقييم شبكات الري باستخدام خطوات محددة مما يتيح الفرصة لمقارنة شبكات الري المختلفة. وطريقة MASSCOTE تتكون من عشر خطوات على مجموعتين. المجموعة الأولي من الخطوات تختص بفحص شبكات الري لتحديد نقاط الضعف فيها، في حين تقوم المجموعة الثانية بتحديد متطلبات التطوير بناء على مخرجات المجموعة الأولي. وتقوم هذه الدراسة بتطبيق خطوات المجموعة الأولي من طريقه MASSCOTE على ترعة ميت يزيد كنموذج لشبكة الري في مصر. وتبدأ تلك الخطوات بتطبيق Rapid Appraisal Procedure أو (إجراء تقييم سريع) والذي يحتوي على مؤشرات محددة لتقييم أداء نظام الري، ثم يتم اختبار قدرة نظام الري وقياس حساسية منشأت الري للتغير في المناسيب ومدي تذبذب المناسيب حولها. وقد أوضحت تلك الدراسة نقاط الضعف المختلفة في شبكات الري وأوضحت أن كفاءة الأداء تقل بصورة كبيرة عند الانتقال من المستوى الأعلى (الترع الرئيسية) إلى المستوي الأدنى (المساقي والترع الفرعية)، كما ناقشت الدراسة أسباب الانخفاض في الكفاءة في المستويات الأدنى من شبكات الري وتأثير مشاريع تطوير الري على معالجة ذلك الانخفاض في الكفاءة.