



MANAGEMENT OF WATER RESOURCES IN EGYPT: CASE STUDY ON SHARKIA GOVERNORATE*

Yasser A. M. Abdullah** and Maha R. F. El-zawalaty.

Water Engineering Department, Zagazig University, Egypt

ABSTRACT

The government of Egypt is currently implementing projects that expand the new cultivated area and accordingly the supplies of River Nile to the Nile Delta will be negatively affected. So, enormous interest toward management water of resources has been taken in the Egyptian water sector. Conveyance infrastructure and irrigation technology have been gradually improved to ensure efficient distribution and utilization of scarce water resources. The present study is focused on the optimum utilization of water resources in Sharkia governorate, Egypt. Operational and Planning Distribution Model (OPDM) is applied to the selected case study (Sharkia governorate) to develop appropriate water plan. The gross revenue of all crops is correlated to surface water discharge, ground water discharge, surface water salinity, and ground water salinity. In addition, the effect of varying both of surface and groundwater quantities and qualities on the gross revenue has been investigated. Moreover, the effect of limiting rice production on the gross revenue is allocated.

KEY WORDS: Water Resources Management- Sharkia Governorate- OPDM- Crop Pattern-Surface Water- Groundwater.

GESTION DES RESSOURCES HYDRIQUES: ÉTUDE DE CAS GOUVERNORAT DE SHARKIA, EGYPTE

RÉSUMÉ

Le gouvernement de l'Égypte est actuellement mise en œuvre des projets qui élargissent la nouvelle zone cultivée et en conséquence les livraisons de Nil dans le delta du Nil sera affectée négativement. Donc, un énorme intérêt vers des ressources en eau a été prise dans le secteur de l'eau égyptienne. L'infrastructure de moyens de transport et de la technologie d'irrigation a été progressivement amélioré pour assurer la distribution et l'utilisation des rares ressources en eau. La présente étude est axée sur l'utilisation optimale des ressources en eau dans le gouvernorat de Sharkia, en Égypte. Opérationnelle et le modèle de planification de la distribution (OPDM) est mis en œuvre sur l'étude de cas sélectionnés (Gouvernorat de Sharkia) d'élaborer un plan d'eau approprié. Les recettes brutes de toutes les cultures est corrélée à la surface de décharge de l'eau, évacuation des eaux souterraines, la salinité des eaux de surface et la salinité des eaux souterraines. En outre, l'effet de la variation des quantités à la fois de surface et souterraines et des qualités sur le revenu brut a été étudiée. En outre, pour effet de limiter la production de riz sur le revenu brut est attribuée.

MOTS-CLÉS: gestion de l'eau Ressources en eau-Sharkia Pattern Gouvernorat-OPDM-Crop-surface-eaux souterraines.

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** Contact author (yasser_eng1997@zu.edu.eg).

1. INTRODUCTION

Egypt is facing increasing water needs, demanded by a rapidly growing population, by increased urbanization, by higher standards of living and by an agricultural policy which emphasis expanded production in order to feed the growing population. The main source of water in Egypt is surface water from the River Nile. Egypt's share of Nile water is fixed at 55.5 billion m³/year. Groundwater, and to a lesser extent desalination and wastewater reuse, make up the remainder, (El-Sadek et al. [7]). Water resource management in Egypt is closely linked with numerous aspects of the national economy and social stability, and at the same time has very direct effects on the health and livelihoods of many citizens. Two other management dimensions that deserve special mention are the regional hydro-politics in the Nile Basin, driven by ever stronger claims on the part of upstream countries for a higher share of the river runoff, and the increasing budgetary pressures on the water agencies, Luzi [9]. The need for effective and innovative water policies is evident, and the proposed strategies increasingly exceed the task of irrigation water distribution as traditionally performed by the Ministry of Water Resources and Irrigation (MWRI) in Egypt. Demand management was strengthened through improved irrigation techniques, drainage water reuse, groundwater development, and restrictions on water release from Lake Nasser for non-consumptive uses (Elarabawy et al., [6]; MWRI & USAID, [12]; MWRI & World Bank, [13]). Water management strategies in the 1990s still focused

mainly on water quantity issues (MWRI & World Bank, [13]), even though water pollution problems had already reached alarming levels. Water scarcity is generally defined as the situation where there is insufficient water to satisfy normal requirements of the population. This means that water scarcity is a flexible term which depends on water use. The causes of water scarcity are varied. Some are natural and others are as a result of human activities. Kenneth et al. [8] investigated the vulnerability assessment of water resources in Egypt to climatic change in the Nile Basin. Dennis [4] clarified the importance of the economic efficiency and irrigation water policy with an example from Egypt. The fresh water supply is essential and desalination is a feasible option that can cover the wide gap between the available capacities and the accelerating demands, El-sadek, [5]. Cecilia et al. [2] draw on the policy network perspective on governance to shed light on the strengths and weaknesses of watershed-based processes of collaboration and integration for water quality protection in agricultural areas. Bou-zied and El-Fadel, [1] characterize water resources in several Middle Eastern countries and evaluates regional climate predictions for various scenarios using general circulation models. In the present study, the technique of Operational and Planning Distribution Model (OPDM) will be applied in Sharkia Governorate, to correlate the gross revenue with the crop pattern of this zone. The command areas (78 command areas) in the Sharkia governorate are implemented into the OPDM model and also crop pattern for each command area.

Moreover, the effect of changing the quantities and percentage of salts of surface and ground water on the gross revenue is studied. In addition, the networks of canals and drains are allocated through the simulation model of OPDM. Moreover, the effect of reducing the cultivated rice area on the gross revenue is highlighted.

2. MODEL DESCRIPTION

A few attempts have been made to develop irrigation system management or decision support systems to assist water managers in taking appropriate decisions, e.g., Command Area Decision Support Model (CADSM) (Prajamwong [14]); Operational and Planning Distribution Model (OPDM) by Utah State University, USA (USU [15]); Operational Management Information System (OMIS) by the Delft Hydraulics, The Netherlands ((Delft Hydraulics and DHV Consultants 1989); Irrigation Network Control and Analysis (INCA) by the Overseas Development Unit of HR Wallingford, UK (Makin [10]); Scheme Irrigation Management Information System (SIMIS) by the Water Resources Development and Management Service of FAO's Land and Water Division, Italy (Mateos et al. [11]), etc.

The Operational Planning Distribution Model (OPDM, USU [15]) was developed by the department of biological and irrigation Engineering, Utah state university to be used in the planning for water resources and training. It can also be applied in design and analysis studies of agricultural irrigation systems. The model was developed to perform simulation of

water distribution and crop yield response for irrigation and other uses in complex canal and drainage networks. Crop water requirements are calculated based on specified cropping patterns and weather information and simulated flows are routed through the systems from main supply sources and open drains. The model is highly interactive with powerful capabilities for system layout and configuration the canal and drainage networks which are built interactively by inserting and arranging nodes graphically.

OPDM can generate system flow requirements based on calculated crop water needs specified hydrographically. Daily water balance calculations are performed for soil water and canal reach storage in the supply and drainage system. The model can estimate relative crop yield reduction due to root zone water deficit, soil water salinity, and water logging. Crop yield results are also used to generate tables of expected gross revenue from crop product based on specified maximum production values. The OPDM calculates crop water requirements by one of five ET methods according to the user's choice. Up to three separate planting staggers of each crop can be specified for each command area. Each crop type can have up to five growth stages with different crop coefficients, root depths, durations and yield factors. The model used nodes in the system layout to represent specified physical feature that occur in a real irrigation and drainage system, (Fig. 1). The connection between selected node types become reaches which can have capacity and flow data, and which are managed on a daily basis by the model during a

simulation. The model is used primarily for planning and training activities, but it can also be applied to design and analysis studies of agricultural irrigation systems.

3. CASE STUDY

The area of the case study is located at Sharkia governorate, Egypt. The project area is located at latitude 32.5° N and longitude 30° with an elevation of 10 m above the mean sea level. The area is irrigated through a network of irrigation canals and excess water is drained through a network of open drains, as shown in Fig. 1. Some water is pumped from an aquifer and used for irrigation along with the surface water. The basic data of the project area which includes the canals and drains networks and all command areas are shown in Fig. (1). The information of the delivered water to the command areas as a base case is shown in Table (1). This base case is used for comparison with other simulation models of OPDM.

Table 1 Water Resources Quantity and Quality for the Base Case.

Surface Water discharge (m ³ /sec.)	138.89
Salinity of surface water	0.85
Ground water discharge(M m ³ /year)	500
Salinity of groundwater (ds/m)	0.85

4. SCENARIOS STUDIED USING OPDM MODEL

For all command areas in the case study, different scenarios are considered based on the prospect of water shortage that may be occurred in the future. These scenarios, used by the simulation model of OPDM, include changes in discharge and salinity of both surface water and groundwater. Table (2) shows different scenarios studied by OPDM simulation model. These scenarios include: a) decreasing the amount of surface water or groundwater delivered to the whole command areas, **Scenario (1) and (3)**, b) increasing the salinity of surface water or groundwater, **Scenarios (2) and Scenario (4)**.

Table 2 Different Scenarios Studied by OPDM

Scenario no.	Surface water (m ³ /sec.)	Salinity of surface water (ds/m)	Groundwater (Mm ³ /year)	Salinity of Ground water (ds/m)
1	Decrease by 3% for 10 times	0.85	500	0.85
2	138.89	Increase by 3% for 10 times	500	0.85
3	138.89	0.85	Decrease by 3% for 10 times	0.85
4	138.89	0.85	500	Increase by 3% for 10 times

These scenarios covered a wide range of changes in both surface water and groundwater quantities and qualities. The decrease in surface and groundwater quantities ranges from 3% to 30% with 3% increment. While, the increase, of surface water and groundwater salinity, ranges from 3% to 30% with 3% increment between groups. The results of all groups, by the OPDM model, are studied to investigate the effect of these changes on the gross revenue of the project area.

5. ANALYSIS OF RESULTS

All scenarios in Table 2 were treated by the OPDM model. It was found the gross revenue decreases as the surface water and groundwater discharges decrease as indicated by Figs. (2) and (4). From the previous two figures, the discharges for both surface water and groundwater were reduced relative to the base case, as it probably occurred in the future. On the contrary, the gross revenue decreases as the surface water and groundwater salinities increase as indicated by Figs. (3) and (5). In which, the increase of water salinity above certain values affects the yield of crops.

From Figs. (2) and (4), it was found that, the effect of reducing surface water quantities on the gross revenue is larger than the effect of reducing the groundwater quantities through the simulation model.

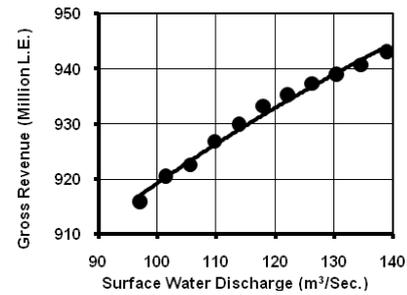


Fig. (2): Simulation of Gross Revenue Related to Different Surface Water Discharges for the Project Area

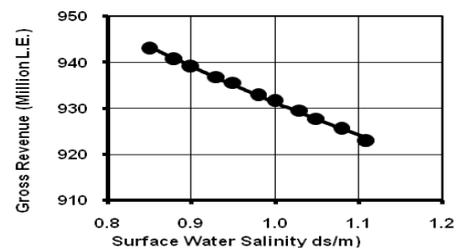


Fig. (3): Simulation of Gross Revenue Related to Different Surface Water Salinities for the Project Area

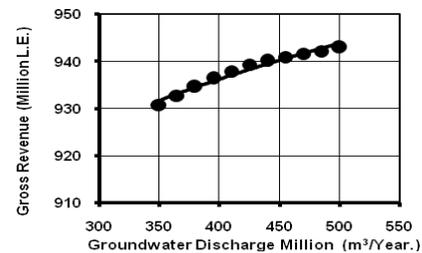


Fig. (4): Simulation of Gross Revenue Related to Different Groundwater Discharges for the Project Area

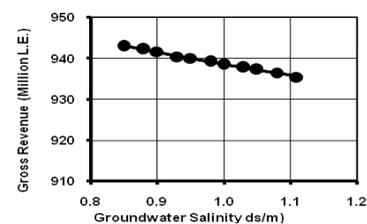


Fig. (5): Simulation of Gross Revenue Related to Different Groundwater Salinities for the Project Area

Another interesting example that offers insights into processes of water resource management in Egypt are the recent attempts to shift cropping patterns towards less water-consuming crops. That can be done by controlling the area grown by some crops such as rice. In the present study, different scenarios were carried out using OPDM model including decreasing the rice area by 40%. In which, the decreased area from rice is replaced by cotton and maize. These scenarios were correlated to different surface water discharges as shown in Fig. (6) From this figure, it can be noticed that, the percentage of gross revenue relative to the base case increases for almost surface water discharges. That means by decreasing the rice area by 40% in Sharkia governorate and replaced it by another crops like cotton and maize, the gross revenue will increase slightly with smaller amount of surface water discharge compared to the base case.

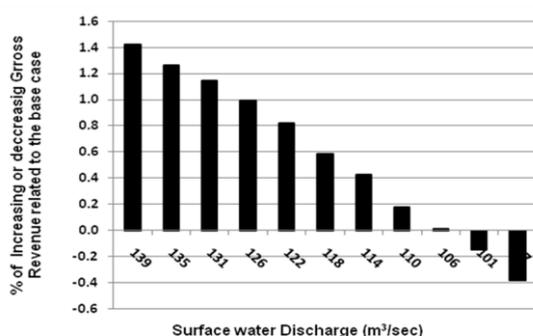


Fig. (6): Results of OPDM Simulation Model for 60% Area Grown by Rice.

6. CONCLUSIONS

The government of Egypt affords great role to the management of water resources especially with

expanding the cultivated areas to meet the increasing growth of population. Accordingly, the supplies of River Nile to the Nile Delta will be negatively affected. In the present study, the Operational and Planning Distribution Model (OPDM) is implemented on Sharkia governorate to show the effect of water resource management on the gross revenue. The gross revenue of all command areas are correlated to surface water discharge, ground water discharge, surface water salinity, and ground water salinity. It is clearly found that, the gross revenue decreases as the surface water and groundwater discharges decrease. The effect of reducing surface water quantities on the gross revenue is larger than the effect of reducing the groundwater quantity in simulation model. In addition, the gross revenue decreases as the surface water and groundwater salinities increase. Scenarios for reducing the grown rice area were carried out. By replacing 40% of rice area by cotton and maize, the gross revenue for all command areas could be slightly increased with lower supplies of surface water discharges relative to the base case. So, other scenarios for new studies should be carried out to clarify the economic and social effects due to change crop patterns on Sharkia governorate.

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