INTEGRATED MANAGEMENT OF WATER RESOURCES IN WESTERN NILE DELTA

2-MANAGEMENT SCENARIOS

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ABSTRACT

Western Nile delta is an important area in Egypt, in which the government has later established new reclamation projects, and irrigation and drainage network. The increase in reclaimed area together with the decrease in the discharge of canals network especially in the 1980's lead to shortage of surface water. The Ministry of Water Resources and Irrigation (MWRI) has an overall development plan, which will increase the reclamation area to be 625,000 feddan at the western delta area before 2017. A number of management scenarios were defined. These scenarios study alternative conjunctive uses for available water resources in western Nile delta (surface water, ground water, drainage water reuse) to prevent the groundwater aquifer from depletion. The proposed scenarios studied the full completion of the development plan proposed by MWRI for western Delta area by the year 2017. The previously built and calibrated ground water flow model was used to predict the effects of various scenarios on the groundwater aquifer for the present development and for the year 2017 development plan.

INTRODUCTION

Western Nile delta is an important area in Egypt, which has limited water resources, although it lies on the western part of Nile Delta aquifer. Due to the increased in the area of the reclaimed lands farmers are suffering from shortage of surface water and are forced to depend on the groundwater abstraction from wells. Number of operating wells is increasing within the basin. Due to excess abstraction from these public and private wells (1.36 bcm during 1990), the water level in the well fields declined significantly. The decrease in the water table in the well field may lead to salt-water intrusion from the Mediterranean Sea. Farms may become covered with saline water.

To avoid the deterioration of the aquifer system in this area an efficient integrated and sustainable management plan for water resources is needed. As a first stage and in order to quantify the possible management plans and their effect on the groundwater levels, a numerical model for the groundwater flow in Nile Delta aquifer was built. The collected data base, the model description, capabilities, calibration and sensitivity analysis were the

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objective of a previous research paper. The second stage (the current research paper) shall make use of this model to predict for the year 2017 management scenarios as planned by the Ministry of Water Resources and Irrigation (MWRI). It should be reminded that maximum withdrawals may place a significant stress on the delta aquifer making it more expensive to pump water and forcing the abandonment of older shallow dug wells.

During recent years the use of integrated management of water resources scenarios for environmental policy-making has attracted considerable attention from both the scientific community and policy-makers. Management scenarios attempt to construct general representations of possible future alternative solutions.

The definition and different applications of the Integrated Management of Water Resources are best expressed by scanning the in hand literature as demonstrated herein after.

LITERATURE REVIEW

The definition and concept of the Integrated Management of Water Resources (IMWR) was the subject of several researches and conferences.

IMWR uses a 'water balance' approach to quantify the amount of water entering a system (through precipitations and rivers and groundwater flows) and the amount leaving a system (through evaporation, plant transpiration and river and groundwater flows). The amounts depleted within the basin are then classified according to use, whether or not the use is intended and whether or not it is beneficial. It provides a clear view of water resources in river basin. It shows where water is going, how it is being used, and how much remains available for further use. (IWMI, International Water Management Institute, 2001).

IMWR is a process, which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP-TAC4, 2001).

Diab, M.S. and Zahab, K.A., (1992), Studied management of groundwater resources in Egypt and indicated that salt water fresh water interface zone had moved landward underneath the Pleistocene Nile Delta aquifer and further advance could occur if the Pleistocene aquifer has to be pumped at higher rates than the present ones. For this reason, precise water – budget calculation for the Pleistocene aquifer should be carried out for proper usage and management of this aquifer.

Walid S. and Jad I., (1996), have presented an evaluation for water resources management in Ramalla district. The study highlighted the ground water resources available for Palestinian in Ramalla district as well as the flow pattern (16 wells, and 122 springs) and water quality. They compared the consumed and demanded water between Palestinian and Israel, available wells for Palestinian are only 5 wells that covers one third of their needs and remaining needed water is purchased from Israelis. Groundwater model was carried out and classified the district into three zones. They concluded that extensive pumping of Israelis wells would destroy the aquifer system.

Nigel Weekes (1997), outlined the water resources management plan for St. Vincent and the Grenadines. He stated that a water resources management strategy for this limited land base

needed to consider the multiple user issue, the decline in agricultural productivity, increasing incidence of drought and floods, environmental decline, and a consequent decline in water quality over the nation's 13 watersheds. He described the model watershed plan collaboratively developed by the Forestry Department and Canadian expertise beginning in 1989. He concluded that community empowerment and participation were necessary for achieving compliance.

Van Der Zaag and B. Gumbo, 2001 confirmed that the challenge ahead for water resources management is to strike a balance between the use of the resource as a basis for the livelihood of the world's increasing population and the protection and conservation of the resource to sustain its functions and characteristics.

Stef S., et al, (2004), have discussed the use of water resources computer modeling for large amounts of data as part of the application of the RIDE methodology (The Resource, Infrastructure, Demand and Entitlement) in Sand River Catchments, South Africa. In order to assess possible management, five scenarios for water resources management were discussed in details. A comparison between scenarios' results was done. From the previous analysis the authors gave some recommendations for future work to study the groundwater potentiality, recharge to the aquifer, irrigation infrastructure and dam storage capacity.

MANAGEMENT PLANS

In order to apply the ambitious plans of MWRI at Western Nile Delta region, it is clear that management plans are required in order to provide the water needs for the new proposed reclaimed areas.
To reach to the best possible management scenarios, the existing (at the year 1991) water balance of the area should be quantified and understood together with the proposed development plans and their extra requirements in the area.

Summary of Water Budget during the Year 1991 for Western Nile Delta:

- Water supply: irrigation water supply is 10.98 bcm flows to western delta region through Rosetta branch.
- Water flow to the sea: 4.7 bcm from drainage water.
- Aquifer recharge: recharge to the aquifer from the cultivated area equal to 1.58 bcm.
- Groundwater abstraction: 1.36 bcm.
- Reuse of drainage water: from El-Omum drain 1.000 billion m3, Barsik zone 140 million m3 and from bossily drain 40 million m3 with total amount of 1.180 bcm annually.
- Waste water treatment: provides 250 million m3.

As quantified by the Ministry of Public Works and Water Resources, 1999.

Western Delta Development Plan

The new available area for reclamation in western Nile delta is determined by 465,000 feddan. The Ministry of Water Resources and Irrigation, (MWRI) assumed water demand of 7000 m^3/year/feddan as an average in this area. Therefore the excess inflow required for irrigation water supply is nearly 3.25 bcm. Figure [1] shows the land distribution of the

available areas for reclamation. It should be noted that some parts of these areas are currently being reclaimed, mainly depending on the groundwater abstraction.

The future recharge seeping down to the aquifer due to the full reclamation of the available area was estimated with a value equal to 1.2 mm/day per feddan as recommended by the Ministry of Water Resources and Irrigation.

Several runs for the calibrated model were used to calculate the safe abstraction from the groundwater aquifer in year 2017 after reclaiming all available area for cultivation in western Nile delta. The "safe abstraction" is defined as keeping the new piezometric head as much as possible the same as those measured during the year 1991. This would reduce land salination and further salt water intrusion areas.

Management Scenarios

Key scenarios describing alternative conjunctive uses for available water resources in western Nile delta were defined.
The proposed scenarios studied the full completion of the plan proposed by MWRI for western delta area in the year 2017 to reclaim extra 465,000 feddan.

- First scenario: construction of the new proposed canal at the southern part of the studied area.
- Second scenario: consumptive use of drainage water by decreasing water amounts flowing to the sea.
- Third scenario: decreasing the irrigation water supply by that used in Toshka project.

Scenario-I [construction of the new proposed canal in western Nile delta]

In this scenario a new canal, as proposed by MWRI, in the southern part of western Nile delta off taking from Rayah El-Bihiry is to be constructed. This canal will feed the new reclaimed areas with their water requirements. Impact of the new canal is discussed in this scenario. The proposed route for the new canal is shown in Figure [2].

Assumption and input data

In this scenario the previously built and calibrated groundwater model was used to predict for the new statues of water budget. The simulation of the new reclaimed areas in western Nile delta was carried out by adding net recharge value of 1.2 mm/day over these areas (as recommended by the Ministry of Water Resources and Irrigation). Percolation from the new canal to the aquifer was determined using conductance of 100 mm/day for the canal bed and sides.

Results and discussion

By the construction of the new proposed canal, the planned reclamation projects in western Nile delta can be safely constructed. The increase of safe groundwater abstraction, as determined by the model, is about 1.0 bcm/year.

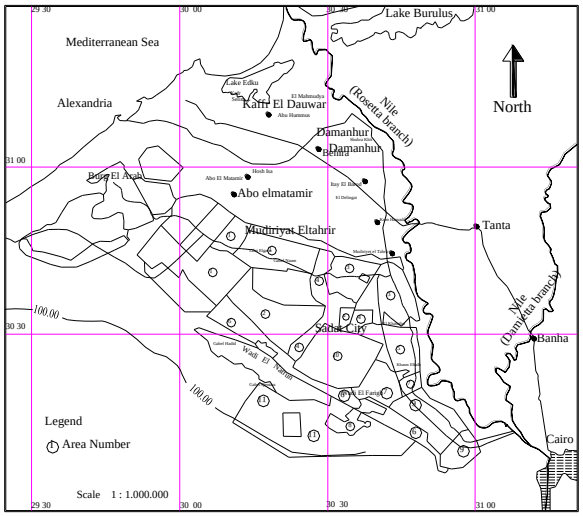

Figure [1], Layout of new reclamation lands

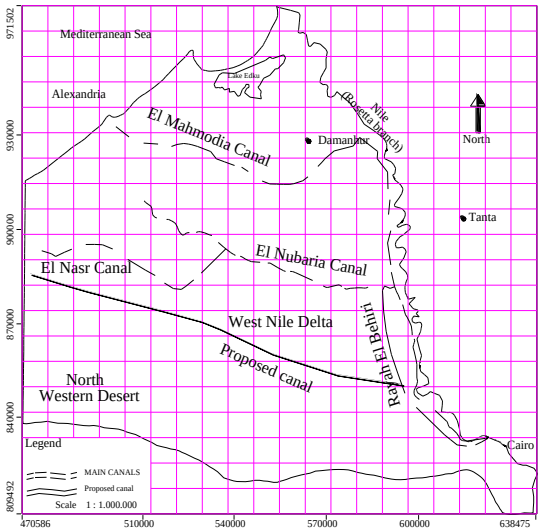

Figure [2], proposed route of the new canal

Therefore the new proposed canal discharge should be at least 2.25 bcm/year. Water budget for the groundwater aquifer is shown in Figure [3]. New groundwater piezometric heads for scenario [I] is shown in Figure [4]. It is clear that observed excess recharge has affected the piezometric head in the southern part of the study area, which is raised from –15m to 3m. On the other hand these changes caused moving back for the contours in the northern part especially in the area near to the Rosetta branch. Contour lines in the southern part near Rosetta branch was decreased by about 1m. It should be noted that the amount of abstraction was approximately taken equal to the net recharge applied to the aquifer. Therefore eventually no changes in piezometric level should take place except for local conditions. Local conditions are mainly attributed to the vicinity of the modeled abstraction wells. Water budget shows an increase in recharge with 1.0bcm according to the increased in the cultivated area. Increase in river leakage was found to be minor at 0.02 bcm due to leakage from the new canal. Constant head outflow increased with 0.05 bcm, influx changed only with 0.001 bcm.

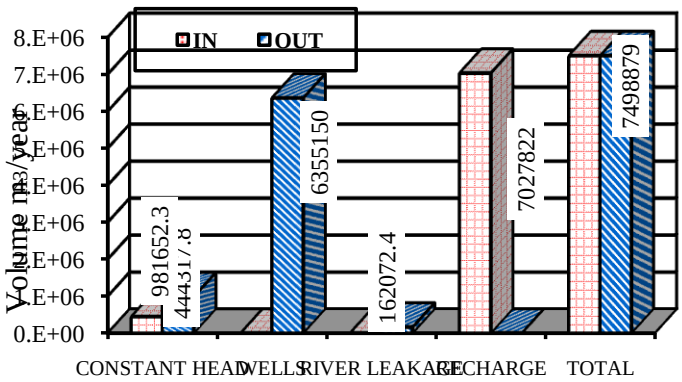

Figure [3], Water budget for Western Nile Delta aquifer in Scenario I

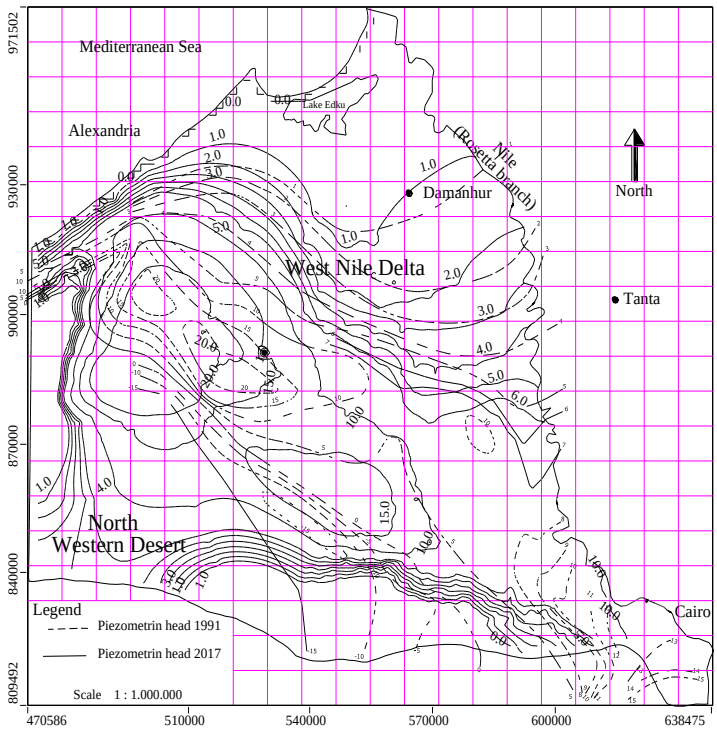

Figure [4], Calculated head in Scenario I

Scenario-II [Drainage water reuse]

Drainage water quantities flow to the sea from western delta equals to 4.49 bcm. In fact, some of drainage water quality is influenced by seawater intrusion and upward seepage pressure. This quantity is estimated to be 2.0 bcm as reported in Shaden, 1998.

Assumption and input data

This scenario was developed by using the same input data as in the previous scenario but without the proposed canal therefore extra 2.25 bcm was gained from the used of drainage water.

Results and discussion

Quantitavely, this scenario is similar to the first one except for the extra amount of freshwater needed for mixing with drainage water. But, qualitatively, this scenario should be checked against the increase in the salt concentration.

Scenario-III [Decrease Rosetta branch discharge to account for Toshka project]

Water demand for Toshka project, located in Upper Egypt, requires 5.5 bcm annually. The Ministry of Water Resources and Irrigation in the year 2017 is planning to decrease 1.5 bcm from current discharges from Upper Egypt and 4 bcm from delta region by changing the crop patterns and other means. This reduction of 4 bcm will be divided between western, middle and eastern delta with a ratio according to the current recharge.

Assumption and input data

Current water distribution for the delta area is,

Region	Total volume	% Value
Western Nile delta	10.98 bcm	32.3%
Middle Nile delta	10.44 bcm	30.7%
Eastern Nile delta	12.48 bcm	36.8%

Accordingly the new flow in Rosetta branch will become 9.69 bcm annually. In the study, it was assumed that the water demand for the western delta region is kept unchanged.

Results and discussion

This scenario has an impact on the total water resources availability in the western Nile delta. Rosetta branch flow will decrease to 9.69 bcm, which it is not enough for the existing cultivation area.

Groundwater levels are generally declined, the highest groundwater level is about 6m. This lowering in piezometric head would increase the salt-water intrusion from the Mediterranean Sea. Water budget for the groundwater aquifer indicated a clear shortage in the recharge values in comparison to the abstraction. The water budget for the study area in 2017 can be listed as follows:

Available water quantities: -

1. Rosetta branch, 9.69 bcm
2. Abstraction from groundwater aquifer. 2.08 bcm

Required water quantities: -

1. Old cultivated areas, 10.9 bcm
2. New cultivated areas. 3.25 bcm

Deficiency of about 2.38 bcm/year would occur if this scenario was used. It is therefore recommended to either change the crop pattern to decrease irrigation water application or alternatively decrease cultivated area (don’t reclaim all the planned areas) or increase the canals' network discharge by the 2.38 bcm.

The groundwater discharge could not be increased than the safe yield of 2.08bcm annually or aquifer depletion and increase in salt loads shall take place.

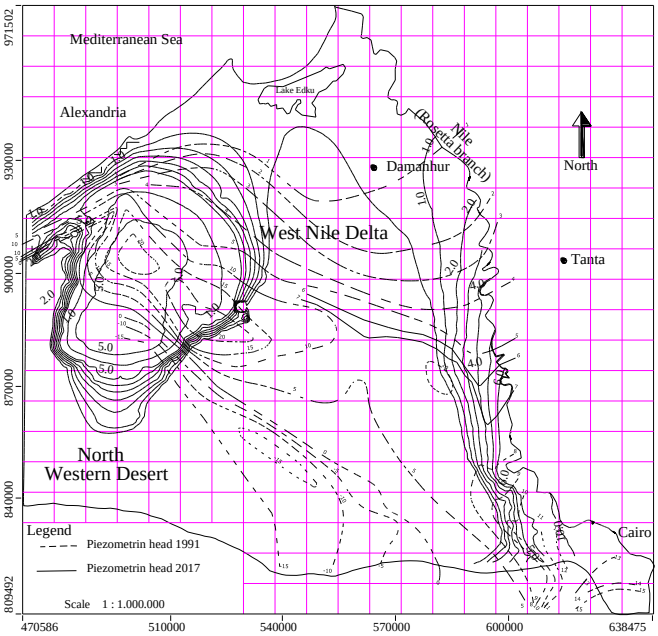

Figure [5], Calculated head in Scenario III

SUMMARY AND CONCLUSION

- Water is a basic need. No human being can live without a basic volume of fresh water of sufficient quality. Humans have a basic human right of access to water resources. This policy is a principle related to the Integrated Management of Water Resources (IMWR).

- The groundwater models can be used to address a wide range of water related issues in Integrated Management of Water Resources as, ground water quality and quantity.

- As a result of the year 2017 development plan of MWRI, the most critical part that has been affected by lowering in the groundwater levels is the southwestern part which include Dina farm, Elkhatatba and Sadat city.

- In case of planned reclamation completion for 460,000 feddan, the regional water balance indicated that the extra abstraction must not increase more than 1.0 bcm/year to avoid aquifer exploitation.

- Water budget in western Nile delta show the need to increase the surface water quantity by 2.1 BCM through the new proposed canal to fulfill the required irrigation demands for the new reclamation area.

- In case of re-use of drainage water, the water quality and the mixing proportions should be thoroughly studied.

RECOMMENDATIONS FOR FUTURE WORKS

- It is required to get detailed studies to determine the maximum amount from drainage water reuse, their locations and salt concentration.

- A complete study for the groundwater quality together with the salt water intrusion is strongly recommended for best understanding of the water management scenarios especially if re-use of drainage water is implemented.

- It is also recommended to apply well controlled license system of well abstraction in and to update the wells inventory in order to avoid groundwater deterioration at western Nile delta.

- The extra 1.0 bcm in the aquifer potentiality, which can be, used in the future development detailed potentiality maps needed to define where it can be exactly used without local aquifer deterioration. This can be carried out with the aid of the groundwater model.

- For the groundwater abstraction systems some baseline information is available, but it is full of inconsistencies due to several reasons from which the unregistered abstraction. Updating and understanding this information would be a first step. Additional research will need to be done on investment and operation and maintenance of these systems.

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الإدارة المتكاملة للموارد المائية في غرب دلتا النيل-٢- سيناريوهات الإدارة

تعتبر منطقة غرب دلتا النيل أحد المناطق المهمة في مصر لذا أنشأت الحكومة فيها مشروعات جديدة لاستصلاح الأراضي ، وشبكات الري والصرف. وقد أدت الزيادة في الأراضي المستصلحة جنبا إلى جنب مع انخفاض أداء شبكة القنوات وخاصة في الثمانينات إلى النقص في كميات المياه السطحية.

وقد طورت وزارة الموارد المائية والري خطة تنمية شاملة ، سوف تزيد مساحة الأراضي المستصلحة إلي ٦٢٥،٠٠٠ فدان في منطقة غرب الدلتا قبل عام ٢٠١٧. وقد تم اقتراح عدد من السيناريوهات لإدارة المياه تقوم علي استخدام موارد المياه المتاحة معا (المياه السطحية ، المياه الجوفية ، وإعادة استخدام مياه المجاري) بنسب مختلفة لمنع استنزاف المياه الجوفية وطبقا لخطة التنمية التي اقترحها وزارة الموارد المائية لمنطقة غرب الدلتا بحلول عام ٢٠١٧.

وقد تم استخدام النموذج السابق بناءة ومعايرته لدراسة تأثير السيناريوهات المختلفة لخطة التنمية في الحاضر والمستقبل .