شبكة المعلومات الجامعية

بسم اللّه الرحمن الرحيم

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم باللّه العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

Irrigation and Hydraulics Department

Sustainable Groundwater Management for New Reclamation Areas in Egypt

A Thesis Submitted in Partial Fulfillment of the Requirements
of the Degree of Doctor of Philosophy in Civil Engineering
(Irrigation and Hydraulics)

By

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Master of Science in Civil Engineering
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Statement

This thesis is submitted as a partial fulfillment of Doctor of Philosophy in Civil Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Signature

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Date:25 March 2021

Dedication

It is a great pleasure to dedicate my

Ph.D. Thesis

To the most persons I love in my life;

My Parents,

My Wife “Marwa”,

My Children “Fayrouz, Omar, Hamza, and Ali”, and My Family.

To all of them my deepest gratitude

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Abstract

Sustainable Groundwater Management for New Reclamation Areas in Egypt

Egypt's agricultural land is very limited with respect to its population food demand. This leads Egypt to be a heavily dependent on imported food products. To fulfil the expanding demand of agricultural products, successive governments have initiated many land reclamation projects since 1930s. In 2014, the Egyptian government initiated an ambitious horizontal expansion plan through reclamation of about 1.5 million feddans (1 feddan = 4200.83 m^2) as part of sustainable economic development aligned with Egypt's vision towards 2030. The majority of this project areas depend on groundwater as the only source of irrigation water. There is a great concern about groundwater sustainability which considered the main challenge to this project.

The Western Desert of Egypt is one of the main regions of the 1.5 million feddan project, including oases and southern area. These oases are characterized by artesian wells with high flow rate of fresh water which extracted from the Nubian Sandstone Aquifer (NSA), a huge nonrenewable aquifer. It stores about 150,000 BCM (km^3) and it is considered the main water source for this region.

Intensive well-drilling process in NSA area has been going on since 2014. This may result in developing huge drawdown around the well fields which leads to lowering the groundwater potentiometric (piezometric) level ($GWL_{potent.}$) and occurrence of undesirable consequences. It is extremely important to sustainably manage groundwater extraction from this aquifer. Sustainable extraction rates and the most beneficial sustainable extraction rate have to be determined.

However, safe yield concept, outflow equals inflow, is not applicable for NSA. Sustainable groundwater management definition for nonrenewable aquifers is not

unique because compromising between benefits of groundwater exploitation and its negative side effects is different from case to another. Hence, groundwater sustainability assessment and management criteria are determined on case by case basis.

A new groundwater-dependent reclaimed area of 10,000 feddan in Sahl Baraka, Farafra oasis, was taken as a case study area. For the study area, the Egyptian Government, represented by the Ministry of Water Resources and Irrigation (MWRI), set the limits of the adopted sustainable groundwater management criteria. These limits depend on two factors of the same weight. The first factor is the range of the economic lifting depth (Economic $D_{lifting}$) (set to be $\leq$ 40m beneath the land level (LL) at well location). The second factor is the duration during which the lifting depth ($D_{lifting}$) becomes not economic (set to be at least 100 years). Lifting depth ($D_{lifting}$) could be defined as the distance between the land level (LL) and the groundwater potentiometric level ($GWL_{potent.}$) at the well, including the Depression Cone Drawdown (DD_{well}).

GIS functions were used to develop the initial groundwater potentiometric map. 3-D MODFLOW model, for the study area, was constructed, calibrated, and run to obtain the Depression Cone Drawdown (DD_{well}) associated with different extraction rates. All NSA regional drawdown rates at Farafra oasis were considered. Methodologies for duration and lifting depth sustainability assessment, using Benefit-Deficit analysis, have been developed and applied. Also, methodology for determination of the most beneficial sustainable extraction rate has been developed and applied.

Groundwater sustainability for extraction rates Q_{well} = 1000, 2000, 2500, 3000, 4000, and 5000 m^3/day have been assessed, according to the MWRI adopted sustainability criteria. It could be concluded that all considered extraction rates