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An Economic Study of the Role of Groundwater in Development in Egypt

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ABSTRACT

This article provides study of state of groundwater in Egypt, available, are used in agriculture, and Scheme of agro socio-economic development depending on Groundwater at Egypt. Currently, 55.5 BCM/yr of water from the Nile River, 2 BCM/yr of non-renewable groundwater from the Western Desert and Sinai, 1.3 BCM/yr of effective rainfall in the northern part of the Nile Delta, 0.35 BCM/yr of desalination of sea water, 7.5 BCM/yr of shallow groundwater (Delta), and 13.5 BCM/yr of reuse of agricultural drainage water are available for use in Egypt. (a total of 80.25 BCM/yr .Egypt consumes water in agriculture, on average, about 35.58 MCM annually during the period (2010-2017), Surface water contributes 99.6% on average, Ground water contributes 0.09%, Agricultural Drain Water contributes 0.325 %, and Drain Water contributes 0.001% .the amount of groundwater used in agriculture is estimated at about 32,879 million cubic meters annually on average .The Agro-Socioeconomic Development are dependent on groundwater system of boreholes in Egypt, where is planning to cultivates about 7684 thousand feddans of the old Delta lands in the Lower Egypt region with available Nile water estimated at 25,122 Billion cubic meters, and cultivating about 2,509 thousand feddans in Middle (Ancient) Egypt with an estimated water quantity of about 8.637 BCM, and cultivating about 1,720 thousand acres in Upper Egypt (ancient) with a quantity of water estimated at 8.163 BCM.Egypt depends mainly on groundwater in the new agricultural development plans (2030), compared to the waters of the Nile.

Keywords: Nile Delta , western desert , Rever Nile

I. BACKGROUND:

Egypt Possesses a high potential of brackish groundwater available from different aquifers.(Mariam G. Salim, 2012).The Egyptian water resources system is composed of many interacting components and intermingles with social, economic and environmental systems, Fresh water resources include River Nile flow, precipitation and groundwater from both renewable and non-renewable aquifers.(Ashour et al.,2009).Egypt is anticipated to utilise groundwater to some extent in the development of new projects like Tushka in Upper Egypt and East Oweinat. Egypt's water supply is limited at 55.5 billion m3 annually despite the Nile River being its primary source of water. This is because of the country's rapidly expanding population and the rising need for water for domestic, industrial, and agricultural uses, among other things.(El-Tahlawi et al., 2008). Production and crop yield are positively impacted by the efficient and safe use of agricultural water. Production and yield can decline as a result of a reduction in applied water. The most crucial method for enhancing agricultural water use and preserving optimal production and yield is through management strategies. The secret is to put management techniques in place that increase water

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use effectiveness without lowering yield. (California Department of Water Resources).

II. METHODOLOGICAL FRAMEWORK

2.1. Basic concepts

The role of groundwater in the water cycle Polar ice caps and glaciers contain more than 68% of the world's fresh water, making it mainly inaccessible to society. (Shiklomanov 1993). Just 1.2% of the world's fresh water is located in streams and lakes, whereas around 30% of it is groundwater. Aquifers are geologic formations that provide wells or springs with a substantial volume of water. An aquifer is made up of two or more permeable subterranean layers that are at least locally separated by other layers.Humans have used groundwater throughout history, but over the past century, both the need for it and society's capacity to consume and poison it have grown tremendously. Aquifers that supply population and agricultural production centres in China, India, and the United States have been overused due to unevenly distributed human populations and variances in the quantity and accessibility of groundwater. Groundwater supply and quality are facing significant present and future problems that demand consideration from the policy and planning perspectives. (Edwin Brands, et al., 2017).

The flow of water through an aquifer is governed by Darcy's Law, which states that the rate of flow is directly proportional to the hydraulic gradient: Q = - K i A

Where Q is the rate of flow through unit area A under hydraulic gradient i. The hydraulic gradient dh/dl is the difference between the levels of the potentiometric surface at any two points divided by the horizontal distance between them. The parameter K is known as the hydraulic conductivity, and is a measure of the permeability of the material through which the water is flowing. The similarity between Darcy's Law and the other important laws of physics governing the flow of both electricity and heat should be noted.(UNESCO/WHO/UNEP, (1992, 1996).

2.1. Data source and analysis

2.1.1. Region of the study:

The study was conducted in Egypt. During the period (2010-2017).

2.1.2 Data Collection:

Data were collected from an irrigation water consumed in the irrigation network. Based on (CAPMAS, 2010- 2020), and (MWRI, 2003-2017).

2.1.3 Analytical methods

Descriptive statistics such as percentage, and averages was used to analysis, and econometrics to estimate the time-trend, Equation (Y=a+bx).

III. RESULT AND DISCUSSIONS

3-1 State of Water Resources in Egypt:

Egypt is fed by the River Nile, lies at the end of the Nile's route toward the sea, share the Nile water with many countries (Sudan, Ethiopia, Eritrea, Tanzania, the Democratic Congo, Uganda, Burundi, Rwanda, and Kenya). This means that it receives the Nile after it has emptied much of its water along the way. In 1959 Egypt signed an agreement with Sudan. The agreement specifies that Egypt's share of the Nile water is 55.5 billion M3 /year. There are currently 55.5 BCM/yr of water resources from the Nile River, 2 BCM/yr of non-renewable groundwater from the Western Desert and Sinai, 1.3 BCM/yr of effective rainfall in the northern part of the Nile Delta, 0.35 BCM/yr of desalination of sea water, 7.5 BCM/yr of shallow groundwater (Delta), and 13.5 BCM/yr of reuse of agricultural drainage water available for use. (a total of 80.25 BCM/yr). (Table 1,Figure 1).

Table 1.water resource in Egypt.

Water resource in Egypt	Volume (BCM/ year)
Water (High Aswan Dam)	55.50
Deep groundwater	2.1
Rainfall/flash floods	1.30
Desalination of sea water	0.35
Shallow groundwater (Delta)	7.5
Re-use Ag. Drainage Water	13.5
Total water resources	80.25 BCM/year

Source: MWRI, 2017.

3-2 Ground Water in Egypt:

Natural mineral water resources abound in Egypt. Yet, the majority of them are still mostly untapped. (Strategy for sustainable development: Egypt Vision 2030) A total of 40,000 BCM of deep groundwater is thought to exist. The high depth (up

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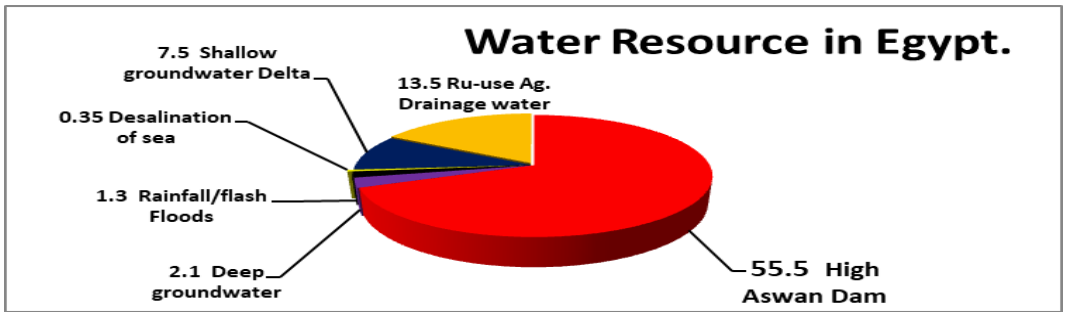
to 1,500 metres in some regions) and worsening water quality with increasing depth are the key barriers to using this resource, which makes up around 8% of all water resources..(fao, 2018).



Source:table No (1).

Figure 1: water resource in Egypt.

The Nubian sandy aquifer of the Western Sahara is considered one of the largest in North Africa. The quantities of groundwater are large, including the oases of Dakhla, Kharga, Farafra, East Oweinat and Darb Al-Arba'in , but the economically exploitable volume of them is limited. The annual withdrawal amounts of groundwater in the Western Desert and oases are about 3.75 billion cubic meters to ensure sustainability. Currently, only about 1.75 billion cubic meters are exploited (MWRI, 2010). The Nubian aquifer in the Eastern Desert, its potential is relatively limited and needs detailed studies to find out the possibility of exploiting it. In Sinai, groundwater is found in three reservoirs: shallow, medium and deep, in addition to the deep Nubian sandstone reservoir. The total deep groundwater used in Egypt is about 2.4 billion cubic meters per year (Omar, M., 2016),(table 2).

Table 2.main aquifers in Egypt.

Aquifers	Main Features
Nile aquifer	87% of the total groundwater in Egypt, 100-300 m3/hr
Nubian sandstone aquifer	Covers 2 million km2, the total volume stored is about 150,000 BCM
Fissured aquifer	Covers 50% of the surface area of Egypt, with productivity from 5 m3/hr to more than 300 m3/hr
Moghra aquifer	Found near the surface from WadiNatun to WadiFarigh
Coastal aquifer	On the northern and western coasts. Recharged by rainfall
Hardrock aquifer	Located in the Eastern Desert and southern Sinai. Recharged by small quantities of infiltrating rainwater

Source: MWRI, 2005. National Water Resources Plan 2017.

3-3 Groundwater Quality

One of the most secure sources of water has traditionally been groundwater. However, it might not be viable to use water from these sources for irrigation depending on the field's location and size. Poor planning of industrial sites, livestock farms, barnyards, and feedlots can have an impact on water quality. Up until recently, the possible risks of pollution were correlated with the type of water source. Bad water quality can harm crops used for food and make people sick who consume them. For instance, the water can have pathogenic microorganisms. When crops are irrigated with tainted water, contaminated food products that are consumed can result in sickness. (Centers for Disease Control and Prevention, 2016).

The Nile system's groundwater is of reasonable quality. Nonetheless, some shallow groundwater sources have been impacted by pollution. Around 20% of the groundwater in the Nile aquifer does not fulfil drinking water requirements, particularly near the edges where the protective clay cap is either minimal or nonexistent. The quality of the groundwater in the Nile Delta is often higher than that of the Nile Valley. While the Eastern Desert and Sinai have severely saline groundwater, the Western Desert's is often very good. Although the carbonate aquifer is mostly

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brackish, recharge regions do contain some fresh water. (MWRI, 2013).

3-4 Water use for Agricultural in Egypt:

Agricultural water is water that is used to grow fresh produce and sustain livestock. The use of agricultural water makes it possible to grow fruits and vegetables and raise livestock, which is a main part of the diet. Agricultural water is used for irrigation, pesticide External and.

Agricultural water comes from a variety of sources. Typical sources of agricultural water include :

1- Surface water (Rivers, streams, and irrigation ditches Open canals)
2- Impounded water such as (ponds, reservoirs, and lakes)
3- Groundwater from wells
4- Rainwater
5- Locally collected water such as cisterns and rain barrels
6- Municipal water systems such as city and rural water can also be used for agricultural purposes.

In table (3,4) Egypt consumes water in agriculture, on average, about 35.58 MCM annually during the period (2010-2017), between about 30.89 MCM of water in agriculture as a minimum (2011) and about 43.69 MCM (2016).By estimating the simple linear regression equation, it turns out that there is an increase in the rate of water consumption estimated at approximately 1.261 million cubic meters annually, with statistical significance...Surface water contributes 99.6% on average, Ground water contributes 0.09%, Agricultural Drain Water contributes 0.325 %, and Drain Water contributes 0.001%There is an increase in the general total of water used for agriculture, It is estimated at about 1.178 million cubic meters annually with statistical significance. (Figure 2).

Table 3. Water using in Agriculture According to Regions (2010 - 2017).(BCM/yr.).

Irrigation System	2010	2011	2012	2013	2014	2015	2016	2017	average
Service water	37.97	30.87	32.11	37.82	38.26	36.75	43.66	41.92	37.42
%	97.5	99.9	99.6	99.9	99.9	99.9	99.9	99.9	**99.6**
Ground Water)	0.01	0.01	0.12	0.01	0.02	0.02	0.03	0.02	0.03
%	0.03	0.04	0.38	0.04	0.05	0.06	0.06	0.04	**0.09**
Agricultural Drain Water	0.971	0.007	0.004	0.006	0.006	0.006	0.006	0.006	0.127
%	2.493	0.022	0.011	0.017	0.017	0.016	0.013	0.015	**0.37**
Drain Water	0	0	0	0.0009	0.0010	0.0007	0.0009	0.0008	0.0009
%	0.000	0.000	0.000	0.003	0.003	0.002	0.002	0.002	**0.001**
total	38.96	30.89	32.24	37.84	38.28	36.78	43.69	41.95	37.58
%	100	100	100	100	100	100	100	100	**100**

Source: CAPMAS, 2020.

Table (4): Simple linear regression equations for water use in agriculture. (2010-2017).

variable	The equation		F	annual rate of change%
Service water	$\hat{y}$ = 31.744 + 1.261X_1 **(12.370) * (2.482)	0.507	6.162**	0.033
total	$\hat{y}$ = 32.276 + 1.178X_1 **(11.757) **(2.168)	0.439	4.699**	0.031

Source: Table No (3).

-$\hat{y}$ is the estimated value of the dependent variable.X_1: time element = (1. 2.3. ...) .

* Significant at 5% , ** Significant at 1%, The numbers in parentheses refer to the calculated (t) value.

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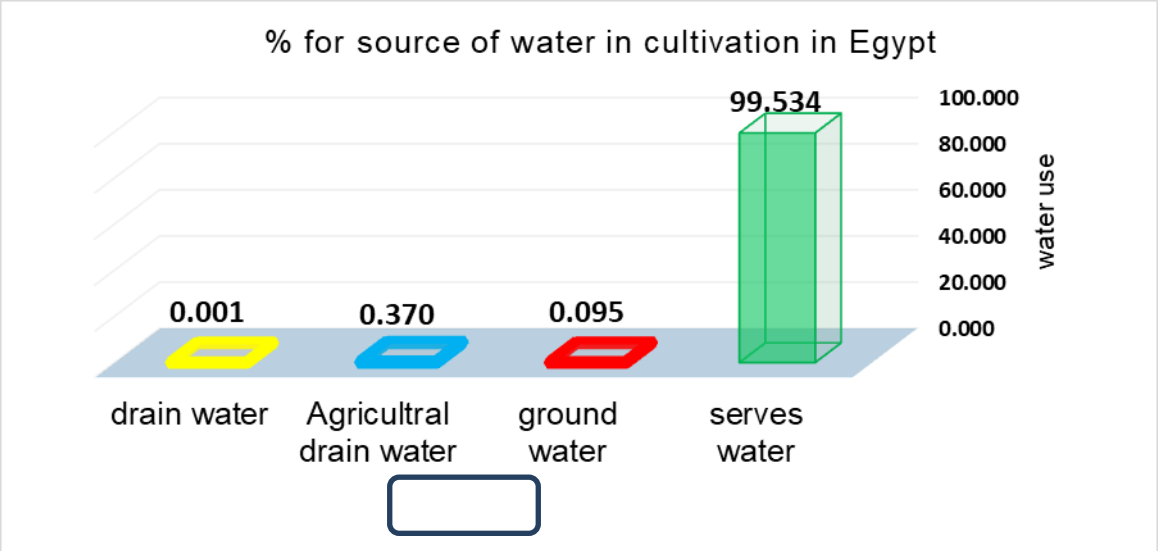

Source: CAPMAS, 2020.

Figure 2.for source of water in cultivation in Egypt %.

3-5 the important of ground Water in agro socio-economic development in Egypt:

3-5-1 development of groundwater quantity used in agriculture

Table 3.the amount of groundwater used in agriculture is estimated at about 32,879 million cubic meters annually on average during the period (2010-2021). By Linear trend estimation for groundwater used in agriculture, it was found that it took a general decreasing trend (non-significant) during the same period.

Y= 41156.75 - 2262.67 x * (-0.37) R2= 0.14 F =0.13

* The general Time-trend equation

Where: Y= quantity of groundwater are used in agriculture in Egypt,

X = time

3-5-2 Ground water use in Agriculture According to regions in Egypt

Table (5 .6).Groundwater is used agriculture in five region in Egypt. It's including four governorates, which are not reached by the Nile River, which are: New Valley, Matrouh, North Sinai, and South Sinai, and it depends mainly on groundwater for agriculture and irrigation, in addition to Giza Governorate, on the Nile River.South Sinai governorate is considered one of the largest governorates using groundwater in agriculture, as it uses about 55 % of the water used in agriculture on averageA decrease estimated at approximately 3355 million cubic meters annually, without statistical significance during the period (2010-2017), which explains that agricultural development in South Sinai depends mainly on groundwater. It was followed by the New Valley Governorate with an average of 25.6%An increase estimated at approximately 927.3 million cubic meters annually, with statistical significance during the same period, then the Matrouh Governorate by 12%An increase estimated at approximately 550.7 million cubic meters annually, with statistical significance, then the Giza Governorate by 5.8%, A decrease estimated at approximately 210.1 million cubic meters annually, without statistical significance, then the North Sinai Governorate with an average of 1.5 %An increase estimated at approximately 15.02 million cubic meters annually, almost without statistical significance during the same period, (Figure 3).

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Table 5. Groundwater used in Agriculture Seasons According to regions in Egypt (2010 - 2017). (MCM/yr).

Governorates	2010	2011	2012	2013	2014	2015	2016	2017	Average
Giza	6018	314	228	1457	1351	2505	2098	1262	1904.125
%	32.9	2.5	0.2	9.0	6.3	9.6	7.6	6.9	5.8
Elwady El gedid	4952	6137	7035	7830	9615	9795	10537	11499	8425
%	27.1	49.4	5.7	48.6	44.9	37.5	38.0	63.0	25.6
Matrouh	2505	3258	3822	189	3810	6259	6776	5039	3957.25
%	13.7	26.2	3.1	1.2	17.8	23.9	24.4	27.6	12.0
North Sinai	460	197	575	581	547	586	605	349	487.5
%	2.5	1.6	0.5	3.6	2.6	2.2	2.2	1.9	1.5
South Sinai	4332	2520	111000	6065	6078	7008	7726	111	18105
%	23.7	20.3	90.5	37.6	28.4	26.8	27.8	0.6	55.1
Total	18267	12426	122660	16122	21401	26153	27742	18260	32878.88

Source: CAPMAS, 2020.

3-6 Scheme of agro socio-economic development depending on Groundwater in Egypt:

Egypt is planning to cultivates about 7684 thousand feddans of the old Delta lands in the Lower Egypt region with available Nile water estimated at 25,122 Billion cubic meters, and cultivating about 2,509 thousand feddans in Middle (Ancient) Egypt with an estimated water quantity of about 8.637 BCM, and cultivating about 1,720 thousand acres in Upper Egypt (ancient) with a quantity of water estimated at 8.163 BCM.

Egypt depends mainly on groundwater in the new agricultural development plans (2030), compared to the waters of the Nile.

Table (6): Simple linear regression equations for groundwater used in agricultural seasons by region of Egypt (2010 - 2017).(MCM/yr).

	variable	The equation		F	annual rate of change%
Governorates	Giza	$= 2849.5-210.1X_1 \hat{y}$ *(1.922)(-0.716)	0.075	0.501	11.03
	Elwady El gedid	$= 4252.1 + 927.3X_1 \hat{y}$ ** (16.33) (17.985) **	0.982	323.5**	11.01
	Matrouh	$= 1479 + 550.7X_1 \hat{y}$ (1.081) *(2.032)	0.408	4.128**	13.92
	North Sinai)	$= 419.9 + 15.02X_1 \hat{y}$ **(3.549)(0.641)	0.064	0.411	2.87
	South Sinai	$= 35005-3355.7X_1 \hat{y}$ (1.140)(-0.618)	0.060	0.382	18.53

Source: Table No (5).

yˆ is the estimated value of the dependent variable. X_1: time element = (1. 2.3. ...)

* Significant at 5% , ** Significant at 1%, The numbers in parentheses refer to the calculated (t) value.

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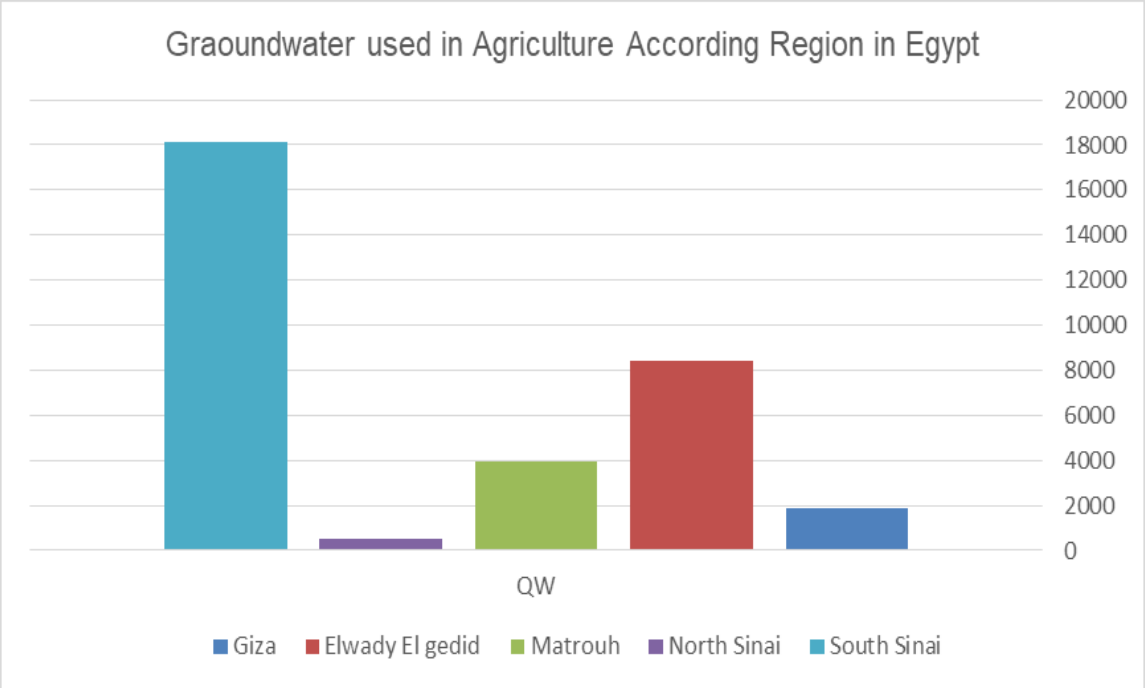

Source: CAPMAS, 2020.

Figure 3.Groundwater used in Agriculture According regions in Egypt.

1- Toshka& Abu Simbel (South Valley Project)

Egypt plans to cultivate about 697 thousand feddans in Toshka and Abu Simbel (South Valley Project) depending on the waters of the Nile and Lake Nasser.

2- El- Salam Canal (the New North Sinai Project)

Table7.Egypt plans to plant 412 thousand feddans (the Salam Canal Project), in five areas, two of which depend on the Nile water, namely: Tina Plain area of 51,000 feddans, and the South Qantara area of 77 thousand feddans, which require a quantity of water estimated at about 2225 million cubic meters. . The rest of the three regions depend on groundwater (wells water), which are: Rabea area with an area of 72,000 feddans, BirElAbd area with an area of 72,000 feddans, and Al-SirrWaEquarir area with an area of 139 thousand feddans and it needs a quantity of water estimated at about 2225 million cubic meters that can be provided through wells. Underground water.

3- One Million and half Fadden project

Egypt plans to cultivate one and a half million feddans in various regions in Egypt, and depends on it mainly on groundwater in all regions, in three areas: Al-Amal village in Ismailia with an area of 4,000 feddans, in Toshka in Aswan with an area of 148 thousand feddans, and West Al-Marashda in Qena with an area of 3,000 feddans, while the rest of the areas depend on groundwater wells as follows:

The New Valley (Old& New El farafra, and the Dakhla Extension) with an area of 289,000 feddans, with a quantity of about 1180 wells.

-New Vally (Southeast El Monkhafad Extension) with an area of 52,000 feddans, with a quantity of about 210 wells.

-Giza (Southeast The Monkhafad) with an area of 94,000 feddans, with a quantity of about 380 wells.

-Matruh (Almaghra) with an area of 175,000 feddans, with a quantity of about 720 wells.

-Aswan (West KomOmbo)with an area of 198,000 feddans, with a quantity of about 100 wells.

-Aswan (Toshka) with an area of 25,000 feddans, with a quantity of about 102 wells.

-Qena (West Al-Murashada) with an area of 19,000 feddans, with a quantity of about 90 wells.

-Minya(West-West El-Minya) with an area of 227,000 feddans, with a quantity of about 755 wells.

-Minya (West El-Minya (Ministry of Electricity) with an area of 257,000 feddans, with a quantity of about 700 wells.

-Minya (WesT- West El-Minya (2) with an area of 154,000 feddans, with a quantity of about 625 wells.

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- South Sinai (Altuwr) with an area of 20,000 feddans, with a quantity of about 144 wells.

Table 7. Scheme of agro socio-economic development depending on Groundwater in Egypt (2020).

Scheme Name		Area (thousand Fadden)	Status of the Scheme (Existing/ Proposed)	Sub basin	Water Source	Water Requirement way& Quantity		Available
						Irrigation way	**MCM**	
Lower Egypt (Old Area-Delta)		**7684**	Existing	Main Nile	Nile Delta	Surface irrigation	25122	25122
Middle Egypt (Old Area-Valley)		**2509**	Existing	Main Nile	Nile Valley	Surface irrigation	8637	8637
Upper Egypt (Old Area-Valley)		**1720**	Existing	Main Nile	Nile Valley	Surface irrigation	8163	8163
Toshka& Abu Simbel (South Valley Project)		**697**	Proposed	Main Nile	Lake Nasser	Surface irrigation	10-15	6
El- Salam Canal (the New North Sinai Project)		**412**	**Proposed**			**Irrigation way**	**BCM**	
1	Tina Plain Area	**51**	Proposed	Main Nile	Nile Delta	Surface irrigation	2225	
2	South Qantra Area	**77**						
3	Rebaa Area	**72**		Ground Water	Aquifer	Surface irrigation	2225	
4	BirElAbd Area	**72**						
5	El-SerrWaEquarir Area	**139**						
One Billion and Half Fadden Project		**1695**	**Proposed**			**Irrigation way**	**Well(n)**	
1	**Ismailia** (El- Amal Village)	**4**	Proposed	Main Nile	Nile Delta	Surface irrigation		
2	**Aswan** (Toshka)	**148**	Proposed	Main Nile	Lake Nasser	Surface irrigation		
3	**Qena**(West Al-Murashada)	**3**	Proposed	Main Nile	Nile Valley	Surface irrigation		
4	**New Vally** (Old & New El farafra, El-DakhlaExtention)	**289**	Proposed	Ground Water	Aquifer	(wells)	**1180**	
5	**New Vally** (Southeast El Monkhafad Extension)	**52**	Proposed	G.W	Aquifer	(wells)	**210**	
6	**Giza** (Southeast The Monkhafad)	**94**	Proposed	G.W	Aquifer	(wells)	**380**	
7	**Matruh** (Almaghra)	**175**	Proposed	G.W	Aquifer	(wells)	**720**	
8	**Mutruh**(east Siwoa)	**31**	Proposed	G.W	Aquifer	(wells)	**125**	
9	**Aswan** (West KomOmbo)	**198**	Proposed	G.W	Aquifer	(wells)	**100**	
10	**Aswan** (Toshka)	**25**	Proposed	G.W	Aquifer	(wells)	**102**	
11	**Qena**(West Al-Murashada)	**19**	Proposed	G.W	Aquifer	(wells)	**70**	
12	**Minya**(West-West El-Minya)	**227**	Proposed	G.W	Aquifer	(wells)	**755**	

13	**Minya**(West El-Minya (Ministry of Electricity)	**257**	Proposed	G.W	Aquifer	(wells)	**700**	
14	**Minya** (WesT- West El-Minya (2)	**154**	Proposed	G.W	Aquifer	(wells)	**625**	
15	**South Sinai** (Altuwr)	**20**	Proposed	G.W	Aquifer	(wells)	**144**	

Source: MWRI, 2020.

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IV. CONCLUSION

Egypt Possesses a high potential of brackish groundwater available from different aquifers .The Agro-Socioeconomic Development are dependent on groundwater system of boreholes in Egypt, where is planning to cultivates about 7684 thousand feddans of the old Delta lands in the Lower Egypt region with available Nile water estimated at 25,122 Billion cubic meters, and cultivating about 2,509 thousand feddans in Middle (Ancient) Egypt with an estimated water quantity of about 8.637 BCM, and cultivating about 1,720 thousand acres in Upper Egypt (ancient) with a quantity of water estimated at 8.163 BCM.Egypt depends mainly on groundwater in the new agricultural development plans (2030), compared to the waters of the Nile.

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