American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-7, Issue-5, pp-452-465
www.ajer.org
Research Paper Open Access

The Future Role of Groundwater and Desalination in Reallocation of Domestic Water Sources in Egypt

Osama M. Sallam [(1)]

(1) *Prof. Asst, Researcher, Research Institute for groundwater, National water research center, Egypt.*
Water projects manager, Environment agency, Abu Dhabi, UAE
Corresponding Author: Osama M. Sallam

ABSTRACT: *Many researches and studies discussed in depth the management of water resources in terms of supplying, uses and demands in Egypt,most of them discussed agricultural water uses as the largest water users in Egypt, on the same time, there are no studies about water sources,uses, and demands of the domestic sector. Currently; the domestic water sector is one of the largest water users in Egypt, which consumes more than 16% of the total renewable water resources. So, the current researchis to assess the role of groundwater, and sea water desalination to reallocate as sources of fresh water to face the expected water shortage in the near future in Egypt, due to population growth and the expected negative impacts on the Egyptian water system after the operation of the Great Ethiopian Renaissance Dam.In this research; the status of existing domestic water sources for all Egyptian governorates have been analyzed and evaluated in terms of types of each source and efficiency of domestic water systems for each governorate.One of the main results of this study;Egypt is urgently required to plan to increase the current consumption of domestic water from around 9.2 Billion Cubic Meter in 2016 to about 15 Billion Cubic Meter of water by 2040 from outside the Nile waters.*
KEY WORDS*: Groundwater,Desalination,Domestic water,Nile River, Egypt.*

Date of Submission: 12-05-2018 Date of acceptance: 28-05-2018

LIST OF ACRONYMS

AMSL	Above Mean Sea level
AHD	Aswan High Dam
BMC	Billion Cubic Meter
BMC/yr.	Billion Cubic Meter per year
CAPMAS	Central Agency for Public Mobilization and Statistics
CM	Cubic Meter
CM/yr.	Cubic Meter per year
GERD	Great Ethiopian Renaissance Dam
GW	Groundwater
lcd	Litter per capita per day
MCM	Million Cubic Meter
MCM/yr.	Million Cubic Meter per year
Mg/l	Milligram per Litter
m^2	Squire meter
MWRI	Ministry of Water Resources and Irrigation
km	Kilometer
RIGW	Research Institute for Groundwater
SW	Surface Water
SWD	Sea Water Desalination

I INTRODUCTION

Egypt is located at the south eastern corner of the Mediterranean and enjoins an area of one million square kilometers. Egypt measures 1262 km from west to east (Mediterranean coast), and 1073 km between latitudes 22 and 23 N. This latitudinal location means that; Egypt lies within the arid belt of North Africa,(Figure 1) andhas a semi-arid to extremely arid climate.Because ofthe population growth from 59 million in 2000 to more than 94 million in 2017,and the horizontal expansion outside the Nile Valley and the Delta, the water demands of suitable quality are increasing.The continues increase in population and subsequent increase in the demand for fresh water in agriculture, industrial and mining activities, is causing a continuous decrease in per capita quota (Abu-Zied, 1998).Since ancient times the Nile has been the main source of fresh water to the country covering all water Demands for Egypt's population, which inhabited the Nile Valley and the Delta. (El Tahlawi,et al 2008).Groundwater is one of the most important resources of water in Egypt. It ranks as the second source after the Nile River. In addition, there are different groundwater aquifers with variable importance for different usages. They are ranging from shallow local aquifers, recharged by rainfall, to deep non- replenishableaquifers. (Elnashar,2014).Egypt's water recourses can be categorized into: Nile River as Surface water (SW), Groundwater (GW) aquifers, rain fall, waste water reuse and Sea Water Desalination (SWD). The conventional water resources in Egypt are limited to the Nile River, groundwater, rainfall and flash floods. More than 96% of Egypt' all fresh water resources are supplied by the Nile River, which originates from outside of the country boundaries and supplies eleven countries. Fresh water sources from the Nile are limited for Egypt by the agreement between Sudan and Egypt since 1959. This agreement entitled Egypt to 55.5 Billion Cubic Meters per year (BCM/yr.) of Nile water.

In 2017, the per capita water consumption from the renewable water resources of Egypt was about 630 CM/yr. which dropped from about 1000 CM in 2000.The increase in population, industrial and agriculture activities have resulted in a rapid deterioration of water resources, in particular in the Nile Delta. This low water quality threatens public health, reduces its use for economic activities and damages the natural ecology of the water system.

Egypt has been listed among the ten countries that are threatened by need of water by the year 2025 due to the rapidly increasing population,(Diana RK.2000). At present, there are significant challenges to water resources development and uses in Egypt;beginning with a single source of water (Nile River), uncertainties in climate, developments upstream, and population growths.

Figure (1) Map of Egypt(MWRI. 2005)

In 2011, the Ethiopian Government announced a plan to construct a hydroelectric dam on the Blue Nile River, 45 kilometers (km) east of its border with Sudan, which has been named the Grand Ethiopian Renaissance Dam, (GERD). It will create a lake with a volume of 74 BCM, (IPoE 2013). It is believed that the construction of GERD will affect the quota of Egypt, this effect on Egypt quota will decrease the Aswan High Dam (AHD) discharges.

The reduction of the AHD outflows has its adverse impacts on water supply, industrial and irrigation pump stations efficiency, navigation, and hydropower stations. It was further reported that Egypt is vulnerable to severe droughts even at present conditions (without the GERD construction) and therefore, the GERD will drastically alter the historical Nile flow regime on seasonal and inter-annual time scales, enabling high degree of flow regulation in the Blue and main Nile reaches. As such, the GERD has the potential to exacerbate water stresses in Egypt if it is operated unwisely without Egypt and Sudan participation (Fahmy et al 2015).

GERD negative impacts on Egyptian water resources are dominant. In turn, Egypt water policy and management should be changes or modified to overcome the great challenges of constructing dams such as GERD. Otherwise, Egypt will face many severe environmental, economic and social problems if the GERD is completed without complete supervision from Egyptian Ministry of Water Resources and Irrigation. (Ramadan, at el 2013).

Elnashar(2014) concluded that the effective management of available groundwater resources requires an integrated approach, combining both supply side and demand side measures. Similarly, urgent action is required to augment the groundwater in the water stressed areas. Barbary (2008)studied the effect of low flow releases during low demand period on the operation ofdomestic and power stations along the Nile River.Wagdy A. (2008) described how Egypt would safeguard its water resources in the future, both with respect to quantity and quality, and how it would use these resources in the best way from a socio-economic and environmental point of view.

II THE OBJECTIVE AND METHODOLOGY

Many researches and studies discussed in depth the management of water resources in terms of supplying, uses and demands in Egypt,most of them discussed agricultural water uses as the largest water users in Egypt, on the same time, there are no studies about water sources,uses, and demands of the domestic sector. Currently; the domestic water sector is one of the largest water users in Egypt, which consumes more than 16% of the total renewable water resources.So, the current researchis to assess the role of groundwater, and sea water desalination to reallocate as sources of fresh water to face the expected water shortage in the near future in Egypt, due to population growth and the expected negative impacts on the Egyptian water system after the operation of the Great Ethiopian Renaissance Dam.

In this research; (i) the status of existing domestic water sources for all Egyptian governorates have analyzed and evaluated in terms of types of each source and efficiency of domestic water systems, (ii) the future domestic water demands of each governorate were estimated according its population growth and the national average of domestic water consumption per capita. Also, (iii) the appropriate sources of domestic water for each governorate have been reallocated according to, hydrological characteristics and the availability of alternative water sources as; groundwater (GW) and sea water desalination (SWD) to cover the expected shortage of the Nile water.

III WATER SUPPLY AND USES IN EGYPT

Estimated figures of water resources and uses in Egypt are greatly different from report to another, year to year and from agency to another, even the Ministry of Water Resources and Irrigation (MWRI), that entrusted with the management of water resources; has many estimates for both water resources and water uses, however, Egypt's share of Nile River water is the only fixed figure. The following is a brief of water resources of Egypt which has been collected and checked from various published resources.

Water Supply Resources

Flash floodsPrecipitation which occurs in winter and late autumn accounts for 1.05 BCM/yr. of internal renewable water resources recharging shallow aquifers. The Nile River supplies about 97% of the annual renewable water resources in Egypt. Out of the Nile ‘s average natural flow of 84.0 BCM/yr. reaching Aswan, a share of 55.5 BCM/yr. is allocated to Egypt according to the Nile Water Agreement (1959).Fossil groundwater is hosted in deep aquifers as non-renewable water resources. Also, non-conventional resources include agricultural drainage water reuse, sea water desalination, municipal wastewater reuse, rain harvesting, and brackish water desalination,Wagdy (2009), MWRI. (2005).Table (1) shows water supply resources and its Percentage.

Table (1) Sources for water supply

Type of resources	Resources (BCM)	The percentage (%)
Nile water	55.5	72.08
GW Desert	1.65	2.14
GW Nile Aquifer	6.1	7.92
Reuse Agriculture Drainage	9.7	12.6
Reuse Treated Wastewater	2.9	3.77
Rain Fed Harvesting	1.05	1.36
Desalination	0.1	0.13
Total	77	100

Plan Bleu (2011)

There are four major groundwater systems in Egypt (Figure 2), namely; the Nile Aquifer, the Nubian Sandstone Aquifer, the Moghra Aquifer, and the Coastal Aquifer.

- The Nile aquifer is renewable and underlies the Nile Delta and is characterized by its high productivity and shallow depth of the groundwater table allowing the abstraction of large quantities of water at low pumping cost. Shallow aquifer is extremely vulnerable to pollution by surface induced sources which is directly connected to the Nile River system, and thus will be directly affected by programs for reducing conveyance losses in waterways.
- The Nubian sandstone aquifer is shared by four countries namely; Egypt, Sudan, Chad, and Libya. The whole aquifer contains about 150,000 BCM of fossil water at depths reaching 2000 m. Pumping costs and economies of scale control the development of groundwater from the Nubian Aquifer. The Nubian Aquifer extends also beneath the Eastern Desert.
- In the Moghra aquifer, the groundwater flow is in general directed towards the Qattara Depression. The aquifer is recharged by rainfall and lateral direct inflow from the Nile aquifer. Due to the sharp increase in abstractions for groundwater- based reclamation projects in the Egyptian Western Desert and industrial and municipal supply, notably in the Western fringes of the Nile Delta, the water quality and sustainability of this resource is at risk.
- The Coastal aquifers exist near the western northern coast of Egypt and are recharged by rainfall on the western coast. Quantities that can be abstracted are limited due to the presence of saline water underneath the fresh water layers.MWRI. (2005).

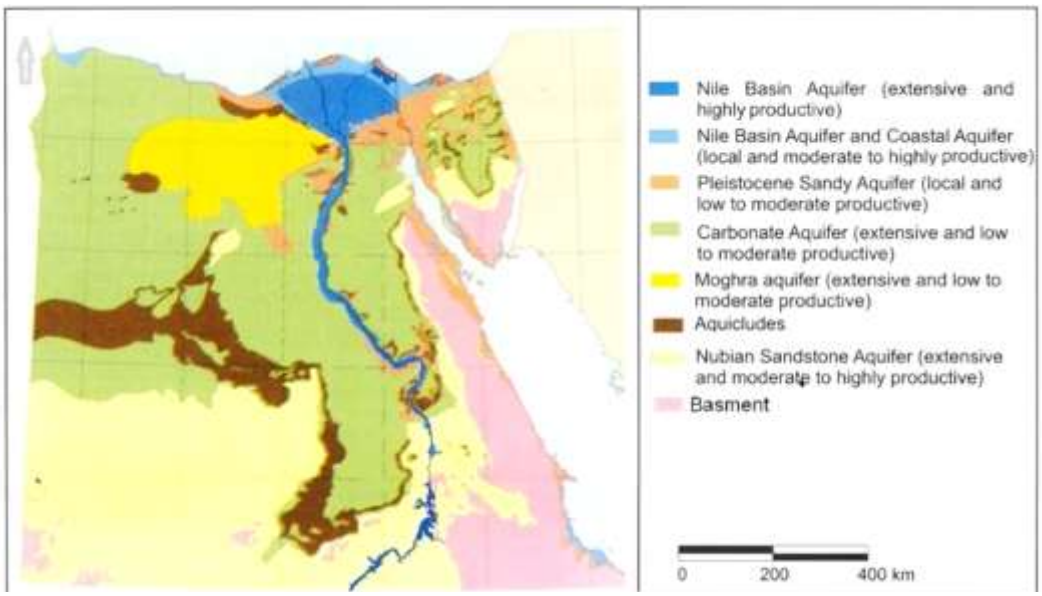

Figure (2) Hydrogeological map of Egypt (After RIGW 1988, 1993) and RIGW/IWACO (1999),

WaterUses

In 2011, the agricultural sector was the highest consumer, utilizing about 77.7% of the available supplies, while the domestic and industrial sectors consume 19% of the total supplies, The navigation and hydropower, maintain the ecosystem/habitats of the northern Delta/Lakes and Evaporation losses from the 31,000 Km-long water conveyance networks is estimated at about 2.6 BCM/yr.Table (2) Shows water resources uses in Egypt and its percentages, Plan Bleu(2011),IDSC (2007).

Table (2) Uses for water Resources in Egypt

Type of Uses	Water Uses (BCM)	The Percentage (%)
Agriculture	59.8	77.7
Industrial and Domestic	14.6	19
Others	2.6	3.3
Total	77	100

IV DOMESTICWATER DEMANDSIN EGYPT

Domesticwater requirements for major urban towns and rural villages have been estimated to be 4.6 BCM in 2000 where approximately 97% of urban population and 70% or rural population of Egypt relies on piped water supply. In 2017; the major cities in Egypt (217 cities) currently enjoy full Domestic water coverage (100%). Rural access to improveddomesticwater is 99%. Domestic water is diverted from two main sources: surface water (SW) which supplies about 88.99% of total Domestic water demand and groundwater(GW), which supplies about 10.77% of total demands and about 0.24%fromsea water desalination (SWD) as shown in figure (3) while,table (3) showsdomestic water sources for each Governorates, and figure (4) shows the percentages of eachdomestic water sources.(CAPMAS2017).

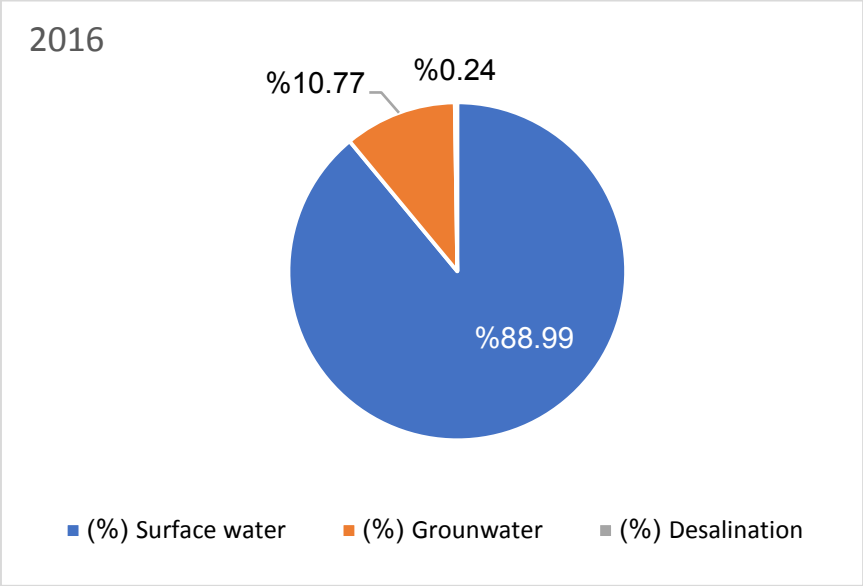

Figure (3)Domestic Water Sources

Source: CAPMAS (2017)

Table (3)domestic water sources for Egyptian Governorates

S.N.	The Governorate	SW (MCM)	GW (MCM)	SWD (MCM)	Total (MCM)
1	**Cairo**	2096.5	1.8	0	2098.3
2	**Alexandria**	1056.3	0	0	1056.3
3	**Port Said**	9.7	0	0	9.7
4	**Suez**	18.9	0	0	18.9
5	**Damietta**	188	0	0	188
6	**Dakahliya**	463.9	64.8	0	528.7
7	**Sharqeia**	299.8	71.7	0	371.5
8	**Kalyobiya**	123.9	90.7	0	214.6
9	**Kafr el-Sheikh**	287.5	0	0	287.5
10	**Gharbya**	196.8	139.2	0	336
11	**Monofiya**	174.6	151.6	0	326.2
12	**El Beheira**	471.7	16.7	0	488.4
13	**Ismailia**	139.8	0	0	139.8
14	**Giza**	1165.5	69.4	0	1234.9
15	**Bani Souwaif**	195.7	7.3	0	203
16	**Fayoum**	249.1	0	0.04	249.14
17	**Menia**	228.5	59.2	0	287.7
18	**Assiut**	112.5	112.3	0	224.8
19	**Sohag**	155.8	114.9	0	270.7
20	**Qena**	187.1	15.5	0	202.6
21	**Aswan**	116.3	2.8	0	119.1

23	**Luxor**	99.7	4.3	0	104
22	**Red Sea**	35.5	0	5.4	40.9
24	**New valley**	0	46.5	0	46.5
25	**Matrouh**	62.6	1.7	2	66.3
26	**North Sinai**	45.6	20.7	3.1	69.4
27	**South Sinai**	12.7	0.7	11.1	24.5
total		**8194**	**991.8**	**21.64**	**9207.44**

Data Source: CAPMAS (2017)

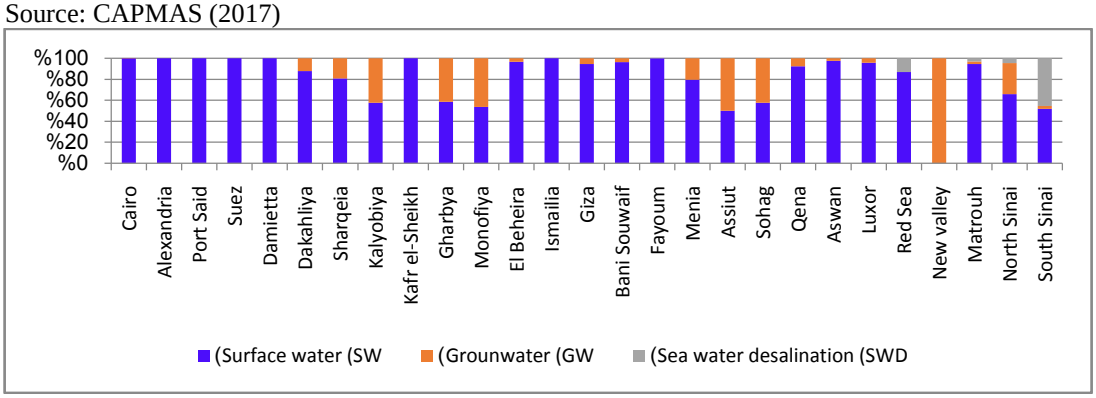

Figure (4) percentages of eachdomestic water source for Egypt governorates

Domestic Water Losses in Egypt

The domestic water use efficiency is the ratio between the total volume of domestic water which have been billed by the consumer and the total produced volume of domestic water, so the major factor affecting the amount of diverted water for domestic use is the efficiency of the delivery networks

In 2005 the accumulative annual volume of billeddomestic water is equal to 5.395 BCM while the total volume of produced water has been 7.179 BCM,thus, the efficiency ofdomestic water use was 75%. In 2009 the accumulative annual volume of billeddomestic water is equal to 6.014 BCM while the total volume of produced water has been 8.249 BCM,thus, the efficiency ofdomestic water use was 73%.While, in 2016 the accumulative annual volume of billeddomestic water in 2016 is equal to 6.474 BCM while the total volume of produced water has been 9.207 BCM,thus, the efficiency ofdomestic water use is 70.31%. Table (3) shows the values ofdomestic water produced,billed and losses for each governorate,whilefigure (5) shows the percentages of water billed and the percent lost during conveyance for eachgovernorate, where a 29.69% average loss is envisioned. Maximum losses occur in Port Said Governorate (about 57.73%) while minimum losses (17.57%) occur in Assiut. (CAPMAS 2017).

Table (4)production, billed and losses ofdomestic water for each governorate(2016).

S.N.	Governorate	Total production (MCM)	Billed (MCM)	Losses (MCM)
1	Cairo	2098.3	1399.6	698.7
2	Alexandria	1056.3	753.2	303.1
3	Port Said	9.7	4.1	5.6
4	Suez	18.9	8	10.9
5	Damietta	188	142.9	45.1
6	Dakahliya	528.7	396.5	132.2
7	Sharqeia	371.5	285.3	86.2
8	Kalyobiya	214.6	159.9	54.7
9	Kafr el-Sheikh	287.5	201.8	85.7
10	Gharbya	336	273.8	62.2
11	Monofiya	326.2	259.3	66.9
12	El Beheira	488.4	349.2	139.2
13	Ismailia	139.8	59.3	80.5
14	Giza	1234.9	825	409.9
15	Bani Souwaif	203	143.1	59.9
16	Fayoum	249.14	179.2	69.94
17	Menia	287.7	186.7	101
18	Assiut	224.8	185.3	39.5
19	Sohag	270.7	207.9	62.8
20	Qena	202.6	141.6	61
21	Aswan	119.1	88.1	31
23	Luxor	104	62.7	41.3
22	Red Sea	40.9	31	9.9

24	New valley	46.5	38.2	8.3
25	Matrouh	66.3	31.6	34.7
26	North Sinai	69.4	44.9	24.5
27	South Sinai	24.5	15.9	8.6
Total		9207.44	6474.1	2733.34

Data Source: CAPMAS (2017)

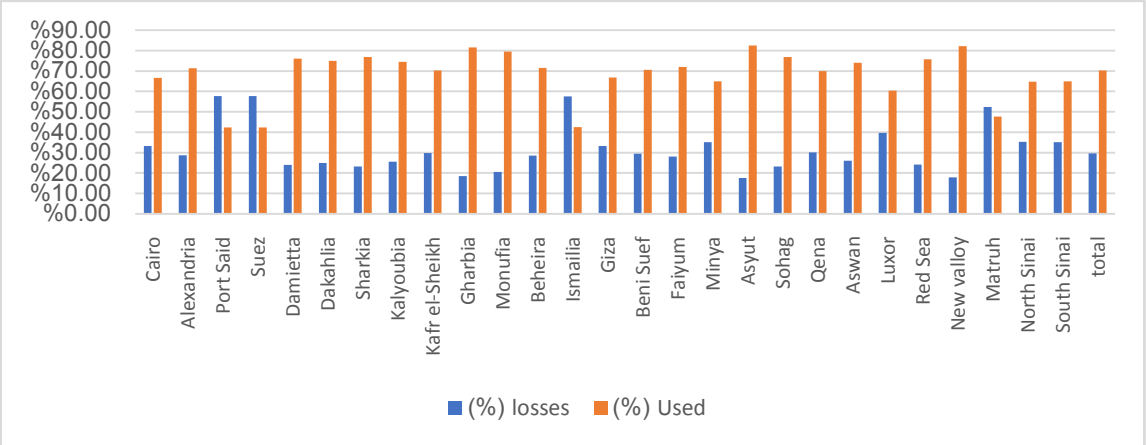

Figure (5) percentages of billeddomestic water and losses for each Governorate (2016) Data Source: CAPMAS (2017)

Domestic Water Sources

To reallocatethedomestic water sources, Egypt governorates have been classified according to the available sources ofdomestic water into two main categories: The first category is the governorates which depending on surface and ground water, whilethe second category is mainly depending on surface water, which has been subdivided geographically, into two sub-categories; coastal governorates and non-coastal governorates. Figure (6) showsthe classification of governorates according type ofdomestic water sources,while figure (7) shows the value and types of each water source for each category.

Tables (5, 6, and 7) and figures (8, 9, 10) presentwith details the classification of governorates according to types ofdomestic water sources;(SW and GW)Governorates, (SW) Coastal Governorates, and (SW) Non-Coastal Governorates respectively,

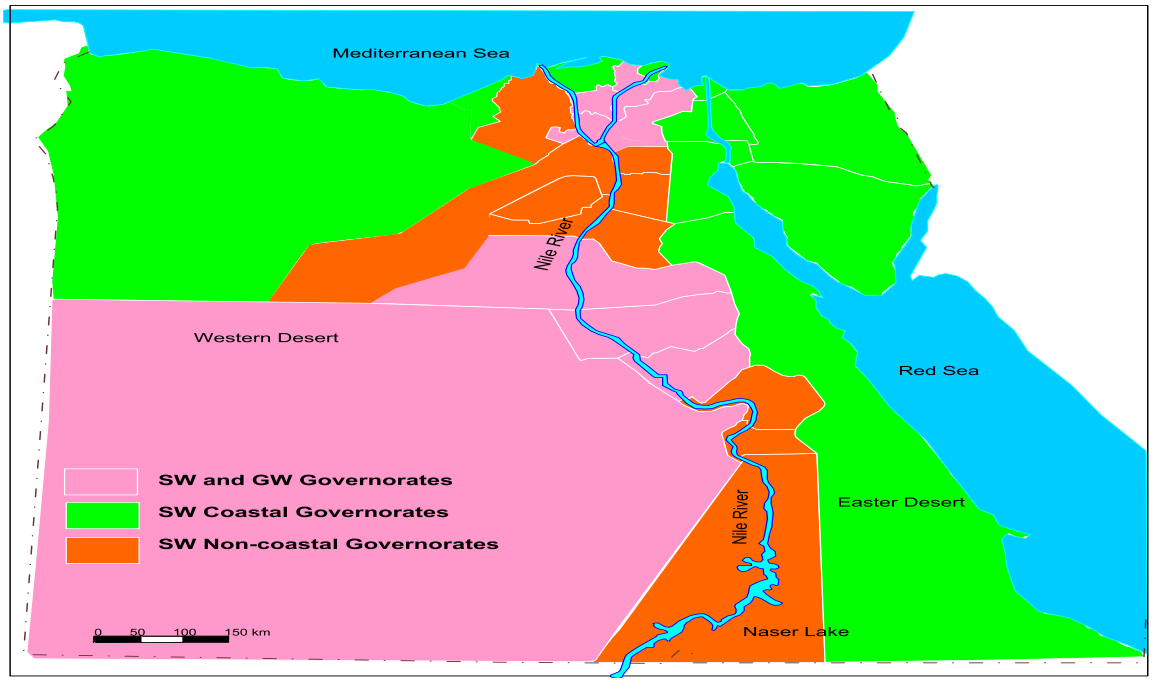

Figure (6) Classification of governorates according type ofdomestic water sources.

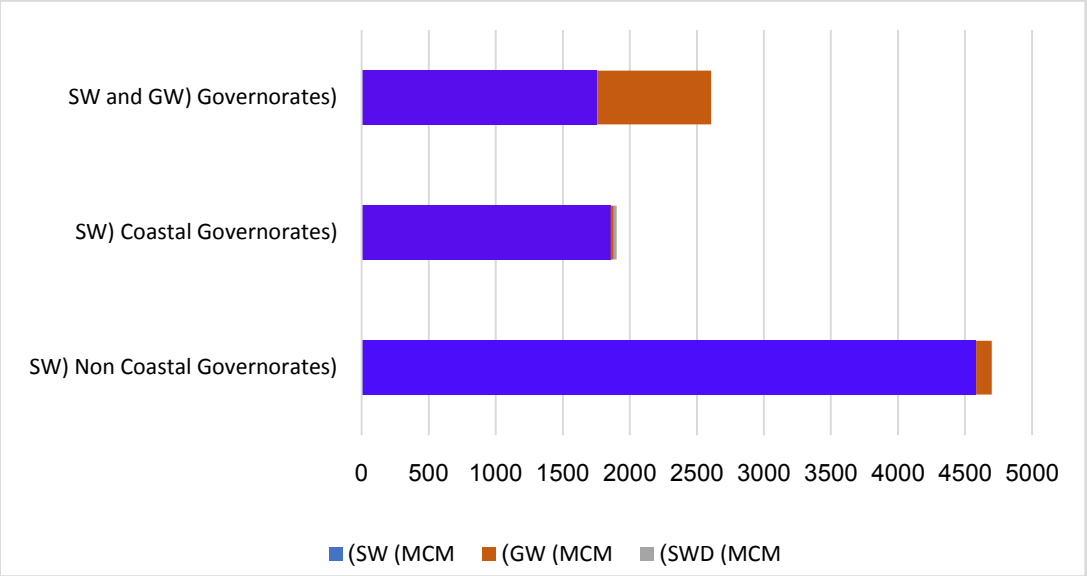

Figure (7) values and types of each domestic water source for each category.

Table (5) Domestic water sources in (SW and GW) Governorates (2016)

S. N.	The Governorate	SW (MCM)	GW (MCM)	SWD (MCM)	Total (MCM)	SW (%)	GW (%)	SWD (%)
1	**Sharqeia**	299.8	71.7	0	371.5	80.70	19.30	0
2	**Gharbya**	196.8	139.2	0	336	58.57	41.43	0
3	**Dakahliya**	463.9	64.8	0	528.7	87.74	12.26	0
4	**Monofiya**	174.6	151.6	0	326.2	53.53	46.48	0
5	**Menia**	228.5	59.2	0	287.7	79.42	20.58	0
6	**Sohag**	155.8	114.9	0	270.7	57.55	42.45	0
7	**Assiut**	112.5	112.3	0	224.8	50.04	49.96	0
8	**Kalyobiya**	123.9	90.7	0	214.6	57.73	42.26	0
9	**New valley**	0	46.5	0	46.5	0	1006	0
Total		**1755.8**	**850.9**	**0**	**2606.7**	**67.36**	**32.64**	**0**

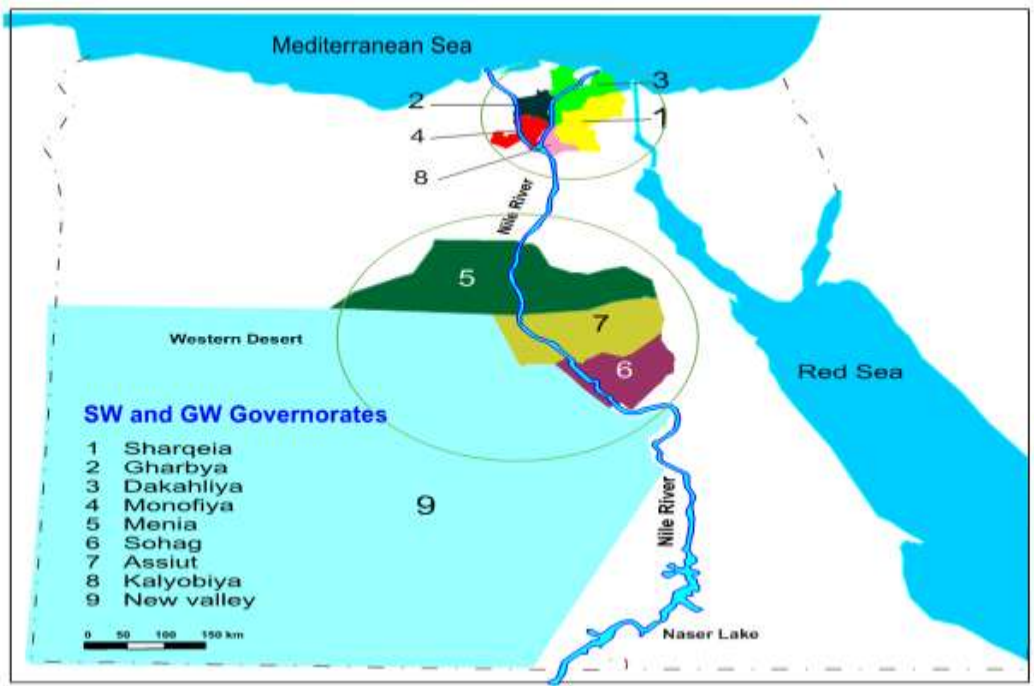

Figure (8) location map of (SW and GW)governorates.

Table (6) Domestic water sources in (SW)Coastal governorates (2016).

S.N	The Governorate	SW (MCM)	GW (MCM)	SWD MCM)	Total (MCM)	SW (%)	GW (%)	SWD (%)
1	**Alexandria**	1056.3	0	0	1056.3	100	0	0
2	**Kafr El-Sheikh**	287.5	0	0	287.5	100	0	0
3	**Damietta**	188	0	0	188	100	0	0
4	**Ismailia**	139.8	0	0	139.8	100	0	0
5	**North Sinai**	45.6	20.7	3.1	69.4	65.70	29.83	4.45
6	**Matrouh**	62.6	1.7	2	66.3	94.42	2.56	3.02
7	**Red Sea**	35.5	0	5.4	40.9	86.8	0	13.20
8	**South Sinai**	12.7	0.7	11.1	24.5	51.84	2.86	45.31
9	**Suez**	18.9	0	0	18.9	100	0	0
10	**Port Said**	9.7	0	0	9.7	100	0	0
Total		**1856.6**	**23.1**	**21.6**	**1901.3**	**97.649**	**1.215**	**1.136**

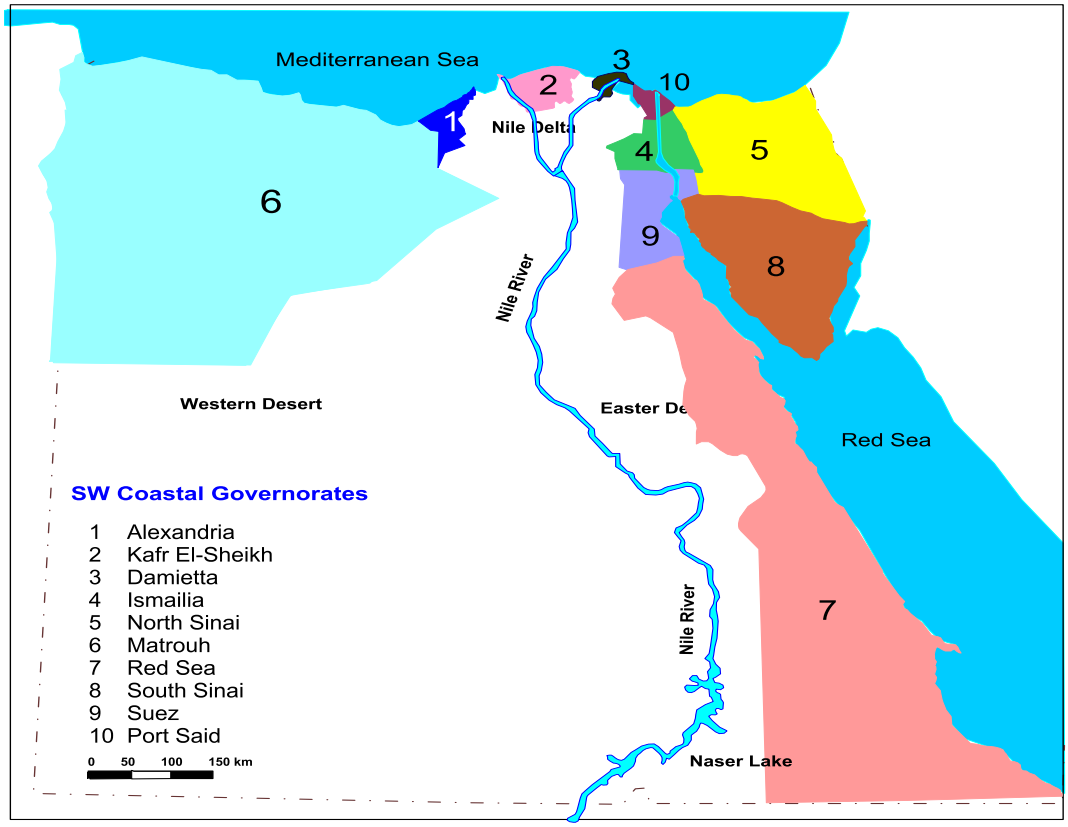

Figure (9) location map of (SW) Coastal governorates.

Table (7) Domestic water sources in (SW)Non-coastal governorates (2016).

S.N.	The Governorate	SW (MCM)	GW (MCM)	SWD (MCM)	Total (MCM)	SW (%)	GW (%)	SWD (%)
1	**Cairo**	2096.5	1.8	0	2098.3	99.91	0.086	0
2	**Giza**	1165.5	69.4	0	1234.9	94.38	5.62	0
3	**El Beheira**	471.7	16.7	0	488.4	96.58	3.42	0
4	**Fayoum**	249.1	0	0.04	249.14	99.98	0	0.016
5	**Bani Souwaif**	195.7	7.3	0	203	96.40	3.6	0
6	**Qena**	187.1	15.5	0	202.6	92.35	7.65	0
7	**Aswan**	116.3	2.8	0	119.1	97.65	2.35	0
8	**Luxor**	99.7	4.3	0	104	95.87	4.14	0
total		**4581.6**	**117.8**	**0.04**	**4699.44**	**97.492**	**2.507**	**0.001**

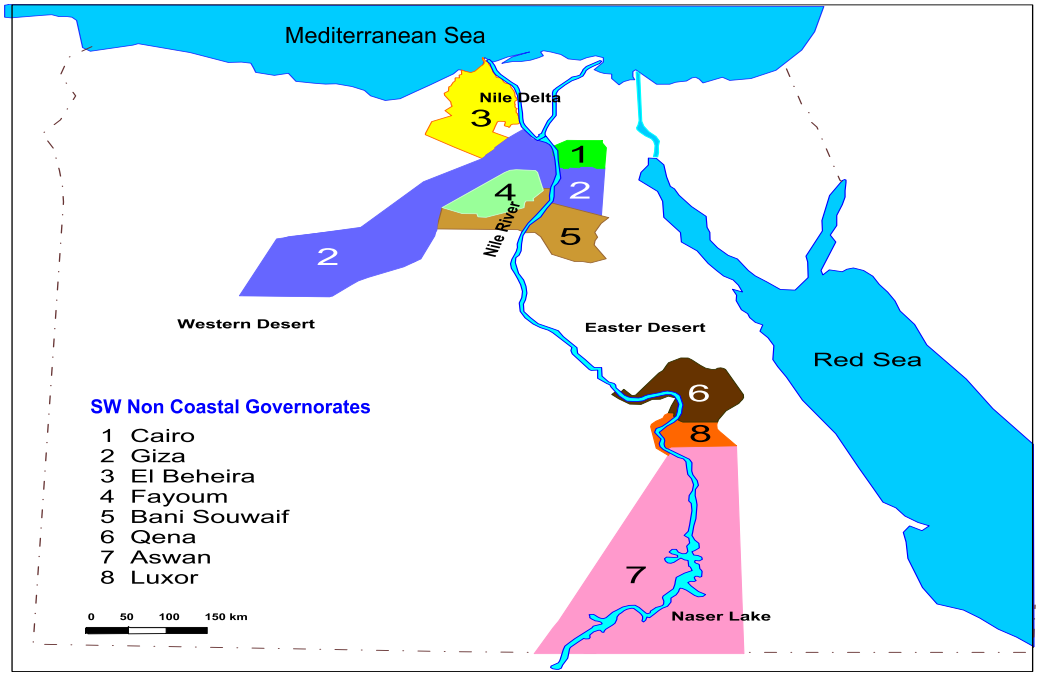

Figure (10) location map of (SW) Non-coastal governorates.

V FUTURE DOMESTICWATER DEMANDS

The future demands of each category were estimated based on two main criteria: (i) Egypt's overall population growth rate of 2.05%, and (ii) Egypt's annual per capita water consumption of 102 CM/yr. Figure (11) shows the estimated future demands ofdomestic water which will be increased steadily from about 9.207 BCM at 2016 to 14.98 BCM in 2040 in case of the current system efficiency will be not improved.Tables (8, 9, and 10) present the future DomesticWaterdemands of each governorate separately during years 2025, 2030, 2035 and 2040 respectively.

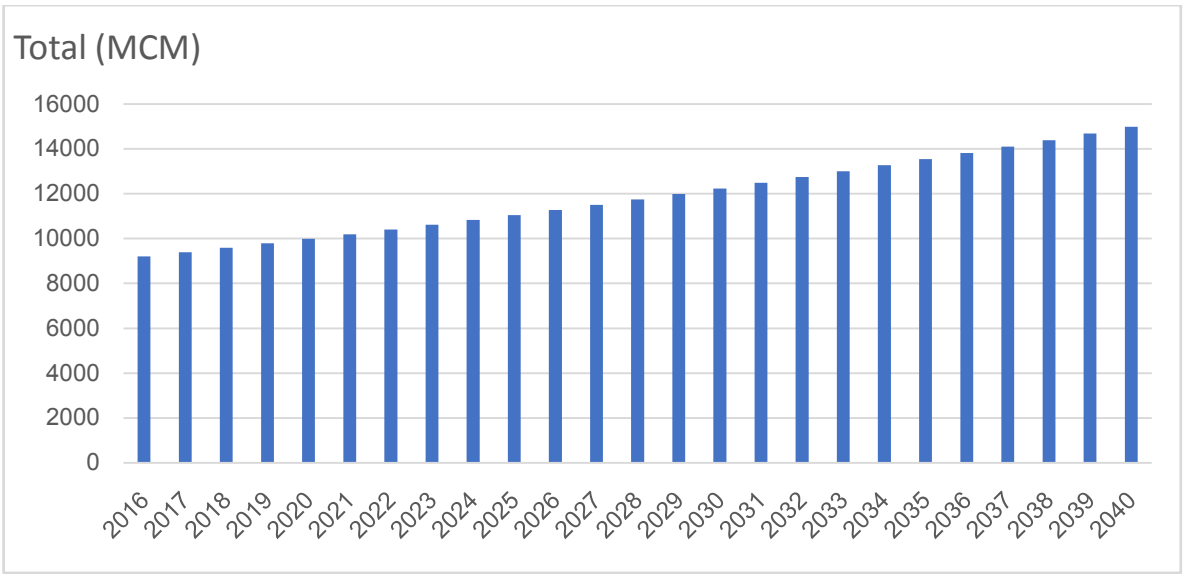

Figure (11) Future demands ofdomestic water DataSource: (CAPMAS 2017)

Table (8)Future domesticwater demands of (SW and GW) Governorates.

S.N.	Governorates	2016	2025	2030	2035	2040
1	**Sharqeia**	371.5	793.8	878.52	972.34	1076.17
2	**Gharbya**	336	579.38	641.17	709.64	785.42
3	**Dakahliya**	528.7	725.1	802.533	888.24	983.09
4	**Monofiya**	326.2	482.3	533.756	590.76	653.84
5	**Menia**	287.7	636.4	704.362	779.58	862.83
6	**Sohag**	270.7	567.4	627.996	695.06	769.28

7	**Assiut**	224.8	522.53	578.339	640.09	708.45
8	**Kalyobiya**	214.6	622.69	689.19	762.79	844.24
9	**New valley**	46.5	27.57	30.51085	33.77	37.375
Total		2606.7	4957.01	5486.37	6072.25	6720.71

Table (9)Future domesticwater demands of (SW) Coastal governorates

S.N.	Governorates	2016	2025	2030	2035	2040
1	**Alexandria**	1056.3	584.28	646.67	715.73	792.1
2	**Kafr El-Sheikh**	287.5	388.51	429.993	475.91	526.73
3	**Damietta**	188	162.38	179.72	198.91	220.15
4	**Ismailia**	139.8	144.75	160.21	177.32	196.26
5	**North Sinai**	69.4	53.26	58.95	65.25	72.21
6	**Matrouh**	66.3	56.54	62.58	69.26	76.66
7	**Red Sea**	40.9	42.36	46.89	51.9	57.43
8	**South Sinai**	24.5	20.24	22.4	24.8	27.43
9	**Suez**	18.9	76.03	84.15	93.1	103.09
10	**Port Said**	9.7	80.84	89.47	99.03	109.6
Total		**1901.3**	**1609.2**	**1781.04**	**1971.2**	**2181.7**

Table (10)Future domesticwater demands of (SW) Non-coastal governorates

S.N.	Governorates	2016	2025	2030	2035	2040
1	**Cairo**	2098.3	1125.109	1245.258	1378.239	1525.42
2	**Giza**	1234.9	927.9332	1027.027	1136.702	1258.09
3	**El Beheira**	488.4	713.09	789.2	873.5	966.8
4	**Fayoum**	249.14	391.87	433.7	480.04	531.3
5	**Bani Souwaif**	203	353.01	390.7	432.43	478.6
6	**Qena**	202.6	374.79	414.8	459.11	508.1
7	**Aswan**	119.1	175.43	194.17	214.9	237.9
8	**Luxor**	104	140.35	155.34	171.9	190.3
Total		**4699.44**	**4201.6**	**4650.3**	**5146.9**	**5696.51**

VI REALLOCATION OF FUTURE DOMESTIC WATER SOURCES

In order to manage and reallocate domestic water sources; the future needs for each category and governorate has been calculated as the value of difference between the future needs of domestic water and domestic water uses in 2106.

6-1 SW and GW Governorates

In SW and GW Governorates(Sharqeia , Gharbya Menoufia, Kalyobiya, Dakahliya, Menia, Assiut, Sohag and New Valley (New Valley Governorate was added within this category, although it is the only governorate relies groundwater as a single source of domestic water)), the required domestic water to meet the future demands and to raise the per capita share of domestic water to the current national rate (270 lcd) during years 2025, 2030, 2035 and 2040 are: 2369, 2896, 3478, 4123 MCM/yr., respectively.These quantities should be supplied and managed through fresh groundwater, treated groundwater, treated waste water, and brackish groundwater desalination, (Table11 and figure 12).

Table (11) future domestic water needsfor SW and GW governorates

S.N	Governorates	Uses in 2016 (MCM)	Future Domestic waterneeds (MCM)			
			2025	2030	2035	2040
1	**Sharqeia**	371.5	422.3	507	600.8	704.7
2	**Gharbya**	336	243.3	305.2	373.6	449.47
3	**Dakahliya**	528.7	196.4	273.8	359.5	454.4
4	**Monofiya**	326.2	156.1	207.6	264.6	327.6
5	**Menia**	287.7	348.7	416.7	491.9	575.1
6	**Sohag**	270.7	296.7	357.3	424.6	498.6
7	**Assiut**	224.8	297.7	353.5	415.3	483.6
8	**Kalyobiya**	214.6	408.1	474.6	548.2	629.6
9	**New valloy**	46.5				
Total		2606.7	**23697**	**2895.7**	**3478.3**	**41233**

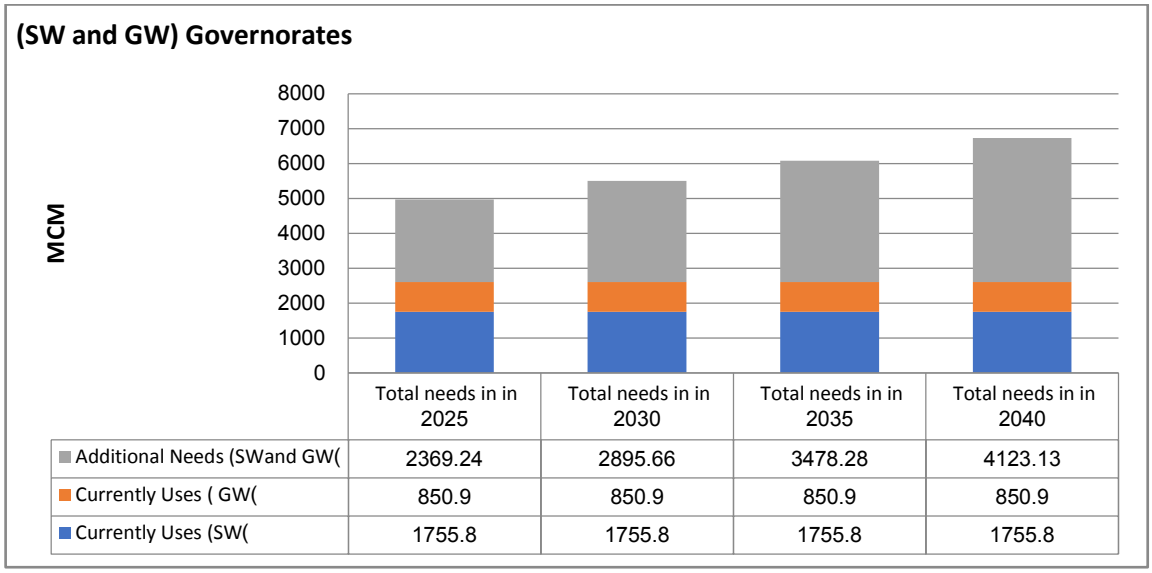

Figure (12) total amount of Future domestic water demands forSW and GW governorates

6-2SW Coastal Governorates

In SW Coastal Governorates, (Alexandria, Kafr el-Sheikh,Damietta,Ismailia,North SinaiMatrouh,Red Sea, South Sinai, Suez, and Port Said),the required domestic water to meet the future demands and to raise the per capita share of domestic water to the current national rate (270 lcd) during years 2025, 2030, 2035 and 2040 are: 236, 306, 415 and 545 MCM/yr. respectively.These quantities must be managed through SWD; moreover the amount of SW which currently used (1901.3 MCM/yr.) should be replaced with SWD, (Table12, and figure 13).

Table (12) future domestic water demands for SW Coastal governorates

S.N	Governorates	Uses in 2016 (MCM)	Future Domestic water needs (MCM)			
			2025	2030	2035	2040
1	Alexandria	1056.3				
2	Kafr El-Sheikh	287.5	101.0	142.49	188.41	239.23
3	Damietta	188	0	0	10.91	32.15
4	Ismailia	139.8	4.95	20.41	37.52	56.46
5	North Sinai	69.4				2.81
6	Matrouh	66.3			2.96	10.36
7	Red Sea	40.9	1.46	5.99	10.99	16.53
8	South Sinai	24.5			0.29	2.94
9	Suez	18.9	57.13	65.25	74.24	84.19
10	Port Said	9.7	71.14	79.77	89.33	99.91
Total		1901.3	**235.7**	**305.64**	**414.66**	**544.58**

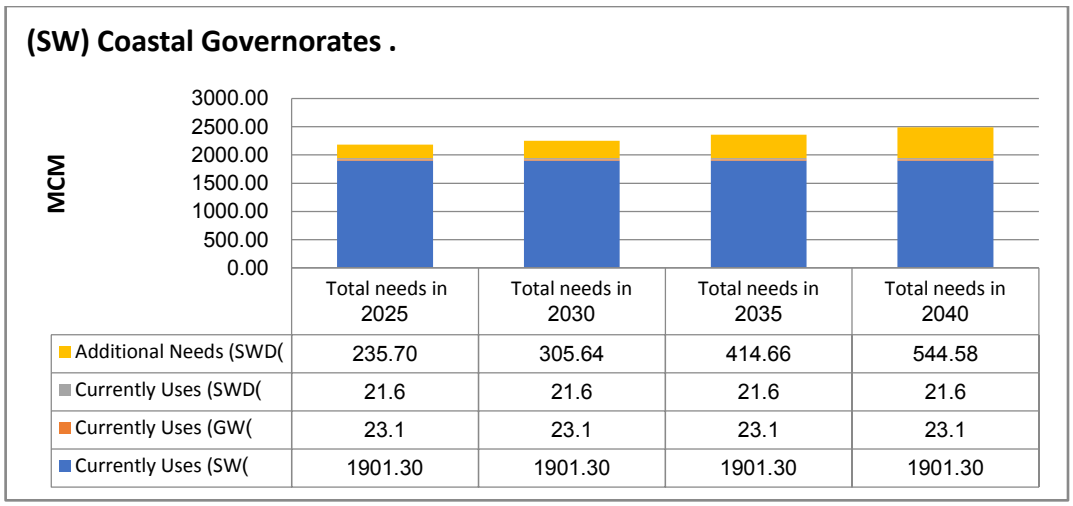

Figure (13) total amount of Future domestic water demands forSW Coastalgovernorates

5-3SW Non-Coastal Governorates

In SW Non-Coastal governorates, (Cairo, Giza, El Beheira, Fayoum, Bani Souwaif, Qena, Aswan, and Luxor) the required domestic water to meet the future needs and to raise the per capita share of domestic water to the current national rate (270 lcd) during years 2025, 2030, 2035 and 2040 are; 782, 1012, 1266 and 1570 MCM/yr. These quantities should be supplied and managed through treated groundwater, treated waste water, and brackish groundwater desalination, (Table13 and figure 14).

Table (13) future domestic water demands for SW Non-coastalgovernorates.

S. N	Governorates	Uses in 2016 (MCM)	Future Domestic water needs (MCM)			
			2025	2030	2035	2040
1	Cairo	2098.3				
2	Giza	1234.9				23.19
3	El Beheira	488.4	224.692	300.84	385.12	478.41
4	Fayoum	249.14	142.7	184.58	230.9	282.16
5	Bani Souwaif	203	150.0	187.7	229.43	275.60
6	Qena	202.6	172.19	212.21	256.51	305.54
7	Aswan	119.1	56.33	75.07	95.80	118.75
8	Luxor	104	36.35	51.34	67.93	86.29
Total		4699.44	**782.31**	**1011.75**	**1265.7**	**1569.95**

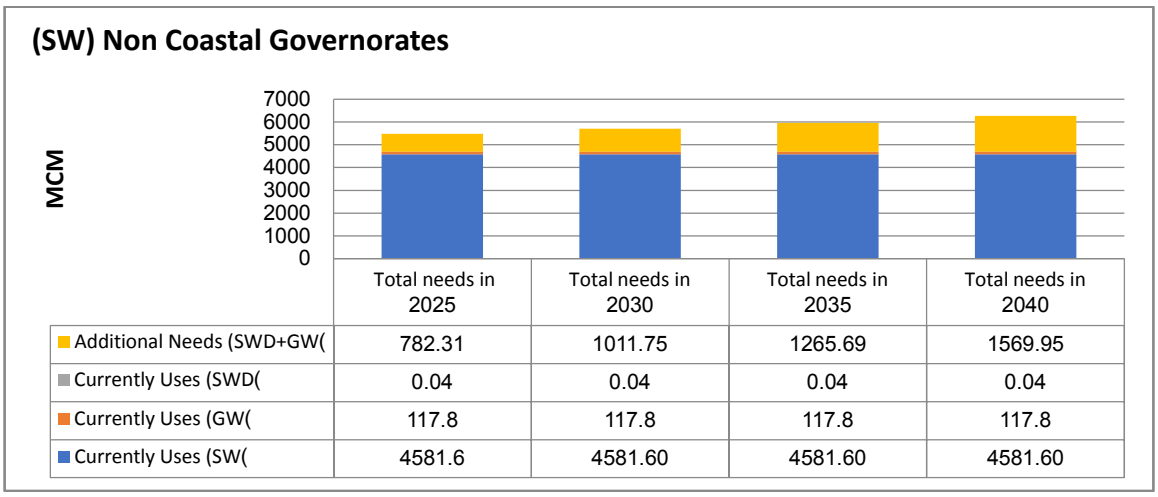

Figure (14)total amount of Future domestic water demands forSW Non-coastalgovernorates.

VII. CONCLUSION AND RECOMMENDATIONS

(1) Domestic water in Egypt is diverted from two main sources: surface water (SW) which supplies about 88.99% and groundwater (GW), which supplies about 10.77% of total demands and about 0.24% from sea water desalination (SWD).

(2) The major factor affecting the amount of diverted water for domestic use is the efficiency of the delivery networks,in 2016 the accumulative annual volume of billed domestic water is equal to 6.474 BCM while the total volume of produced water hasbeen 9.207 BCM, thus, the efficiency of domestic water use is 70.31%.

(3) The Egyptian governorates have been classified according to the available sources of domestic water into two main categories: The first category is depending on surface and ground water,the second category is mainly depending on surface water, which has been subdivided geographically, into two sub-categories; Coastal governorates and Non-coastal governorates.

(4) The future demands of each category were estimated based on two main criteria: (i) Egypt's overall population growth rate of 2.05%, and (ii) Egypt's annual per capita water consumption of 102 CM/yr. the estimated future demands of domestic water sources will be increased steadily from about 9.207 BCM at 2016 to 14.98 BCM in 2040 in case of the currentsystem efficiency will be not improved.

(5) In SW and GW Governorates (Sharqeia , Gharbya Menoufia, Kalyobiya, Dakahliya, Menia, Assiut, Sohag and New Valley)the required domestic water to meet the future demands during years 2025, 2030, 2035 and 2040 are: 2369, 2896, 3478, 4123 MCM/yr., respectively. These quantities should be supplied and managed through fresh groundwater, treated groundwater, treated waste water, and brackish groundwater desalination.

(6) In SW Coastal Governorates, (Alexandria, Kafr el-Sheikh,Damietta,Ismailia,North SinaiMatrouh,Red Sea,

South Sinai, Suez, and Port Said),the required domestic water to meet the future demands during years 2025, 2030, 2035 and 2040 are: 236, 306, 415 and 545 MCM/yr. respectively. These quantities must be managed through SWD, moreover the amount of SW which currently used (1901.3 MCM/yr.) should be replaced with SWD.

(7) In SW Non-Coastal Governorates, (Cairo, Giza, El Beheira, Fayoum, Bani Souwaif, Qena, Aswan, and Luxor) the required domestic water to meet the future demands during years 2025, 2030, 2035 and 2040 are:782, 1012, 1266 and 1570 MCM/yr. These quantities should be supplied and managed through treated groundwater, treated waste water, and brackish groundwater desalination.

(8) The Egyptian government is urgently required to increase the current consumption of domestic water from around 9.2 BCM currently to about 15 BCM of water by 2040 outside the Nile waters.This will need huge investments for sea water desalination in the coastal governorates as well as treatment and desalination of fresh and brackish groundwater in the Nile Delta and the Wadi .

REFERENCES

[1]. Abu Zeid M. (1998) Water is source of Tension in the 21st Century. Al Ahram Center for Publishing and Translation. (in Arabic).

[2]. Barbary Z. (2008) Safe operation scenarios of Water supply stations during low flow. Engineering Research Journal. 2008;117: C1-C18.

[3]. Diana RK. (2000) Water Sharing in the Nile River Valley project gnv011: using GIS/remote sensing for the sustainable use of natural resources, Geneva; 2000. Available.http://www.grid.unep.ch/activities/sustainable/nile/nilereport.pdf(last reach 15/4/2018)

[4]. CAPMAS (2017), Central Agency for Public Mobilization and Statistics, http://www.capmas.gov.eg/

[5]. http://www.capmas.gov.eg/Pages/Publications.aspx?page_id=5109&Year=19630 and http://www.capmas.gov.eg/Pages/Publications.aspx?page_id=5109&Year=19630 (last reach 15/4/2018).

[6]. Plan Bleu (2011) Final version Water use efficiency and economic approach, Plan Bleu, National study Egypt, UNEP/MAP Regional Activity Centre, Sophia Antipolis, July 2011, Available. http://planbleu.org/sites/default/files/publications/efficience_eau_egypte_en.pdf(last reach 15/4/2018)

[7]. El NasharW.Y.(2014) Groundwater Management in Egypt, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 4 Ver. IV (Jul- Aug. 2014), PP 69-78 www.iosrjournals.org)

[8]. El TahlawiM. R., Farrag A. A. andAhmed S. S. (2008)Groundwater of Egypt: ‘‘an environmental overview’’Environ Geol (2008) 55:639–652 DOI 10.1007/s00254-007-1014-1

[9]. Fahmy S. Abdelhaleem and Esam Y. Helal(2015) Impacts of Grand Ethiopian Renaissance Dam on Different Water Usages in Upper Egypt British Journal of Applied Science & Technology, 8(5): 461-483, 2015, Article no.BJAST.2015.225, ISSN: 2231-0843 ,SCIENCEDOMAIN international, www.sciencedomain.org

[10]. IDSC (Information and Decision Support Center), Cabinet of Ministers, Egypt (2007). Egypt's description by Information. 7th ed.

[11]. IPoE (2013) International Panel of experts (IPoE) on Grand Ethiopian Renaissance Dam Project (GERDP), Final Report, Addis Ababa, Ethiopia, May, 31st; 2013.Available:http://www.internationalrivers.org

[12]. Ismail S. (2013) Flow Reduction Impacts along River Nile In Egypt. Proc. of seventeenth Int. Water Technology Conf. (IWTC 17), Istanbul, Turkey. 2013;5-7.

[13]. MWRI. (2005)National Water Resources plan 2017. Ministry of Water Resources and Irrigation, Egypt, (2005).

[14]. Ramadan S.M., Negm A.M., Smanny M., Helmy A.H.M. (2013) Environmental Impacts of Great Ethiopian Renaissance Dam on the Egyptian Water Resources Management and Security. The 23rd International Conference On: Environmental Protection is a Must 11–13 May, Alexandria, Egypt; 2013.

[15]. RIGW/IWACO (1999) Contributions to environmental management of Egypt’s groundwater resources. Final report, EMGR Project, Research institute for groundwater, National Water Research Center, El Kanater El Khairia, Egypt

[16]. RIGW/IWACO(1988, 1993) Hydrogeological map of Egypt, scale 1:2,000,000. Research institute for groundwater, National Water Research Center, El Kanater El Khairia, Egypt.

[17]. RIGW (1992) Hydrogeological Map of Egypt: Map Sheet of Nile Delta. Research Institute for Groundwater, National Water Research Center, El Kanater El Khairia, Egypt.

[18]. RIGW/IWACO, (1990) Development and Management of Groundwater Resources in the Nile Valley and Delta: Assessment of Groundwater Pollution from Agricultural Activities, Internal Report. Research Institute for Groundwater, National Water Research Center, El Kanater El Khairia, Egypt.

[19]. Wagdy A. (2009) Progress in Water Resources Management: Egypt" Proceedings of the 1st Technical Meeting of Muslim Water Researchers Cooperation (MUWAREC), Malaysia, December 2008.

Osama M. Sallam." The Future Role of Groundwater and Desalination in Reallocation of Domestic Water Sources in Egypt”American Journal Of Engineering Research (AJER), Vol. 7, No. 5, 2018, Pp.452-465.