

IMPACT OF INCREASE IN DEMAND FOR POTABLE WATER SUPPLY ON WATER RESOURCES, CASE STUDY OF QENA GOVERNORATE – EGYPT

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ABSTRACT

Efficient water resources management provides optimal use of the available water resources between municipal, industrial, and irrigation. With the rapid increase in population, the need for potable water supply increases and also the need for more food production increases.

In this paper, an attempt is made to investigate the effect of increase of population on the increase of demand for potable water supply. This increase adds to the water scarcity problems in Egypt. It represents additional shortage in the available water for irrigation. Qena Governorate is selected as a case study for demonstration.

Qena Governorate is located in Upper Egypt some 700 km south of Cairo. It has 11 provinces which include 51 towns and main villages and 136 small dependent villages and 2137 Nagas. For each province, field data about population and the available water supply utilities were collected and analyzed. The paper includes the population studies and presents the future demands every 5 years until the year 2037. These data were processed in excel sheets and integrated for each province and for the whole governorate to provide useful conclusions.

The results show the population increase and the increase of demand for potable water as well as the available and planned water production capacities for each province in Qena. The study estimated the value of the negative impact of increase in potable water in Egypt in the year 2037 to increase with 6.4103 billion m³/year. It recommends the reuse of domestic sewage in irrigation subject to the conditions of conducting all necessary collection and treatment systems to agree with the Egyptian laws. The results have potential usefulness in the water resources management in Egypt.

Key words: Potable water, Demands, Water Resources, Qena.

1. INTRODUCTION

1.1 Description of the study area

Qena governorate is located within the territory of Upper Egypt, bordered to the north by Sohag and the south by Aswan and the west is bounded by the New Valley Governorate and east by the Red Sea governorate. The area of the governorate is 10.798 square kilometers. Its length is 240 km along the River Nile. Qena governorate have eleven provinces, from north to south, these are Aboutesht - Farshout - Nag Hammadi - Deshna - Alwakf - Qena - Keft – Quos - Nagada - Armant – and Esna. These include 51 towns and main villages as well as 136 followed villages and 1637 Nagaas.

This study covers Qena governorate. Table (1) and Figure (1) show the administrative division of the governorate of Qena.

The Holding Company, represented by Qena Company for Water and Wastewater, manages the whole water supply system in Qena. Qena is divided into three regions to manage potable water and sanitation systems. These are:

- a) The northern region includes the provinces Abu Tesht, Farshout, Nag Hammadi, Deshna and Alwakf.
- b) Central region includes the provinces of Qena, Keft, and Nagada.
- c) The southern region including provinces Armant and Esna. Recently these two provinces are joined to Luxor Governorate and managed by Luxor Company for water supply and sanitation. However they are included in this research work.

Table (1): Number of Administrative Divisions of the Governorate of Qena

Provence	Number of Cities, Villages, and Belongings		
	Major cities and towns	Villages	Belonging Nagaas
Abo Tisht	5	28	183
Farshot	3	6	79
Naga Hamadi	9	19	270
Deshna	4	13	141
Alwaqf	1	2	77
Qena	7	17	712
Qeft	4	4	87
Qous	5	19	250
Nagada	2	4	98
Armant	3	4	81
Esna	8	20	159
Total	51	136	2137

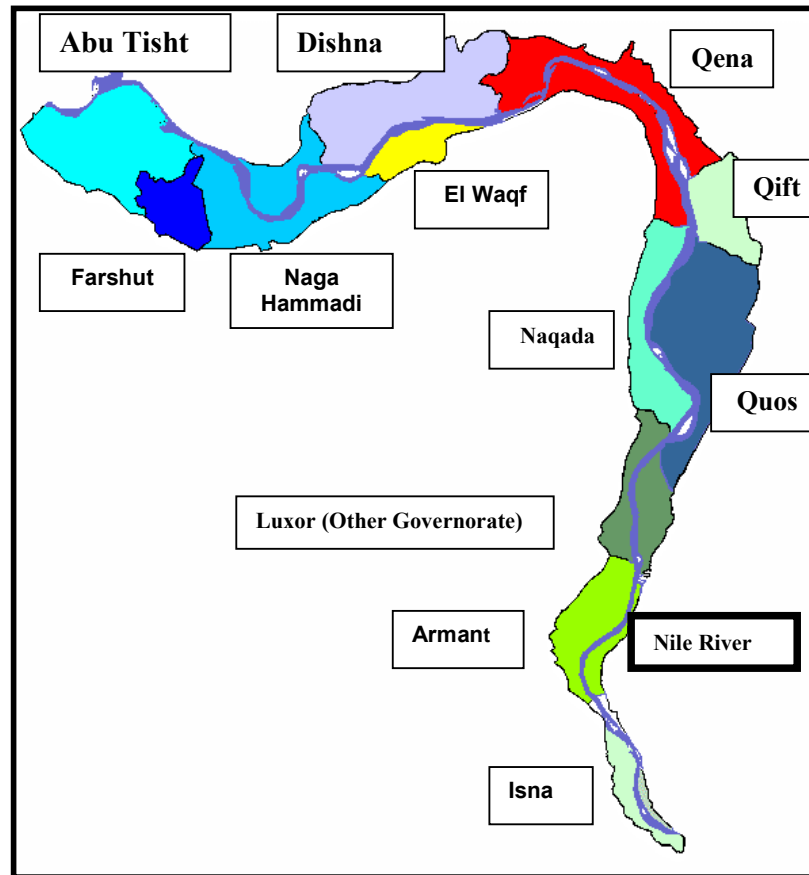


Figure (1) The Administrative Division of the Governorate of Qena.

1.2 Agriculture activities in Qena

Qena governorate has 44.29% of the total agriculture area in the south valley of Egypt. It represents 359598 fedans. Therefore, agricultural is the main activity and works for most of population of the governorate. The cropping pattern in Qena includes 57.6, 91.0, and 154.0 thousands of sedans cropped with Maize, wheat, and sugarcane respectively.

It is planned to add 352600 fedans of the desert land adjacent to the governorate into the existing agriculture area in Qena till the year 2017. It is intended to use groundwater for these lands. Therefore, drip irrigation will be used.

2. POPULATION STUDIES

Official Census (CAPMAS, 2007) of population data were collected and processed for each of the 11 provinces of Qena Governorate, including all belonging villages and Nagaas. These data were processed on excel sheets for the years 1986, 1996, 2001, 2006, and 2007. The following table shows the used population data in this study after integration for urban and rural areas of each province in Qena.

Table (3) Census for Population in Qena Governorate (CAPMAS, 2007)

Provence		Population				
		1986	1996	2001	2006	2007
Abo Tesht	Urban	7,714	10,469	11,649	14,110	13,340
	Rural	222,542	274,457	305,071	346,364	354,570
	Total	230,256	284,926	316,720	360,474	367,910
Farshout	Urban	35,037	43,796	48,614	51,330	52,150
	Rural	59,487	74,772	83,184	93,513	95,630
	Total	94,524	118,568	131,798	144,843	147,780
Naga Hamadi	Urban	29,262	33,252	36,910	45,118	46,520
	Rural	274,273	339,888	378,621	406,815	414,150
	Total	303,535	373,140	415,531	451,933	460,670
Deshna	Urban	36,976	44,125	48,979	52,674	53,620
	Rural	162,697	209,249	232,796	258,409	263,920
	Total	199,673	253,374	281,775	311,083	317,530
Al-Wakf	Urban	21,211	24,033	26,677	27,520	27,900
	Rural	24,407	31,732	35,312	39,976	40,910
	Total	45,618	55,765	61,989	67,496	68,810
Qena	Urban	119,917	155,382	172,905	206,831	212,830
Qena	Rural	237,539	278,552	309,957	343,685	350,980
	Total	357,456	433,934	482,862	550,516	563,820
Queft	Urban	14,334	17,918	19,889	21,336	21,710
	Rural	65,564	81,955	91,195	96,902	98,540
	Total	79,898	99,873	111,084	118,238	120,250
Quos	Urban	39,562	49,054	54,450	60,237	61,490
	Rural	193,189	241,710	268,565	301,189	307,890
	Total	232,751	290,764	323,015	361,426	369,380
Nagada	Urban	15,332	18,905	20,985	21,083	21,310
	Rural	79,283	97,990	109,042	115,227	117,110
	Total	94,615	116,895	130,027	136,310	138,420
Armant	Urban	53,831	65,647	72,868	76,698	77,900
	Rural	42,352	51,253	57,033	63,820	64,726
	Total	96,183	116,900	129,901	140,518	142,626
Esna	Urban	44,054	55,068	61,125	67,217	68,225
	Rural	179,981	224,767	249,750	271,974	276,054
	Total	224,035	279,835	310,876	339,191	345,780

2.1 Future population using different methods

Future water demand estimate requires the estimation of future population. Therefore in this study the future population is investigated every 5 years starting from 2012 until the year 2037.

Many methods are widely used to predict the future population. In this study, four alternative methods were used for calculating the future population according to the planned and expected progress and development of the town or village as well as migration scenarios in each province. The first alternative uses the arithmetic mean method. The second alternative uses the decreasing rate of increase of population. The third alternative uses the geometric method. The fourth approach uses a graphical extension method. The outputs of applying four methods were averaged to obtain an average representative prediction of future population in Qena.

a) Arithmetic increase method, expressed as;

$$P_n = P_1 + K_a (t_n - t_1) \quad (1)$$

b) Geometrical increase method , expressed as;

$$\ln P_n = \ln P_1 + K_g (t_n - t_1) \quad (2)$$

c) Decreasing rate of increase method, expressed as;

$$P_n = S - (S - P_1) e^{-k_d (t_n - t_1)} \quad (3)$$

Where;

P_n : future population in the year 2037.

P_1 :The last census of the area, according to Agency for Public Mobilization and Statistics

K_a :Average annual population growth rate (fixed rate).

K_g :Annual growth rate of the population in geometrical way (growing rate).

K_d :Decreasing rate of increase (decreasing).

S : Maximum value for population (saturated limit)

$(t_n - t_1)$: Target year (2037) – year of sensus

\ln : Natural logarithm of the basis of 2.7.

d) Graphical extension method assumes a rate of increase similar to that between the years 1986 and 2006, and assumes to achieve a fair amount of urban and economic development, and reduce the rates of emigration from the governorate, and at the same time provide social programs and low rates of natural increase as a result of programs of family planning.

Based on the population census, the rates of increase of population are calculated and presented in table (4). These rates are used to obtain the future population as shown in tables (5 and 6). Table (6) shows the population obtained for urban and rural areas in every province as an average of the results of the four methods. Figure (2) represents the obtained growth in population for each province

and the total for the governorate. It shows that the current population is 3.412029 millions and will increase to 5.453019 millions in the year 2037 which represents an average increase of 58.82%.

Table (4) Rates of increase of population.

Provence		Rate of Increase of Population %			
		From 1986-1996	From 1996-2001	From 2001-2006	From 2006-2007
Abo Tesht	Urban	3.6	2.3	2.6	2.4
	Rural	2.3	2.2	2.7	2.4
Farshout	Urban	2.5	2.2	1.1	1.6
	Rural	2.6	2.3	2.5	2.3
Naga Hammadi	Urban	1.4	2.2	4.4	3.1
	Rural	2.4	2.3	1.5	1.8
Deshna	Urban	1.9	2.2	1.5	1.8
	Rural	2.9	2.3	2.2	2.1
Al Wakf	Urban	1.3	2.2	0.6	1.4
	Rural	3.0	2.3	2.6	2.3
Qena	Urban	3	2.3	3.9	2.9
	Rural	1.7	2.3	2.2	2.1
Qeft	Urban	2.5	2.2	1.5	1.8
	Rural	2.5	2.3	1.3	1.7
Quos	Urban	2.4	2.2	2.1	2.1
	Rural	2.5	2.2	2.4	2.2
Nagada	Urban	2.3	2.2	0.1	1.1
	Rural	2.4	2.3	1.1	1.6
Armant	Urban	2.2	2.2	1.1	1.6
	Rural	2.1	2.3	2.4	1.4
Esna	Urban	2.5	2.2	2	1.5
	Rural	2.5	2.2	1.8	1.5

Table (5) Total Future Population in Qena Governorate obtained by using the different alternative methods

Alternative Method	2012	2017	2022	2027	2032	2037
First	3,403,243	3,754,256	4,105,269	4,456,282	4,807,295	5,158,308
Second	3,392,508	3,718,174	4,028,930	4,324,775	4,605,710	4,880,980
Third	3,439,560	3,884,176	4,399,290	5,001,291	5,712,666	6,565,078
Fourth	3,412,805	3,771,786	4,130,766	4,489,747	4,848,728	5,207,709
Average	3,412,029	3,782,098	4,166,064	4,568,024	4,993,600	5,453,019

Table (6) Expected Future population as an Average of the four Alternatives

Provence		2012	2017	2022	2027	2032	2037
Abo Tesht	Urban	17,134	19,778	22,561	25,513	28,669	32,083
	Rural	403,745	454,353	508,743	568,753	637,270	719,141
	Total	420,879	474,131	531,304	594,266	665,939	751,225
Farshout	Urban	56,953	61,683	66,464	71,306	76,220	81,258
	Rural	107,893	120,215	132,904	146,026	159,653	173,942
	Total	164,846	181,898	199,368	217,331	235,873	255,200
Naga Hamadi	Urban	54,270	62,319	70,845	79,952	89,764	100,466
	Rural	457,629	500,723	544,637	589,514	635,516	683,137
	Total	511,898	563,042	615,482	669,466	725,280	783,603
Deshna	Urban	58,841	64,059	69,365	74,773	80,301	86,009
	Rural	296,558	329,116	362,507	396,876	432,385	469,416
	Total	355,398	393,175	431,872	471,649	512,686	555,426
Al-Wakf	Urban	29,893	31,876	33,867	35,869	37,886	39,943
	Rural	46,430	51,969	57,684	63,604	69,767	76,244
	Total	76,323	83,845	91,550	99,473	107,653	116,187
Qena	Urban	248,677	285,178	323,502	364,030	407,218	453,761
	Rural	390,935	431,316	472,791	515,548	559,801	606,056
	Total	639,612	716,494	796,292	879,579	967,019	1,059,817
Queft	Urban	23,890	26,048	28,240	30,471	32,748	35,094
	Rural	108,137	117,628	127,264	137,071	147,080	157,399
	Total	132,027	143,677	155,504	167,542	179,827	192,493
Quos	Urban	68,624	75,775	83,103	90,638	98,413	106,514
	Rural	346,428	385,157	425,006	466,170	508,873	553,597
	Total	415,052	460,932	508,109	556,808	607,286	660,111

Nagada	Urban	22,721	24,077	25,427	26,771	28,111	29,465
	Rural	127,996	138,752	149,637	160,677	171,900	183,426
	Total	150,717	162,829	175,064	187,448	200,012	212,891
Armant	Urban	84,771	91,558	98,413	105,349	112,383	119,592
	Rural	73,175	81,187	89,433	97,955	106,799	116,067
	Total	157,946	172,745	187,845	203,304	219,182	235,659
Esna	Urban	76,356	84,135	92,090	100,253	108,658	117,393
	Rural	310,975	345,196	381,584	420,905	464,185	513,015
	Total	387,331	429,331	473,674	521,158	572,843	630,408
Total for Qena Governorate		3,412,029	3,782,099	4,166,064	4,568,024	4,993,600	5,453,020

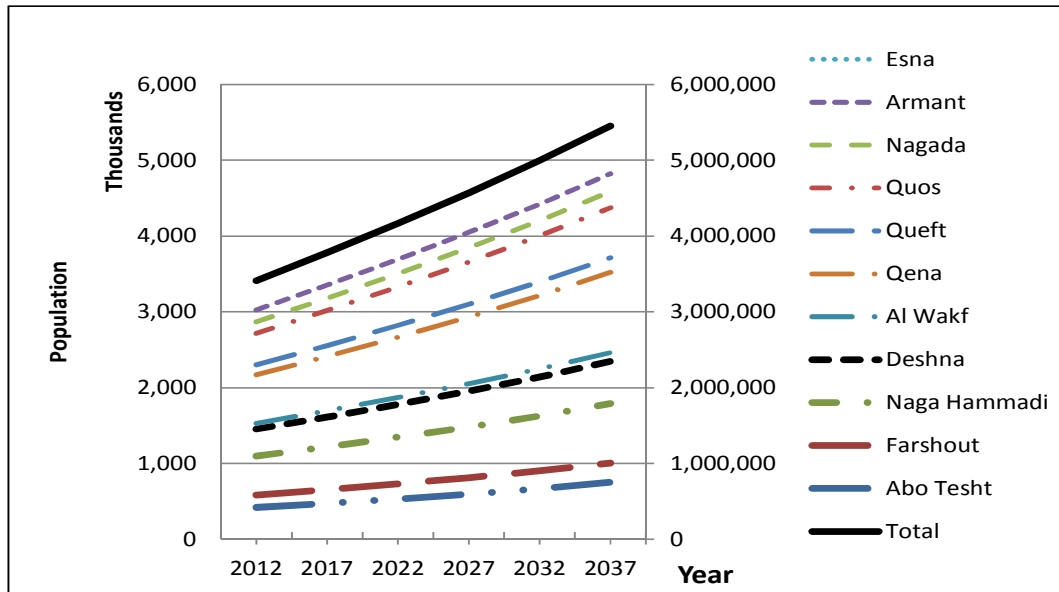


Figure (2) Estimated future population.

3. FUTURE POTABLE WATER NEEDS AND SANITARY DRAINAGE REQUIREMENTS

3.1 Calculation of Potable water Requirements

Following the Egyptian code of practice for design of potable water supply stations, the rates of daily water consumption and the potable water requirements are calculated as presented in Table (7) and Table (8) respectively.

Table (7): The rate of daily consumption per capita in rural and urban of the Provinces of Qena Governorate until the target year

Provence		The consumption rate per capita (l/ca/d)						
		2006	2012	2017	2022	2027	2032	2037
Abo Tisht	Urban	180	191	195	198	201	204	207
	Rural	150	157	160	162	164	167	169
Farshot	Urban	180	186	188	190	191	193	194
	Rural	150	157	159	161	163	165	167
Nage Hamadi	Urban	180	191	195	198	201	204	207
	Rural	150	156	157	159	161	162	164
Deshna	Urban	180	187	189	190	192	194	196
	Rural	150	157	159	161	162	164	166
Alwaqf	Urban	180	185	186	188	189	191	192
	Rural	150	157	160	162	164	166	167
Qena	Urban	220	233	237	241	245	248	252
	Rural	150	156	158	160	162	164	165
Qeft	Urban	180	187	189	191	192	194	196
	Rural	150	155	157	158	160	161	163
Qous	Urban	180	188	190	192	194	196	198
	Rural	150	157	159	161	163	165	166
Nagada	Urban	180	184	186	187	188	189	190
	Rural	150	155	157	158	160	161	162
Armant	Urban	180	186	188	189	191	193	194
	Rural	150	157	159	161	163	164	166
Esna	Urban	180	188	190	192	194	196	198
	Rural	150	156	158	160	162	164	166

Table (8): Estimated Future Needs of Potable Water for the Provinces in Qena Governorate

Provence	The Future Water Needs (m3/d)					
	2012	2017	2022	2027	2032	2037
Abo Tisht	66,835	76,440	86,901	98,581	112,058	128,317
Farshot	27,537	30,724	34,026	37,457	41,033	44,797
Naga Hamadi	81,630	90,969	100,672	110,788	121,377	132,578
Deshna	57,445	64,323	71,454	78,867	86,595	94,724
Alwaqf	12,833	14,235	15,687	17,195	18,767	20,422
Qena	119,199	136,018	153,770	172,597	192,679	214,323
Qeft	21,250	23,373	25,550	27,787	30,091	32,487
Qous	67,237	75,640	84,388	93,525	103,100	113,226
Nagada	24,036	26,205	28,415	30,671	32,979	35,363

Armant	27,230	30,079	33,016	36,050	39,195	42,486
Esna	62,895	70,601	78,829	87,735	97,527	108,542
Total	568,129	638,606	712,708	791,254	875,402	967,265

3.2 The current and future production capacity of potable water plants for the various provinces in the governorate

The number and production capacities of water production units include surface water purification stations and compact units as well as groundwater wells are collected and analyzed. Table (9) shows the number of stations of potable water and the expected production after completion of the ongoing projects in 2012. These produce 769133 m³/day. To meet the future needs, the National Organization of Potable Water and Sanitation Drainage (NOPWASD) and the Holding Company (HC) for water and wastewater are planning to add new production units. Table (10) and Figure (3) show the planned and targeted production capacity as per the Master plan for Qena Governorate (Misr Consult 2011).

Table (9) Current number of stations in Qena Governorate.

Province	The number of surface potable water Plants	The number of moveable potable water Plants	The number of artesian potable water Plants	Current plus ongoing projects Total 2012 (m ³ /day)
Abo Tisht	-	7	25	99965
Farshoot	-	-	9	9763
Naga Hamadi	1	5	17	108778
Deshna	1	-	6	51062
Alwaqf	-	3	6	18922
Qena	3	16	23	183168
Qeft	1	3	12	31795
Quos	1	6	11	96768
Nagada	-	6	11	40522
Armant	1	7	7	47088
Esna	1	14	13	81302
Total	9	61	136	769133

Table (10) Planed Potable Water Production Capacity Until Target Year 2037 (m³/d)

Province	2012	2017	2022	2027	2032	2037
Abo Tisht	131760	131760	131760	131760	131760	131760
Farshot	35683	35683	51840	51840	51840	51840
Naga Hamadi	108778	108778	139104	139104	139104	139104
Deshna	79488	79488	96768	96768	96768	96768
Alwaqf	32659	32659	32659	32659	32659	32659
Qena	192758	192758	192758	211334	211334	211334
Qeft	31795	31795	31795	31795	36288	36288
Qous	91498	91498	117418	117418	117418	117418

Nagada	37498	37498	37498	37498	37498	37498
Armant	78106	78106	78106	78106	78106	78106
Esna	124502	124502	124502	124502	124502	124502
Total (m³/d)	944525	944525	1034208	1052784	1057277	1057277

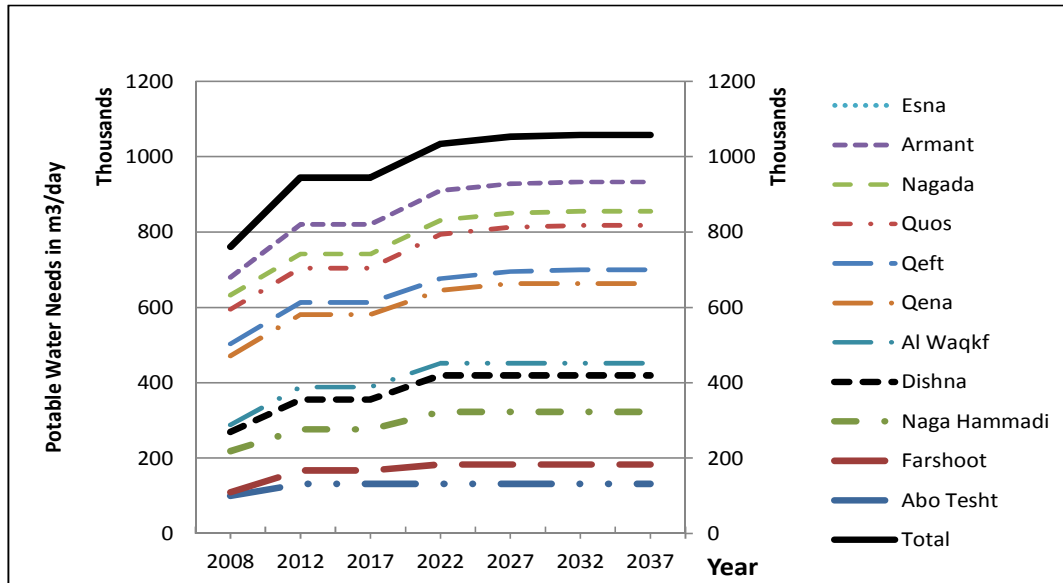


Figure (3) Planned and Targeted Future Potable Water Production in Qena.

4. IMPACT OF THE INCREASE OF DEMANDS

To meet the increasing demands for potable water it was necessary to increase the capacity of existing stations and to add new ones. Artesian wells from groundwater are not considered reliable sources for drinking water in Qena due to the poor quality. The study of Groundwater quality shows that the new plants will depend on surface water either from the Nile River or from the main canals such as Asfon and Alklabia. The River Nile and canals branching from it are considered to be in a very good quality and suitable for refining operations as usual.

The 3.412029 million current population of Qena governorate is 4.01415% of the 85 million total populations in Egypt. The total current demand for potable water in Qena is 568129 m³/day and expected to increase to 967265 m³/day in the year 2037. This increase is 399136 m³/day (0.1457 billion m³/year) and represents 70.25% of the current water needs in Qena. It is a negative impact of water resources.

The total current potable water production for all governorates of Egypt is 25 million m³/day (9.125 billion m³/year), (MWRI 2010). Assuming similar percentage of increase (70.25%) in other governorates, it is expected that the total potable water demand in Egypt will increase to 42.5625 million m³/day

(15.5353 billion m³/year) in the year 2037. This means that the increase of demand for potable water in Egypt is 6.4103 billion m³/year. This considerable amount will be taken from the limited available water resources in Egypt and mainly from the River Nile and adds to the water scarcity problems in Egypt.

Considering the other impacts of increase of water demands in other sectors as industry, new communities, and irrigation, a need exists to maximize the efficiency of the water use. This can be done by using efficient water resources management systems.

5. CONCLUSIONS

In this paper, impact of increase of potable water demands on water resources is calculated and demonstrated. Qena Governorate is considered as a case study which represents 4.1415% of the total population in Egypt.

The calculated total current demand for potable water in Qena is 568129 m³/day and expected to increase up to 967265 m³/day in the year 2037. This increase is 399136 m³/day (0.1457 billion m³/year) and represents 70.25% of the current water needs in Qena and represents a negative impact of water resources.

The expected future potable water requirements in Egypt are 15.5353 billion m³/year in the year 2037. It represents an increase of 6.4103 billion m³/year. This considerable amount will be taken from the limited available water resources in Egypt and mainly from the River Nile and its canal system. It adds to the water scarcity problems in Egypt.

More accurate estimate of demands can be obtained by integrating the demands of all governorates in Egypt.

Considering the other impacts of increase of water demands in other sectors as heavy industry, new communities, and irrigation, a need exists to maximize the efficiency of the water use. This must be done by;

- a) Minimizing the water losses in all sectors. These losses are mainly from evaporation, infiltration, and irrigation systems as well as leakage of potable water distribution networks.
- b) Reuse of sewage wastewater and agriculture drainage water after conducting all necessary treatment required for reuse in irrigation. As per the Egyptian code of design of water supply and sewage systems, the amount of water that can be recovered from municipal sewage could be 80% of water consumption. This represents a considerable amount, subject to the condition of constructing efficient sewage systems in all governorates of Egypt. Industrial wastewater must have a separate collection, treatment, and disposal system separated from domestic sewage system.

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