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Future estimates of water demand in Algeria for the period (2025 - 2080) Statistical and analytical study

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Abstract:

The study was concerned with estimating the size of water demand in Algeria by studying the various determinants and variables that affect water demand in light of the relative scarcity of this important resource, which suffers from many pressures, including population increase, food security and pollution, and this study relied on World Bank data and used the descriptive statistical approach and SPSS program. The study aims to find out the determinants of water demand in Algeria and to reach a model that can estimate and know the amount of future water required and estimates have been reached for the period(2025-2080), which is greatly affected by the number of population, which is the main variable in the model.

Keywords: Water, Water resources, Water use, Water demand, Algeria.

1. Introduction

Water resources are the dominant backbone of all vital economic, social, developmental and environmental activities of any country in the world and their scarcity urgently affects all development programs and projects in all areas of life. Water resources generally consist of rivers, lakes and rainwater in addition to groundwater reservoirs, and in some countries wastewater and sea water are another source of water resources. Water resources in general suffer from a decrease in their quantities as a result of growth. The huge population of the world, the effects of climate change, the great technological expansion and the growing need for water use.

Problematic:

The problem of the study revolves around the following question:

What is the future water volume required for all sectors in Algeria for the period (2025-2080)?

The following questions branch out:

What are the different sources and uses of water in Algeria?

What are the factors affecting water demand in Algeria?

What are the estimates of the future water required in Algeria?

Study hypotheses:

Through the problem of the study, the following hypothesis can be formulated: Population, cultivated area, average per capita income, average temperature, and average rainfall are all factors affecting water demand in Algeria.

The importance of the study:

The topic of water is the topic of the hour on the global and Arab arena and the focus of everyone's attention and Algeria in particular, and the importance of this study is due to the importance of studying water and its link to economic development and achieving food security, and it also allows us to identify the current and future water situation of Algeria by presenting the sources of water resources and the size of their uses and estimating future needs, and the extent of the crisis of the water situation and sounding the alarm in the event that the crisis is proven now or in the future and taking all measures to overcome The crisis and the search for short- and long-term solutions.

Limitations of the study:

Spatial boundaries: The study focused on the state of Algeria.

Time limits: The time period has changed according to variables, relative to the population we studied from 1980 to 2020. As for the future estimates of the population and the volume of water were in the period (2025-2080).

Study Methodology and Tools Used:

To answer the fundamental question of the study and the validity of the hypotheses, we rely on the following approaches:

Historical method: to study and follow up on variables historically during certain periods of time according to the nature of the variable and this to know their general direction in the future and the ability to predict.

Descriptive and analytical approach: It is the basic approach for this study, which depends on collecting data and data, then describing phenomena on their nature and analyzing tables and numerical data.

Tools used: Some statistical tools such as tables and figures were used to understand and interpret phenomena and facilitate the process of reading them and the use of statistical measures to interpret and estimate variables and predict their values in the future and come up with judgments and procedures.

2. Water: sources and uses

Water has natural sources represented in rivers, valleys and torrents and appear on the surface of the earth, and it is also available in the form of underground water that is close or far from the surface of the earth and there are non-natural sources developed by technology in recent years due to insufficient natural resources, These water resources are used in various fields, including domestic and industrial use and agricultural irrigation, which consumes the largest share of these resources.

2.1Water sources: There are many water sources in their forms, and we mention them in the following points:

-Precipitation(1): It is all forms of precipitation on the surface of the earth, whether in the form of liquid or solid, which is rain and snow is a primary source of surface and groundwater.

Surface water(2): It is fresh rivers and lakes that are produced from springs and rain and extend over long distances on the surface of the earth

Groundwater(3): It is the water under the surface of the earth, which is water stored in the layers of the earth over time, as a result of the intrusion of rainwater and rivers

into these layers through the pores, and is divided into several types: Renewable and non-renewable groundwater

Water is available on the surface of the earth by an estimated 75%, however, it is clear that more than 98% of natural water is saline and not suitable for direct use, and even fresh water is the water of rivers, valleys and in the ground, it needs to be extracted, treated, stored and transported before direct use.

– Other sources (non-traditional sources)

Thanks to advanced technologies, they have opened wide areas for countries that lack or have a water deficit to meet their growing needs, and this is through many mechanisms, the most important of which are (4):

A-Water desalination (5):

It is the process of removing or reducing dissolved salts in seawater or groundwater or saline surface water, but the costs of desalination are still relatively high compared to the cost of producing it from natural sources, and there are several desalination methods, including: distillation, vapor pressure, membranes and reverse maturation.

B- Wastewater reuse (6):

The reuse of wastewater is one of the scientific methods used in the development of water resources, especially developed countries to preserve the environment despite its high costs, which is the process of recycling and using water for several times after purification and filtering for agricultural and industrial purposes..

They can be classified as follows:

C- Water Import:

There are several successful experiences regarding water imports, such as Singapore and Hong Kong, where this process needs the cooperation of many countries to develop it, as water transported, whether by pipes, canals and ships, will not be cheap.

D- Artificial Rain:

These experiments appeared in the middle of the last century, and this process aims to increase the amount of natural rain that occurs in semi-arid areas to be used for various purposes, especially to complete the crops' need for rainwater, but it remains difficult to apply, especially in controlling the place of its fall, in addition to its high economic cost.

2.2 Water uses:

Water use is divided into two parts: direct use, which includes the use of water for domestic, agricultural and industrial purposes. Indirect use, which does not cause a shortage of quantities, such as its use in transport, energy production and tourism.

-Agricultural use:

Agriculture consumes the lion's share of the total water resources, and experts have estimated the percentage of consumption between (70-90%) as irrigation water enters the composition of the crop, which is called "formation water", and the proportions of water need for each crop or plant vary, As well as according to natural conditions (especially temperature), while this use directed to the agricultural sector increases every year, in order to increase the population to meet their food needs.

-Industrial use:

Industrial activities are a co-consumer of water resources, but at a small percentage compared to what agriculture consumes, and water is usually necessary for industry, as it enters the cooling processes or as a raw material in the food industry, as well as in mining and oil extraction operations, Sometimes it enters into chemical reactions and this use is constantly increasing, especially in the developed industrialized countries, and industry consumes about 20% of the total water consumption (7).

-Home use:

The population exploits water for drinking, washing and household cleaning, and these uses in the world vary from one region to another according to the geographical location, customs and traditions and the standard of living of the individual, and the

use of the individual ranges from 20 liters per day in undeveloped societies, and 700 liters in developed societies, and home use is estimated at 10% of the total quantities used for water resources(8)**.**

As for the indirect use of water, it is the benefit obtained by man from water resources, it is a non-consumer use, which sometimes makes it free, and the most important of these indirect uses of water is transportation and communications, the seas and oceans have allowed the movement of people and this since ancient times, and this means has increased in importance with the increase in trade International (9)**.** water is also used in water parks for recreation and in public facilities for decoration and fish farming**..**

3.Water resources in Algeria

Due to the vast area of Algeria, it abounds in huge amounts of precipitation estimated between 100-120 billion^{m3} per year, of which about 85% evaporates, i.e. between 85 to 100 billion^{m3}, and seeps into the land through the pores about three billion^{m3}, which is considered as an annual recharge of groundwater, The surface flows, which appear in the form of valleys, are estimated at 12.5 billion^{m3}, of which about 8 billion^{m3} are stored in dams and an estimated 5.5 billion^{m3} descend to the sea (10)**.**

3.1 Surface water:

It is a group of valleys and is divided into valleys that flow into the Mediterranean Sea, which are hill valleys that are characterized by abundant water because they are located in the area with the most rainfall, and valleys that flow into closed basins of sabkhas or Shattout and are called internal drainage valleys, and there are so-called semi-valleys that appear in the desert(11). The National Agency for Water Resources estimated the volume of surface resources in Algeria at 12.5 billion^{m3}.

3.2 Groundwater:

The total and exploitable groundwater in Algeria is estimated at seven billion^{m3} per year, distributed at two billion in the north of the country and five billion in the south of the country.

Groundwater in the north: Groundwater in northern Algeria is estimated at two billion^{m3} per year and seeps a huge amount into the layers of the earth

-Groundwater in the south: There is no surface sewer in the desert, it is characterized by its groundwater, which was formed over thousands of years and is far on the surface of the earth, where its depth reaches 2000 m and groundwater in southern Algeria was estimated at about five billion m^3

Ministry of Irrigation figures confirm that 80 dams in Algeria are exploited, while dams represent only 33% of the water resources produced nationally, compared to 50% of groundwater and 17% of treatment and purification plants..

3.3 Non-conventional water resources: Many countries suffering from a shortage of water resources, including Algeria, have resorted to non-conventional resources to fill the deficit in meeting the needs of citizens, especially in major cultural gatherings, and there are several modern methods of water production, including seawater desalination and wastewater treatment.

Desalination: Algeria has a coastal strip estimated at 1200 km, so I thought to resort to seawater desalination operations, which are dedicated to the domestic and industrial sector, and currently it has 19 large stations with a daily capacity of 2.26 million^{m3}, i.e. 825 million^{m3} per year.

Wastewater treatment: The treatment and purification of wastewater in Algeria remains very weak so that water is discharged into the sea, especially coastal cities and valleys(12); currently Algeria has 211 purification plants with a capacity of 805 million^{m3} / year and the volume of water flowing in the total sewage channels is about 1.400 billion ^{m3} Annually.

Purification of salt water: It is a different process on desalination of seawater, which is the process of torturing groundwater salt water in some areas where salt water has mixed with fresh water, especially in the southern regions of the country

Finally, we can say that the total water resources in Algeria from surface, underground and non-conventional sources are estimated at about 20 billion ^{m3}.

4- Water use in Algeria:

The demand for water has evolved since independence in all its sectors in Algeria clearly, and this is due to several reasons, the most important of which is the population increase and civilizational development, which affected the domestic sector in consumption, and because of economic development that affected the agricultural and industrial sectors in consumption, and these requests are met for various sectors of surface water (rivers and dams) or groundwater (wells and springs), as the public authorities are responsible for providing water to the needs of the population first and then meet other sectors, According to the Food and Agriculture Organization of the United Nations **(FAO),** the volume of water resources used in 1970 amounted to 2 billion^{m3} and increased in 1990 to 4.5 billion^{m3} and reached 8.425 billion^{m3} in 2012.

4.1 Domestic demand for water: According to Algerian law, every natural or legal person subject to public or private law must supply water destined for human consumption, while ensuring that this water meets drinking or quality standards (13)[1] which is part of the national water policy and defines quality in the law.

The volume of resources used for domestic purposes is between 3 to 3.5 billion^{m3} per year, changing every year according to the possibilities of water availability in each region, climate change per season and the population density of each state or municipality, and the average national connection rate is 97% and the rates of connectivity in urban communities are close to 100%, which are distributed as follows(14)**:**

Surface water 1.26 billion^{m3}/year 35%;

Groundwater 1.84 billion^{m3}/year 51%;

-Sea desalination water 0.50 billion^{m3} year i.e. 14%.

International bodies have set the minimum amount to meet the basic per capita needs of water per day at 20 liters, and when calculating the needs of individuals for bathing and laundry, the threshold rises to 50 liters per day, according to this criterion, we find that the withdrawal of water for domestic purposes increases with the increase in the population.

4.2 Industrial demand for water: the intervention of water resources in industrial production processes Since Algeria is not an industrialized country, industrial consumption did not exceed 10% of the total uses, One of the most water-consuming industries in the industry is that used in refrigeration and the manufacture of medicines and soft drinks, in addition to the process of oil extraction, the extraction of one barrel of oil is offset by the use of three barrels of water (a barrel equals 160 L) The extractive and manufacturing industries have known a great development through their contributions to the GDP and there are two types of use of For water in industry, the first type is a simple use that does not change the chemical composition of water and the second type is the use of a compound that changes its composition, for example, the simple is used in cooling in power plants, while the compound use is used in petrochemical plants, mines, leather, for example, and others, and among the water-consuming industries is the paper industry so that to produce one kilogram needs 325 liters and to produce one kilogram of iron needs 100 liters and water industries in Algeria benefit from private networks and Generality, and from dams and cisterns**.**

4.3 Agricultural demand for water: The area of arable land is very limited in Algeria, as the country's estimated area of 238 million hectares has only 8.2 million hectares of arable area (3.44%) 39 million hectares of pastoral land, allied areas and forests, while the remaining 191 million hectares are semi-desert and desert areas, The harsh climatic conditions, especially the lack of rainfall and its poor distribution in space and time, have become an obstacle to the rain-fed crops prevailing in Algeria. To ensure the safety and food security of the population, the state turned to

irrigated crops and doubled efforts in mobilizing traditional and non-conventional water resources, and irrigated areas in Algeria.

The total water cuts for this sector, according to the ministry's statistics, are estimated at 6.78 billion^{m3}, divided as follows: 1.82 billion^{m3} from surface water (27%), 4.83 billion^{m3}from groundwater (72%), and non-conventional resources estimated at 130 million^{m3} (1%) (15). 66% represents the proportion of agricultural use in relation to total uses, and what distinguishes water cuts destined for agriculture is its association with the climatic situation of the country, if the season is rainy, the irrigated areas increase and with it the volume of water used.

5.Estimating the future water demand in Algeria:

To estimate water demand in Algeria, we relied on World Bank statistics of water demand in Algeria from 1980 to 2020, and the most important variables affecting water demand were researched: population, cultivated areas, average per capita income, annual average rainfall, average annual temperature

Using a multiple linear regression model that links the volume of water demand with the previous variables, we found a single statistically significant correlation between water demand and the number of inhabitants, according to the SPSS program, as shown in Table

Table No. (1): results of multiple linear regression

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-,318	3,951		-,081	,936
	Population	2,851E-7	,000	,946	29,839	,000
	Agricultural land	7,846E-6	,000	,045	1,804	,080
	GDP per capita	,000	,000	,067	2,568	,015
	Annual temperature	-,237	,164	-,038	-1,446	,157
	Annual rainfall	-,004	,003	-,027	-1,476	,149

a. Dependent Variable : Water demand

Source: Prepared by the researchers based on the outputs spss –v. 27

According to the table, the hypothesis is incorrect, which considers the factors of population, cultivated areas, average per capita income, average temperature, average rainfall as factors affecting water demand in Algeria.

5.1 Estimate of the population of Algeria:

According to World Bank statistics, by tracking the Algerian population from 1980 to 2020, we found that the population growth rate ranged between1,358% in 2003 and3,343%. In 1986, by applying the geometric average, we find that the average population increase rates are equal to

$$\mathbf{T= T=\sqrt[40]{\frac{4345166}{187393}\frac{66}{78}}-1= 0\ ,0212481}$$

The average population increase rates for the period (1980 – 2020) is 2.12281%

Hence, the first equation for estimating the population is:

$$\mathbf{X=43451666\left(1+0\ ,0212481\right)^{n}}$$

X Population

n The difference between the year in which you want to know its population and the base year 2020

On this basis, the population of Algeria in the coming years can be estimated so that 2020 is the base year in which the population reached 43451666 inhabitants in the following table:

Table No. (2): Projected population in Algeria for the period (2024-2080)

years	2024	2030	2035	2040	2045	2050
population million	47.2641	53.6190	59.5628	66.1655	73.5001	81.6477
years	2055	2060	2065	2070	2075	2080
population million	90.6988	100.7527	111.9214	124.3281	138.1102	153.4200

Source: Prepared by researchers based on the World Bank's data bank 2024

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5.2 Estimation of water demand:

Table No. (3): results of a simple linear regression

Coefficients[a]

	B	Std. Error	Beta	T	SIG
(Constant)	-3,174	,200		-15,876	,000
Population	2,987E-7	,000	,991	47,141	,000

Dependent Variable : Water demand

Source: Prepared by the researchers based on the outputs spss –v. 27

Based on simple linear regression, the linear function that relates the volume of water required and the population is represented in the following second equation:

Y= 2,987E-7 X - 3,174

Y volume of water required

X Population

After adding the first and second equations, the volume of water required in Algeria can be estimated in the following equation

$$\mathbf{Y=2,987E\text{-}743451666\left(1+0,0212481\right)^{n}\times\ -3,174}$$

The volume of future water required in Algeria is estimated in the following table:

Table No. (4): Projected water use in Algeria for the period (2024-2080)

years	2024	2030	2035	2040	2045	2050
Water demand billion cubic metres	10,944	12,842	14,617	16,589	18,780	21,214
years	2055	2060	2065	2070	2075	2080
Water demand billion cubic metres	23,917	26,920	30,256	33,962	38,079	42,652

Source: Prepared by researchers based on the World Bank's data bank 2024

Conclusion:

The water supply in Algeria is estimated at about 20 billion m3 and consists of surface resources, which appear in the form of valleys and rivers at 12.5 billion m3, while the total exploitable groundwater resources in Algeria are estimated at 7 billion m3 per year, distributed at two billion in the north of the country and five billion in the south of the country. As for the demand for water, it has clearly developed, and this is due to several reasons, the most important of which is the population increase, as the total volume of water resources used in 1980 reached 3 billion m3, and increased in 2024 to 8.9 billion m3.

Results: Among the most important results reached are:

- According to multiple linear regression, the population is the only factor affecting the demand for water in Algeria.
- According to estimates and assumptions, the water crisis in Algeria will be resolved by the beginning of 2048, where demand and use exceed 20 billion m3 and the population has exceeded 78 million people.

Recommendations: Which were reached through this study are summarized as follows: Algeria should exploit and develop its water resources in better ways by building dams and barriers to collect surface water and extract groundwater without depleting it, in addition to rationalizing its uses by reducing water losses and waste and educating the population. Since the projects for the development of its water resources are oriented and linked to the agricultural sector, which consumes the largest quantities, Algeria must pay attention to how to reduce and rationalize water without reducing production, using modern irrigation techniques, especially sprinkler irrigation and drip irrigation, which reduces water consumption and reduces losses as well. - Development of non-conventional water sources such as seawater desalination, wastewater purification and reuse in irrigation of agricultural crops, provided that they do not harm human health and the environment.

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- Development of non-conventional water sources such as seawater desalination, wastewater purification and reuse in irrigation of agricultural crops, provided that they do not harm human health and the environment.

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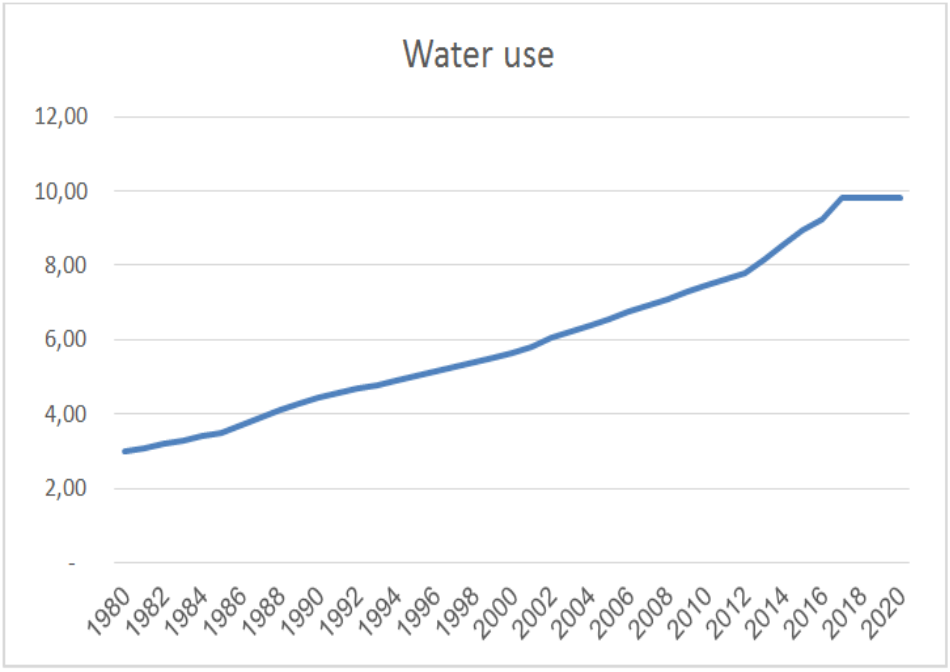
Annexes

years	Water use	Population	Agricultural land	GDP per capita	Annual temperature	Annual rainfall
1980	3,00	18739378	438300	2259,72	22,94	95,82
1981	3,10	19351357	391710	2291,76	23,13	61,75
1982	3,20	20000096	391070	2260,35	23,11	101,37
1983	3,30	20682111	392820	2359,59	23,34	51,68
1984	3,40	21393530	396100	2510,04	22,9	81,73
1985	3,50	22132905	390510	2617,73	23,2	84,22
1986	3,70	22882553	386880	2783,43	23,01	103,99
1987	3,90	23586101	387790	2829,88	23,6	79,43
1988	4,10	24243018	388170	2437,38	23,25	80,26
1989	4,30	24889507	387600	2235,27	23,39	71,58
1990	4,44	25518074	386760	2431,55	23,58	93,99
1991	4,56	26133905	386220	1749,29	22,79	87,61
1992	4,68	26748303	388650	1794,62	22,77	90,88
1993	4,80	27354327	388620	1825,88	23,06	65,96
1994	4,91	27937006	396400	1522,83	23,43	86,58
1995	5,03	28478022	396490	1466,54	23,56	83,76
1996	5,15	28984634	396360	1619,53	23,3	99,31
1997	5,27	29476031	396900	1634,47	23,67	94,2
1998	5,39	29924668	398260	1610,30	23,48	70,55
1999	5,51	30346083	397310	1602,86	23,66	98,12
2000	5,63	30774621	400210	1780,38	23,57	60,79
2001	5,81	31200985	401090	1754,58	23,83	68,06
2002	6,04	31624696	398550	1794,81	23,72	71,21
2003	6,22	32055883	399057	2117,05	23,84	107,72
2004	6,40	32510186	411450	2624,80	23,56	97,67
2005	6,57	32956690	412110	3131,33	23,58	73,31
2006	6,75	33435080	411810	3500,13	23,74	93,24
2007	6,93	33983827	412520	3971,80	23,58	90,24
2008	7,10	34569592	413090	4946,56	23,43	83,53
2009	7,28	35196037	413800	3898,48	23,87	93,89
2010	7,46	35856344	413740	4495,92	24,09	95,86
2011	7,63	36543541	413880	5473,28	23,78	97,61
2012	7,80	37260563	413981,9	5610,73	23,74	86,41
2013	8,18	38000626	414316,35	5519,78	23,48	89,82
2014	8,57	38760168	414310	5516,23	23,92	77,52
2015	8,95	39543154	414564	4197,42	23,79	80,02
2016	9,23	40339329	413602	3967,20	23,99	69,56
2017	9,80	41136546	413351,408	4134,94	23,86	78,31
2018	9,80	41927007	413388,496	4171,79	23,5	95,1
2019	9,80	42705368	413160,71	4021,98	23,65	78,64
2020	9,80	43451666	413160,71	3354,15	23,78	60,66

Water use in Algeria



population of Algeria