Irrigation & Drainage Systems Engineering

Research Article Open Access

Water Supply Prediction for the Next 10 Years in Algeria: Risks and Challenges

Ali Rahmani SE* and Brahim C

Geo-Environment Laboratory FSTGAT, University of Sciences and Technology Houari Boumediene, Algeria

Abstract

Water is the source of life, with population growth, environmental problems and water shortages, water resources management become a major priority for the Algerian government.

The environmental problems and the climate change context apply a high pressure on the policy of groundwater and surface waters management.

Future simulation of water demand is a way for prediction and prevention against climatic and environmental risks through the establishment of real and feasible solutions for better exploitation of water resources. In this study we simulate the future demand of water to supply population need, in the Algerian territory at the horizon of 2020, to show critical situation of lack of water, under a climate change situation. According to the results we are arriving at the conclusion that to solve the continuous arising demand of water we must return to the used unconventional water resources.

Keywords: Water resources management; Algerian government; Climate change; Environmental problems; Simulation of water demand

Introduction

The Mediterranean countries are among the most vulnerable by water stress [1], because of the high climatic variability. Decreases of the amount of precipitations and arising of the temperature change the water cycle and reducing the surface runoff and the aquifer recharge.

The drought, effect directly the hydrologic systems around the world, many country suffer the insufficient water resources. Needs for water resources continue to grow with increasing population [2].

Algeria is an important country in Africa and the world, with its variables natural resources, it see a high growth in the demographic and economic scale. Serious difficulties were facing the Algerian authority to manage its water resources. This finding is reflected in several strategic evaluation reports on the future prospects of the water sector, especially made by the National Economic and Social Council and World Bank.

For a best management of our water resources it is important to think in a new strategy and other techniques to arise our water potentialities to supply the population increases needs. More than 55% of our demand on drinking water is provided by groundwater resources, overexploitation due to increased water demand led to a total degradation of the quality and the complete depletion of our aquifers systems [3].

Simulation of the future demand of water is very important in an actionable plan of water resources management, to make the confrontation between demand and needs. In this study we have established a dynamic geographic information system (GIS) to simulate the future demand on water vs population growth up. The base of our simulation is based on SQL analysis of the data base into professional GIS software (MapInfo 11.0)

Simulation of the future demand on water for population is necessary, to evaluate the degree of problems and to predict any lake of water in the future. In this statistic study we base on data management and simulation with a dynamic GIS.

Risks threatening our water resources

Many risk make our water resources vulnerable to depletion in the two visions (Quality and quantity), these risks can be natural or result to our Industrial, Agricultural, and public activities. Many threats affecting water resources quantity and quality:

- Over-exploitation of groundwater resources (Increase of needs).
- The pollution of water resources (Rivers, Aquifer, dams ...) by all nature of rejects (solid or liquid) into the environment, surface and groundwater.
- The silting of dams.
- The impact of climate change (Drought).
- Alteration groundwater quality due to marine intrusion in coastal zones.

Materials and Methods

The economic and industrial development in Algeria, require a rational use of natural resources.

The vulnerability of water resources to various problems (pollution, climate change, over exploitation), put our country vulnerable to water scarcity, either at local level or regional scale. For these reasons a management plan must be implemented to reduce the effects of these problems at the medium and long range.

The irregular precipitations will induce a long-term water crisis. Furthermore water resources are dependable to the spatial and temporal variation of hydrologic cycle. It's directly related to precipitations,

***Corresponding author:** Ali Rahmani SE, Geo-Environment Laboratory FSTGAT, University of Sciences and Technology Houari Boumediene, Algeria, Tel: + 213 0669606978; E-mail: alirahmani101990@gmail.com

Received November 27, 2017; **Accepted** December 20, 2017; **Published** December 27, 2017

Citation: Ali Rahmani SE, Brahim C (2017) Water Supply Prediction for the Next 10 Years in Algeria: Risks and Challenges. Irrigat Drainage Sys Eng 6: 197. doi: 10.4172/2168-9768.1000197

Copyright: © 2017 Ali Rahmani SE, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Citation: Ali Rahmani SE, Brahim C (2017) Water Supply Prediction for the Next 10 Years in Algeria: Risks and Challenges. Irrigat Drainage Sys Eng 6: 197. doi: 10.4172/2168-9768.1000197

temperature variation, and evapotranspiration intensity. The manager needs a thoughtful way to protect groundwater and surface water, against depletion and to look for other resources to meet the rapid growth of water demand.

In Algeria, 94.51% of revenues are after the export of hydrocarbons (gas and oil), reserves are in continued decline, and even self-satisfaction is not achieved (Diesel, Gasoline and Kerosene).

The aim of this study stimulates the future water demand based on the population growth up. We begin by preparing data and map to make a projection and simulation for the future to see the variation of water-resources in function of population growth up. We give recommendation and solution to avoid any disruption in sourcing of drinking water in the future horizon.

Area of study

Algeria is located along the North African coast (Figure 1), bordered to the east by Tunisia and Libya, to the southeast by Niger, to the southwest by Mali, and to the west by Mauritania and Morocco. It is the first largest country in Africa, with area about 2.47 million km², coastline of 1200 km.

Algeria holds a special place in the Mediterranean basin with its geostrategic position and its demographic and economic weight. 39 millions habitants were estimated at the end of December 2014 by the National office of statistic (ONS). 48 is the total number of province in Algeria, the most important population density was concentrated in the North of the country.

Climatic setting

Algeria is subject to a high degree of climate variability across different regions and seasons. Due to its geographical position and climatic characteristics, it is highly vulnerable to climate change [4].

The climate of Algeria is varied: The northern part has a Mediterranean climate whereas the rest of the country has mainly a desert climate. However between these two major types of climates there is a transition of climates, including the semi-arid climate.

Figures 2-4 show the monthly variation of precipitations in different sites in North, the center, and the south of Algeria.

Preparing data

In this study multi kinds of data are necessary to simulate the future demand on water, which contain actual population water need, the population growth up coefficient. The followings types of data were used in this work:

1. Population and growth index for each province.

2. Population water needs.

3. Water potentiality for each province.

These data are necessary to evaluate the future demand on water vs. the population growth.

Population growth: Growth coefficient and population statistics are the first data used in project calculation and simulation. The number of total population at time t of project was calculated using the following equation (eqn. 1)

$$P_n = P_0 \times (1+\alpha)^n \tag{1}$$

With P_n the future population value, P_0 is the initial or actual population and α is the annual growth rate, and n are the number of year. In Table 1 the actual and the future population for each province in Algeria are showing. The population data are provided by the national office of statistics (Figure 5).

Population water needs: The population water needs is calculated

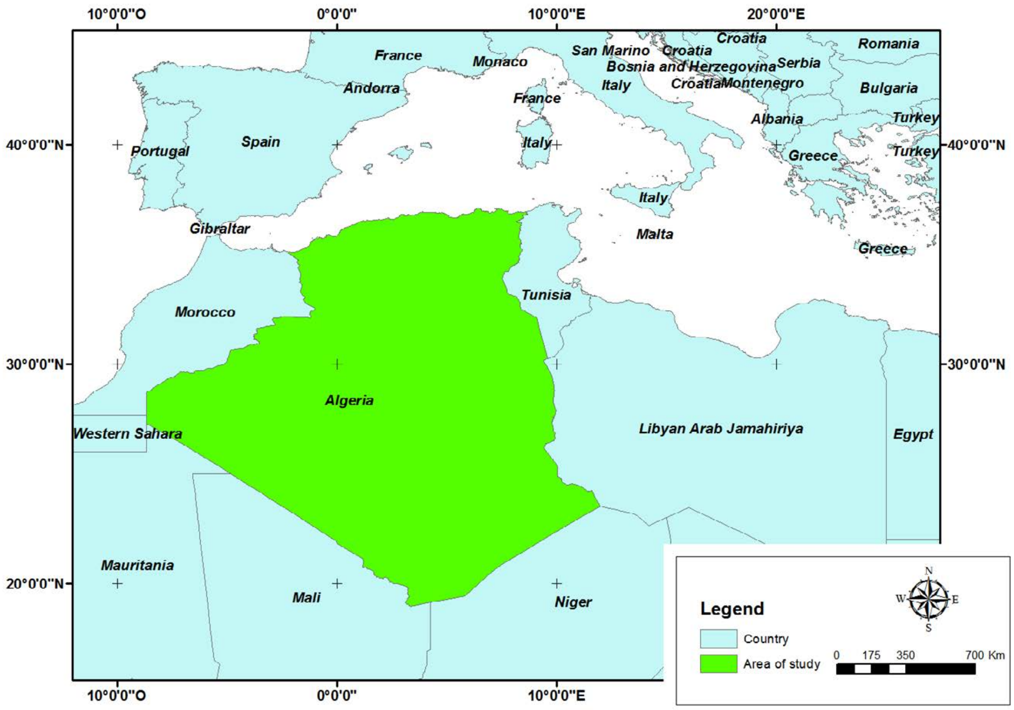

Figure 1: Presentation of study area.

Citation: Ali Rahmani SE, Brahim C (2017) Water Supply Prediction for the Next 10 Years in Algeria: Risks and Challenges. Irrigat Drainage Sys Eng 6: 197. doi: 10.4172/2168-9768.1000197

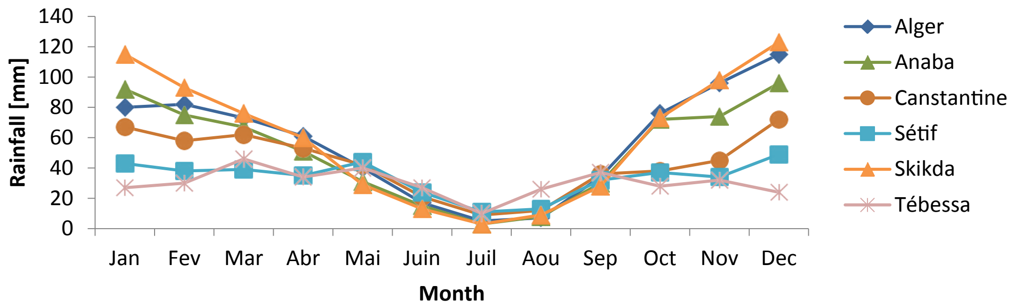

Figure 2: Monthly variations of precipitation in some sit in the North of Algeria.

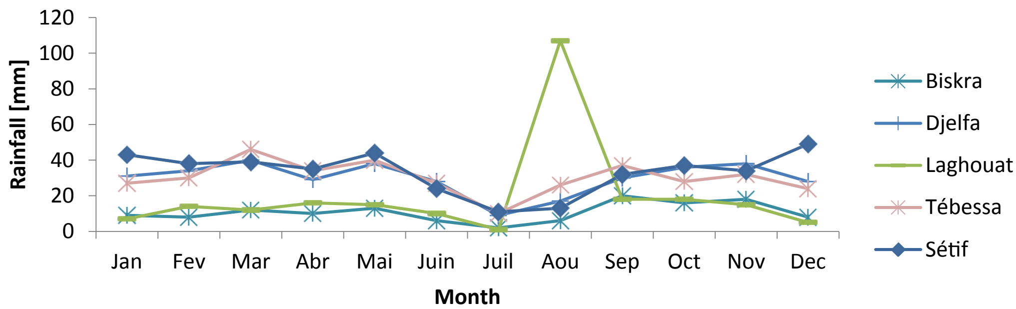

Figure 3: Monthly variations of precipitation in some sit in the middle of Algeria.

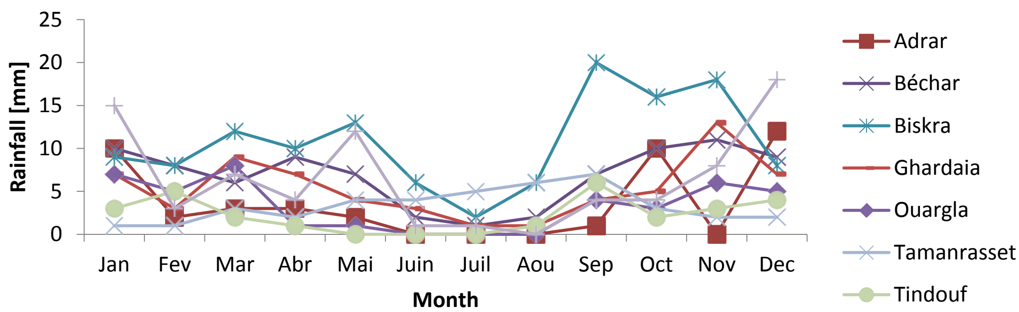

Figure 4: Monthly variations of precipitation in some sit in the south of Algeria.

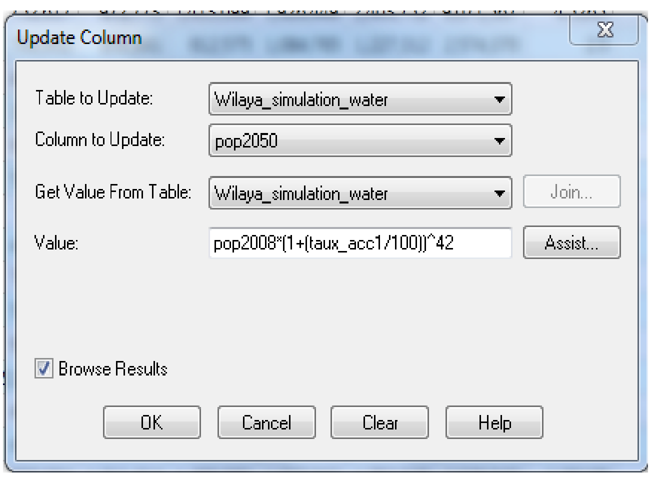

Figure 5: Example of Calculation of the total population for 2050 by MapInfo Update column function.

directly using the daily endowment (d) for each province by application of the next equation (eqn. 2):

$$Q_p = P \times d \times 0,001 \qquad (2)$$

Q_p is the daily average water requirement for the population in (m^3/day); and P is the population and d is the daily water allocation (L/day). In Table 2 we show the daily water population needs in each province. Map in Figure 6 show the spatial variation of the daily water endowment in liter per habitant day.

As we see in the map of Figure 6, we can classify the daily water endowment into three different kind of class: the first class in blue colors present high water endowment, the second in the green show a medium allocation, and the last in red present a low daily water endowment. The spatial variation shows that central axis of the country is characterized by low water endowment; due to low water resources in these areas. Table 2 shows the average daily water endowment for every province in Algeria given in liter/capita/day.

Sl. No.	Province	Pop 1987	Pop 1998	Pop 2008	Pop 2015	Pop 2020
1	CHLEF	684192	858695	1002081	1135370	1241298
2	LAGHOUAT	212388	317124	455868	615200	762080
3	OUM EL BOUAGHI	403936	519168	621615	733873	826268
4	BATNA	752617	972773	1413099	1926449	2403752
5	BEJAIA	700952	856841	912575	1084765	1227312
6	BISKRA	430202	575858	721356	859026	973173
7	BECHAR	183896	225547	190984	227020	256852
8	BLIDA	634687	784286	1002934	1215808	1395000
9	BOUIRA	526900	629561	190432	234207	271510
10	TAMANRASSET	95822	137175	176636	215426	248246
11	TEBESSA	410233	549068	648705	735732	804954
12	TLEMCEN	707453	842054	949132	1036910	1104537
13	TIARET	574787	725854	846532	950103	1031754
14	TIZI OUZOU	936948	1108707	1127165	1140366	1149891
15	ALGER	2128419	2562430	2956061	3288960	3549461
16	DJELFA	494494	200707	1090576	1435124	1746047
17	JIJEL	472312	573206	636951	688220	727348
18	SETIF	1000694	1311414	1489986	1637942	1752538
19	SAIDA	235240	279526	330641	375358	410956
20	SKIKDA	622510	786155	898680	992682	1065788
21	SIDI BEL ABBES	444047	525631	604745	671410	723482
22	ANNABA	455888	557819	609500	650144	680825
23	GUELMA	353309	429998	598376	782969	948751
24	CONSTANTINE	664303	810913	938474	1046820	1131786
25	MEDEA	652863	802077	827824	846606	860281
26	MOSTAGANEM	504124	631056	737118	828337	900326
27	MASCARA	562806	676193	784074	875943	948083
28	OUARGLA	284454	445619	558561	665519	754242
29	ORAN	916578	1213838	1458542	1677241	1853259
30	EL BAYADH	155494	168789	228623	291757	347268
31	ILLIZI	18930	34108	52332	75337	97732
32	BORDJ BOU ARRERIDJ	420897	552746	628275	690890	739400
33	BOUMERDES	510858	647388	801067	944042	1061540
34	EL-TARF	275315	352587	408452	455965	493250
35	TINDOUF	16339	27060	49149	85127	126025
36	TISSEMSILT	227542	264240	294477	318890	337558
37	EL OUED	376909	504400	647551	787682	905982
38	KHENCHELA	246541	327920	386683	437875	478540
39	SOUK-AHRAS	296077	367455	438127	500627	550657
40	TIPAZA	389541	506054	591009	664058	721702
41	MILA	511605	674482	766882	843515	902898
42	AIN-DEFLA	537256	660340	721420	769447	805698
43	NAAMA	112858	127315	192892	274158	352422
44	AIN-TEMOUCHENT	271454	327332	371239	407531	435606
45	GHARDAIA	216140	300517	363598	420508	466534
46	RELIZANE	545061	642204	726180	795315	848691
47	ADRAR	822395	1117132	399714	562438	717829
48	M'SILA	822395	1117132	990592	1137879	1256310
Total		23820661	29628494	33837485	39036571	43395442

Table 1: Variation of population in Algeria from 1987 to 2021.

Daily water production

In the Algerian territory a high variation of Water potentialities was observed, the high Water Potentialities was located in the North part of Algeria with a high difference between the East and the West.

The water potentialities was offered principally from the Ground water resources who present more than 90% in the Sahara, and 55% in the North of Algeria, the rest was offered from surface water, and desalination plant.

The map of Figure 7 illustrates the spatial distribution of the daily water production in the Algerian provinces.

Results and Discussion

In this section we discuss the most important results of our simulation for the ten next year, as we see the total population will achieve the 44 million inhabitants at the beginning of the year 2020, if water resources rest same without any change serious management problems were encountered to satisfy the daily increased water needs

Citation: Ali Rahmani SE, Brahim C (2017) Water Supply Prediction for the Next 10 Years in Algeria: Risks and Challenges. Irrigat Drainage Sys Eng 6: 197. doi: 10.4172/2168-9768.1000197

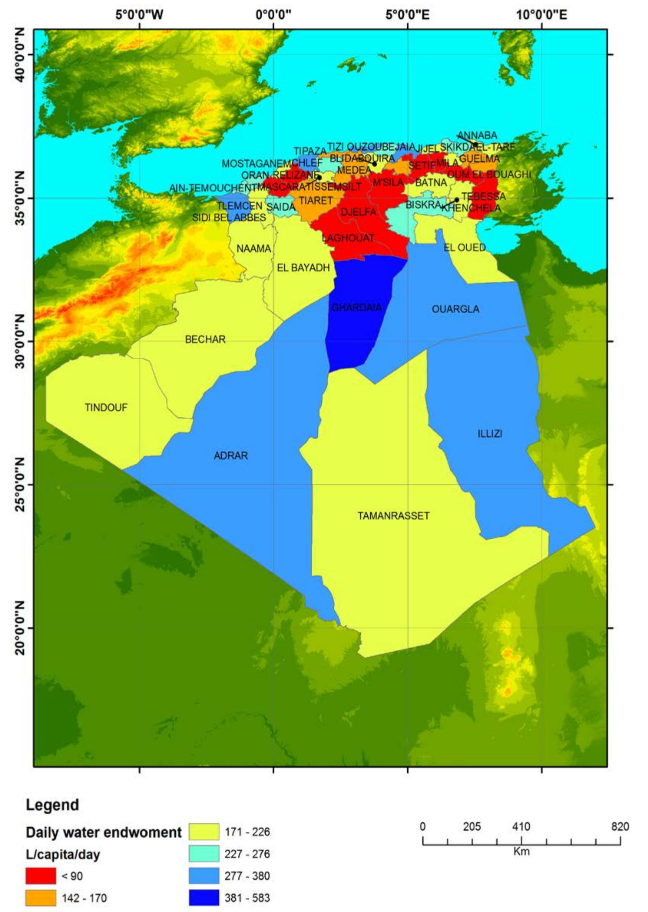

Figure 6: Spatial distribution of daily water endowment in the Algerian province.

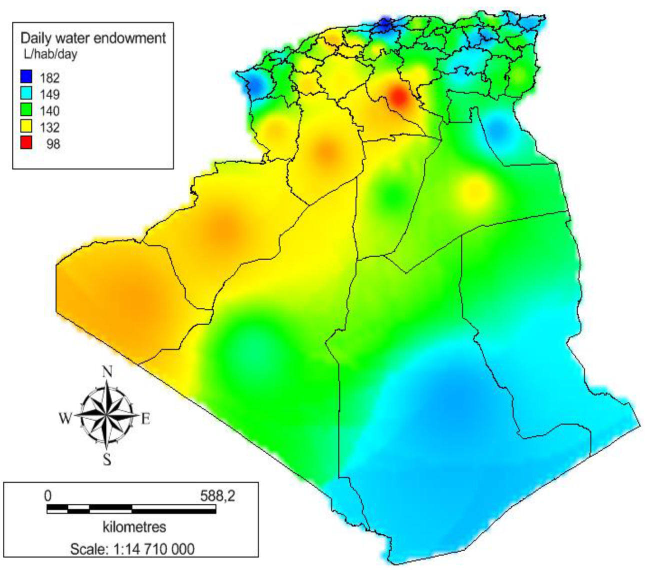

Figure 7: Spatial variation of Daily water endowment in Algeria.

for all sectors. The greatest demand was located in the North of the country, which represent more than 70% of the total population.

FID	Province	Water endowment
1	ADRAR	380
2	AIN-DEFLA	230
3	AIN-TEMOUCHENT	250
4	ALGER	300
5	ANNABA	222
6	BATNA	190
7	BECHAR	216
8	BEJAIA	306
9	BISKRA	276
10	BLIDA	160
11	BORDJ BOU ARRERIDJ	154
12	BOUIRA	205
13	BOUMERDES	302
14	CHLEF	297
15	CONSTANTINE	200
16	DJELFA	99
17	EL BAYADH	183
18	EL OUED	188
19	EL-TARF	201
20	GHARDAIA	583
21	GUELMA	167
22	ILLIZI	358
23	JIJEL	201
24	KHENCHELA	212
25	LAGHOUAT	137
26	M'SILA	125
27	MASCARA	127
28	MEDEA	166
29	MILA	127
30	MOSTAGANEM	193
31	NAAMA	226
32	ORAN	250
33	OUARGLA	346
34	OUM EL BOUAGHI	134
35	RELIZANE	141
36	SAIDA	238
37	SETIF	137
38	SIDI BEL ABBES	192
39	SKIKDA	272
40	SOUK-AHRAS	155
41	TAMANRASSET	191
42	TEBESSA	125
43	TIARET	150
44	TINDOUF	184
45	TIPAZA	170
46	TISSEMSILT	204
47	TIZI OUZOU	272
48	TLEMCEN	296

Table 2: Average daily water endowment for every province in Algeria given in liter/capita/day.

Algeria has an unequal distribution of population density on the national territory; however the major important water potentiality were located in the north of the country.

This will become in the future a very difficult problems, the urbanization will tack all the green place, necessary for agricultural activities, this action will conduct to the overexploitation of groundwater resources; at the same time the quality of this water will degrade as a result of urban reject, the use of fertilizers and pesticides

Citation: Ali Rahmani SE, Brahim C (2017) Water Supply Prediction for the Next 10 Years in Algeria: Risks and Challenges. Irrigat Drainage Sys Eng 6: 197. doi: 10.4172/2168-9768.1000197

and marine intrusion. The problems of water quality will decrease our potentialities in the future.

Figures 8 and 9 show clearly that the most important population density was placed in the North part of Algeria, which present above of 80% of total population.

Calculation of resources need ratio (RNR)

This ratio was calculated by dividing the Volume of water exponible, to the volume of water needed to satisfy population needs.

Here we have three cases: when RV=1 this mean that the offer is the same as the demand; when RV<1 it mean a deficit in satisfaction of population in water need. When RV is more than 1 the balance is in execs.

As we see in the results of this simulation (Figure 10) the Center and the West and some province of the East of the country are the most vulnerable to the water resources deficit (RNR<0). These regions are sensible directly to the climatic perturbation in the time and space scale.

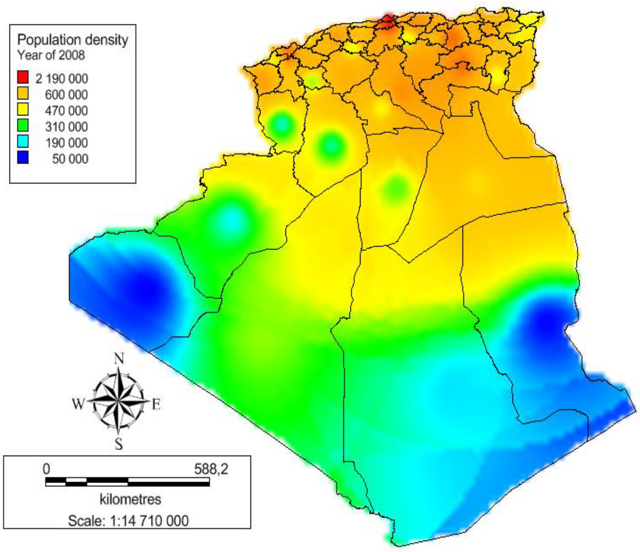

Figure 8: Spatial variation of water potentialities in Algeria.

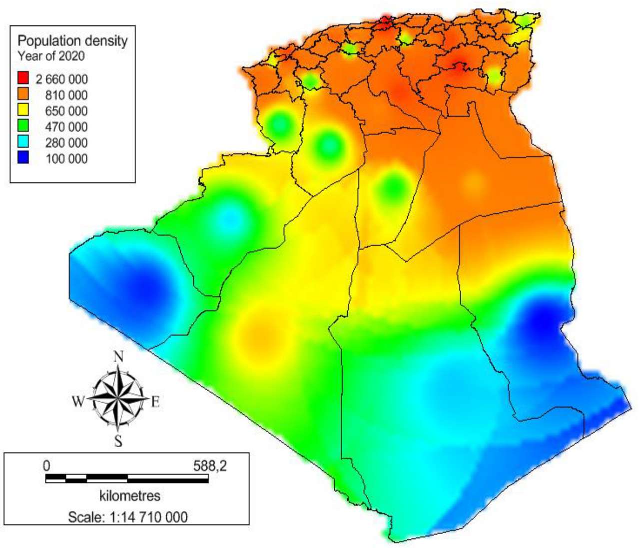

Figure 9: Spatial Population distribution in Algeria (ONS, 2008).

The region of the middle of country and the West are the most vulnerable to the lack of water in the future Horizon.

The majorities of these regions are based on the groundwater, which conduct to aquifer depletion because of the overexploitation of water to satisfy population needs. To control these challenges, many solutions are available for the authority as well as urban water reuse, artificial recharges, water desalination, and artificial aquifer recharge and recovery. In Table 3, we give some statistics of the water endowment evolved by the Algerian ministry of water.

We give the statistics of the water endowment evolved by the Algerian ministry of water (Table 3).

According to the statistic given by the Algerian Ministry of water resource and environment, the average daily endowment is around 175 liter/capita/day, which represent a (64 m^3/year). The reference of water endowment given by the World Bank is around (1000 m^3/year) [5].

In this paper, we give propose three solutions for the short and medium range to be realized in Algeria, in the immediate time.

Urban water reuse: Recycling of water uses is a very important to rise up our water potentialities to satisfy the population daily increased demand in agricultural works, industrial and another economic field. Reuse of urban water, is very interesting in semi-arid area, to solve the problem of lack of precipitation [6]. The non-potable reuse of treated sewage in urban areas provides significant conservation of potable supplies beyond that available through water use efficiency [7].

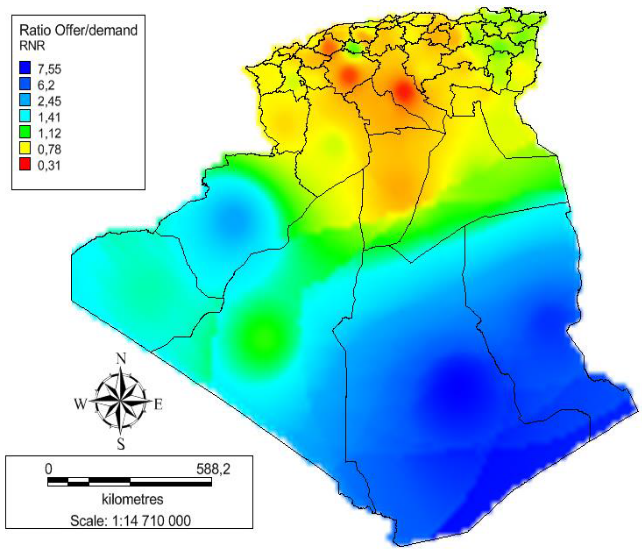

Figure 10: Spatial Population distribution in Algeria (Simulation for 2020).

	Connection rate %	Daily water endowment Liter/capita/day
Mean	95	175
Max	100	518
Min	80	74

Table 3: National statistic about daily endowment and the rate of connection to the drinking water supply network (MRE, 2016).

Citation: Ali Rahmani SE, Brahim C (2017) Water Supply Prediction for the Next 10 Years in Algeria: Risks and Challenges. Irrigat Drainage Sys Eng 6: 197. doi: 10.4172/2168-9768.1000197

Effluent reuse is also an inevitable requirement in novel decentralized wastewater systems [8].

Artificial recharge and recovery: Aquifer recharge and recovery is a basic solution to avoid the lost of surface runoff when the recharge is impossible (Physical conditions don't favorite recharge. In semi-arid zone the infiltration velocity is generally slow which make a high part of precipitation will be lost. Artificial recharge is the practice of increasing by artificial means the amount of water that enters a groundwater reservoir [9]. This includes, for example, direction of water to the land surface through canals, irrigation furrows or sprinkler systems, and injection of water into the subsurface through wells.

The main purpose of artificial aquifer recharge is to store water for later use while improving upon the quality of water [10]. Aquifer artificial recharge is down for many reason as well as augmentation of groundwater resources and storage of the surplus surface water during the flood period, and to improve groundwater quality by dilution.

Water desalination: The scarcity of fresh water resources and the need for additional water supplies is already critical in many arid regions of the world and will be increasingly important in the future. Many arid areas simply do not have fresh water resources in the form of surface water such as rivers and lakes. They may have only limited underground water resources, some that are becoming more brackish as extraction of water from the aquifers continues. Solar desalination evaporation is used by nature to produce rain which is the main source of fresh water on earth. All available man-made distillation systems are duplication on a small scale of this natural process.

Algeria have been realized a high way in water desalination by the realization of lot of big desalination station with high production capacity to assure water supply in the big city. The major desalination stations under exploitation are given in Table 4 (Figure 11).

In this respect, the installation of monitoring networks and water treatment in quantitative and qualitative terms accompanied by an extended study in terms of consumer needs is a particularly important economic decision.

Conclusion

Under climate change situation, the natural water resources will be affected by the irregular rainfall and the increased temperature.

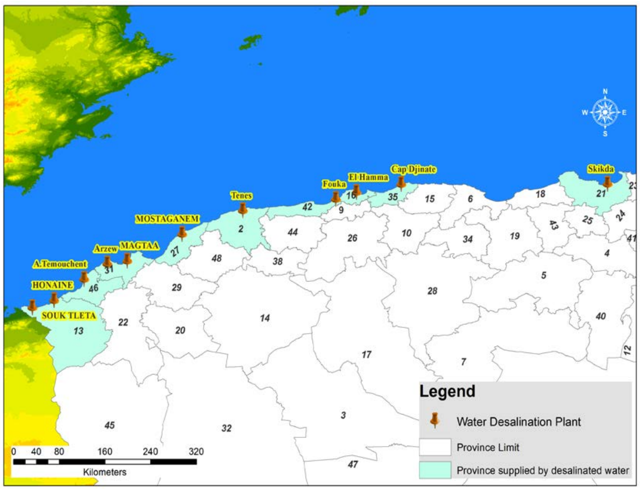

Figure11: Active Water desalination plant in Algeria.

Zone	Region	Capacity (m^3/day)	Date of exploitation
West	Oran	90000	August 2005
	Tlemcen (Souk Tleta)	200000	Mai 2011
	Tlemcen (Honaine)	200000	July 2012
	Mostaganem	200000	September 2011
	Ain Temouchent	200000	December 2009
Middle	Algiers (Hamma)	200000	February 2008
	Boumerdes (Cap Djinet)	100000	August 2012
	Tipaza (Fouka)	120000	July 2011
East	Skikda	100000	Mars 2009

Table 4: Water desalination station under exploitation (MRE, 2016).

Face to this situation, the authority tack in their responsibility to find solution to face scarcity of water resources in short and long range. The simulation show that the regions of center of Algeria are below a serious water scarcity in the few coming year. The introduced resource need ratio (RNR) allows us to calculate the water deficit when the RNR is less than zero.

The purpose discussed in this paper is to show that at the horizon of 2020 if we continue pumping and extract water from aquifers without a sustainable management, the country will live a real water crisis.

Artificial recharge; waste water treatment and reuses, and water desalinization are the principles solution to arise our water resources production to satisfy the growing population demand. The economic based management of water resources is a part of the sustainable development and water resources management policy.

References

1. Rochdane S, Reichert B, Messouli M, Babqiqi A, Khebiza MY (2012) Climate change impacts on water supply and demand in Rheraya Watershed (Morocco), with potential adaptation strategies. Water 4: 28-44.
2. Xiao-Jun W, Jian-Yun Z, Elmahdi A, Rui-Min HE, Li-Ru Z, et al. (2011) Water demand forecasting under changing environment: A System Dynamics approach. IAHS-AISH publication, pp: 259-266.
3. Miller GW (2006) Integrated concepts in water reuse: Managing global water needs. Desalination 187: 65-75.
4. Sahnoune F, Belhamel M, Zelmat M, Kerbachi R (2013) Climate change in Algeria: Vulnerability and strategy of mitigation and adaptation. Energy Procedia 36: 1286-1294.
5. Loucif SN (2002) Water resources and their uses in the agricultural sector in Algeria. INRAA/CRP Algiers.
6. Yi L, Jiao W, Chen X, Chen W (2011) An overview of reclaimed water reuse in China. Journal of Environmental Sciences 23: 1585-1593.
7. Bixio D, Thoeye C, De Koning J, Joksimovic D, Savic D, et al. (2006) Waste water reuse in Europe. Desalination 187: 89-101.
8. Fane SA, Ashbolt NJ, White SB (2002) Decentralized urban water reuse: the implications of system scale for cost and pathogen risk. Water Science and Technology 46: 281-288.
9. Todd DK (1959) Annotated bibliography on artificial recharge of ground water through 1954. US Government Printing Office.
10. Kavuri M, Boddu M, Annamdas VGM (2011) New methods of artificial recharge of aquifers: A review. Poster presented at the 4th International Perspective on Water Resources and the Environment (IPWE), National University of Singapore (NUS), Singapore, pp: 4-6.