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Creating a Sustainable Future in Algeria Water Resource Management

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Abstract. For more than thirty years, Algeria has been subjected to a major deterioration to the extent that resources are scarce in the country. Of course, one of these reasons is climate change, which led to irregular rainfall in terms of time and place, which led to the continuation of drought, thus, a quantitative and qualitative deterioration of water reserves. This study focuses on current situation of water resources supply and management in Algeria. It aims to define the environmental problems related to the water resource and then suggest a sustainable package to solve environmental problems of water in Algeria. The results show that despite the complicated situation of water in Algeria and the multidimensional challenges facing the sustainable development goals in the country, it is possible to implement a global sustainable package to achieve the sixth goal of the SDGs.

Keywords: Algeria, environmental problems, water, sustainability, solutions

1 Introduction

Water is the most important resource on the planet, without it, life would not exist. The world is facing water scarcity in different degrees. However, Africa is the most affected region by water scarcity. This research will focus on Algeria and its water resources

challenges. In 2016, Algeria achieved 98% of potable water, compared to 78% in 1999. The rates of sewage networks reached 90% in 2015 compared to 1970, with a rate of 35%. There is also an increase in the number of dams with the construction of more than 50 dams over the year and it is expected that 123 dams will be operational by 2030, the number of wastewater purification plants reached 177 in 2016. Despite all these improvements, difficulties still exist in terms of water storage capacity and supply and management efficiency. To solve some of these problems, Algeria integrated strategies against drought based on conventional and non-conventional water supply. The Objectives of This Study Are To:

- Evaluate the Water Resources Situation in Algeria
- Highlight Major Environmental Challenges Related to Water in Algeria
- Present A Sustainable Package for Water Resource Management and Conservation

2 About Algeria

Algeria is a country located in North Africa, bordered by the Mediterranean Sea to the north, and its climate varies from north to south. The coastal region has a Mediterranean climate, while the highlands south of the coast have hot summers and cool winters with little rain. Covering about 80% of the area, the desert has very hot summers exceeding 50 degrees and moderately hot winters during the day. (Africa, 2016) With an area of about 2.382 million KM2, Algeria is the largest country in Africa, with a population of over 44 million, mostly in the northern region, which covers only 20% of the total area. Algeria varies with different and unstable climatic systems:

1- Irregular rainfall with variables

2- Protective soil with weak vegetation cover that helps erosion.

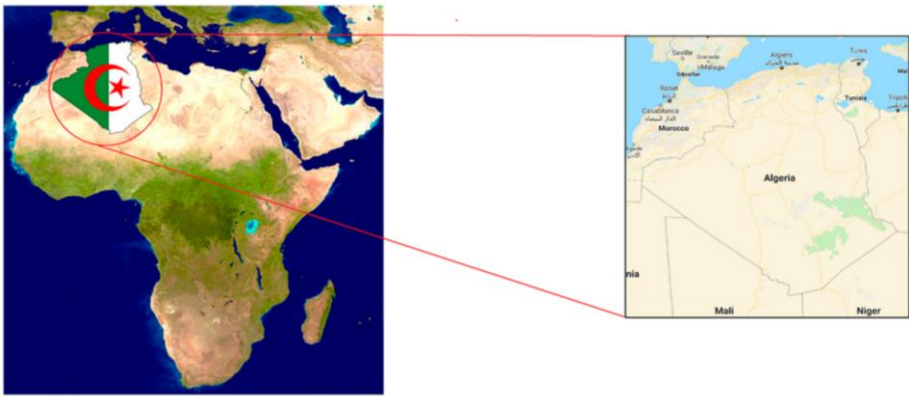


Fig. 1. Algeria, location map(Zahraoui et al. 2021)

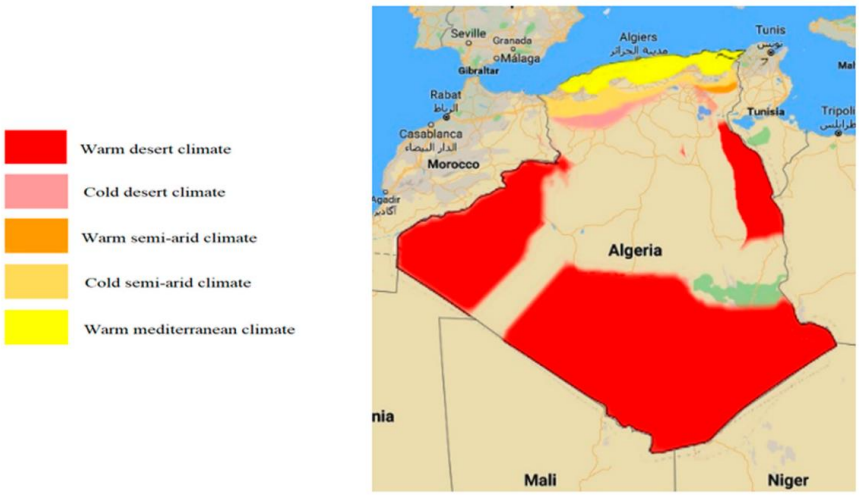


Fig. 2. Different climate regions in Algeria(Zahraoui et al. 2021)

3 Environmental problems in Algeria

Algeria is facing may environmental challenges such as: Air pollution, water pollution, water scarcity, depletion of resources, incontrollable solid waste, and desertification

3.1 Air pollution

After the independence of Algeria, most industrial activities were concentrated in urban centers, this led to internal migration from rural to dense areas thus the demographic explosion in urban cities. this situation got worst during the black decade in Algeria, a lot of buildings were destroyed, big forests were burned, and the government was not capable to control that situation. This causes another vague of rural migration towards saving cities and a significant external migration of skilled young Algerian students and professionals to Europe, the USA, and Canada.(Gherbi 2012)

Industrial activities in cities caused severe air pollution They generated excessive amounts of chemical and organic pollution and were discharged openly into the sea or wadis, mostly without decontamination by networks of cleansing.

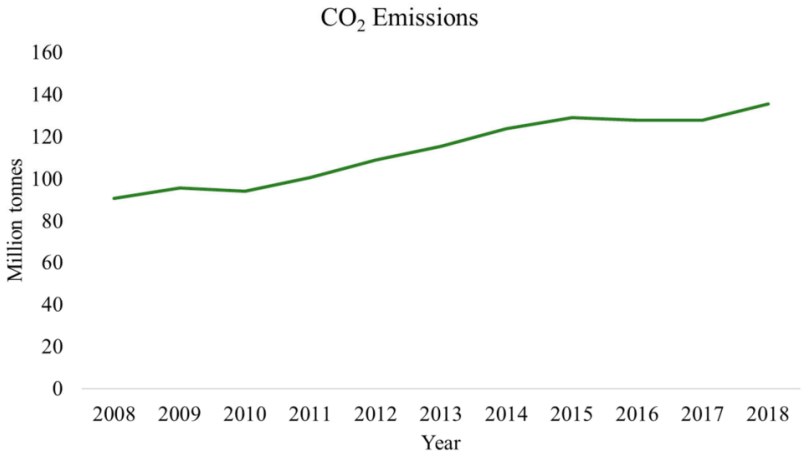


Fig. 3. CO2 Emission in Algeria between 2008 and 2018(Zahraoui et al. 2021)

3.2 Desertification and soil degradation

In Algeria, around 20 million hectares are of steppe regions are under an irrational exploit especially the phenomenon of overgrazing, which is the increase in the number of livestock on a limited area of land. This leads to the despairing of a significant number of pastoral plants, thus the decrease of productivity of these regions Moreover, the land reclamation and the introduction of the machine that is not suitable for the nature of the area to grow grains and which is not adequate with the fragility of the soil in these areas, so every year around 300000 to 350000 hectares of land are loosed. In addition to all these factors, population growth is increasing the soil degradation problem in Algeria(Roux 2009).

the problem of desertification is a problem of serious dimensions in the long run, as land degradation directly affects agricultural production, pastures, and forests, and thus on the national economy

3.3 Solid waste

Algeria is facing a serious environmental issue because of solid waste which is caused by the same factors of air and water pollution:

- Solid: garbage, municipal manure, bird manure, agricultural waste, manure.
- Liquid: sewage, agricultural and industrial waste
- Gaseous: All gases that pollute the environment resulting from factories or through Chemical reactions
- Recyclable waste: includes paper, plastic, glass, metal, old cloth, leather or iron, and aluminum.
- Non-recyclable waste: It includes the organic part of garbage and waste Agriculture of all kinds.

3.4 Water resources depletion and pollution

During the 80s, Algeria was considered as one of the biggest industrial countries in Africa, about 260 big industrial plants were operating in different sectors(carpet factories , cement , chemical , automobile assembly , food-processing , oil refineries, and textile) (Yoshida 2018). This cause a significant amount of pollution especially for water as most of factories were discharging their waste into river or the sea directly without treatment. Things went worst during the 90s, When Algeria was considered as a civil war state during the black decade. No environmental control was applied on industrial companies, many factories and sewage systems were destroyed. In this period, the environmental degradation in Algeria became severe, and it was assessed that conditions would become very catastrophic in the short future. As consequence, international donors planned for the industrial pollution control project (Algeria Industrial Pollution Control Project; World Bank 1996). To reduce the harmful pollution which caused health diseases and ecological issues. Unfortunately, due to the civil ware conditions the project was reported to the 10 years later and didn’t prevent the deterioration of the environment.

4 Water natural resources potential in Algeria

4.1 Surface water

There is a variety of surface water resources in Algeria, some of them with fresh water and others with saltwater.

Rivers: Around 7 principal rivers exist in Algeria, their flow regime is based essentially by the annual mount of precipitation in the country, thus they are characterized by a flood feeding regime which occurs because of heavy rain in the period between October and May, these floods cause a serious damage to hydraulic infrastructures every year. While during summer, the water level decrease significantly in most of them and lead to the crops loose in this period. The rivers flow regime is affected by different factors such as precipitation, air temperature, wind, soil nature. however it is important to mention that the water management measures like riverbeds regulation, the flow of dams and the measures against flood and water transfer techniques play a very important role in conservation and management of water resources coming from rivers(Maalem & Begmatov 2021).

Table 1. Average natural flow north of Algeria(Drouiche, Ghaffour & Naceur 2012)

Districts of Northern Algeria	Catchment area, km^2	Average annual flow, m^3	Average annual balance	
			mm	% of average
El Jazair	27 690	600	22	34
Shelf and coast of Dahra	48 600	1 720	35	54
Al Jazeera (the center)	8 720	1 500	172	276
Sebau and coastal ueda	3 900	1 600	410	681
Summam	9 200	750	82	126
Ores-Honda	61 000	900	15	23
El Jazair-Eastern	34 800	5 500	158	243
North Al Jazair	193 910	12 570	65	100

Lakes: Algeria contains around 20 lakes and shot, some of them have fresh water while the others contain saltwater. Generally, the big lakes have saltwater and the small ones with fresh water are dry during summer, thus the lakes are not considered as an important source of water in Algeria, but they contribute to the diversity of ecosystem as they receive a lot of species coming from Europe during the cold season

Precipitation: Surface water in Algeria relies essentially on rainfall which is very intermittent and variable over the different regions of Algeria. Four regions can be distinguished depending on the annual precipitation:

The coastal region: which receives between 600- and 1000-mm yearly precipitation.
The highlands: with an average of 400 to 600 mm in the year.
The steppe: which receives around 100 to 400 mm annually.
The Sahara: with less than 100 mm.(Drouiche, Ghaffour & Naceur 2012)

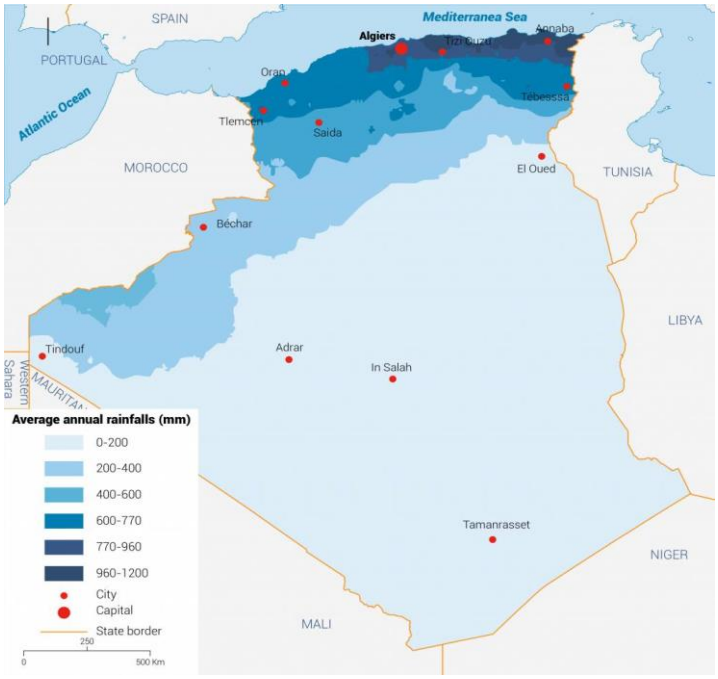


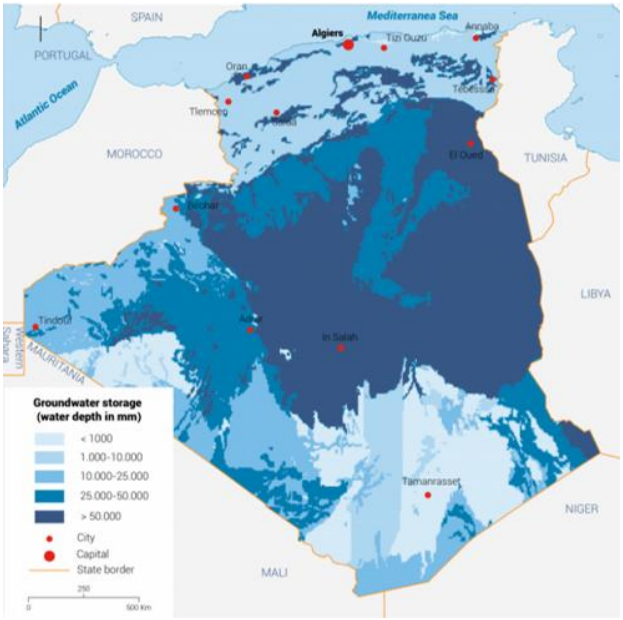
Fig. 4. Precipetation in Algeria(Zahraoui et al. 2021)

4.2 Ground water

7.6 billion cubic meter is the estimation of groundwater resources in Algeria; however, this capacity is less than the demand in water in the north of the country, the aquifers in the south satisfy around 96% of the water need in the south of the country

In the regions of the north the aquifers are shallow and can be exploited by using springs and wells, they are recharged naturally with 1.9 BCM/year. however, the groundwater in the south of the country has a low renewability, two major aquifers exist in the Sahara, the continental intercalary and the complex terminal, together they make the North-Western Sahara Aquifer System (NWSAS).

Fig. 5. Ground water aquifers in Algeria (Remini 2016)



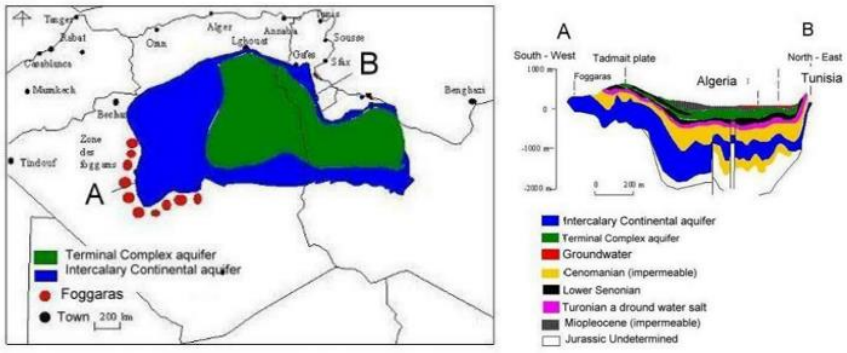


Fig. 6. Terminal complex aquifer and intercalary continental aquifer in Algeria (Remini 2016)

4.3 Sea water

Sea water started being used for desalination after affirming the state`s inability to achieve self-efficiency with freshwater resources. Algeria has a coastline zone of 1600 km giving on the Mediterranean Sea. Thus, desalination presents a magic solution for drought in the country. (Djoher 2020).

Fig. 7. Algerian coastline giving on the Mediterranean Sea (Author).

5 Water infrastructures in Algeria

5.1 Dams

Concentrated in rivers regions, Algeria has constructed around 80 dams with different capacities. the total capacity of all dams was 8.62km³ in 2018. This makes the dams capacity per capita 204. 1m³.The total dam capacity in Algeria made a significant growth by increasing from 1.81km³ in 1972 to reach 8.62 in 2018.The country is planning to construct more dams to rich 140 dams by 2030 to ensure more fresh water for the population and reach the self-sufficiency in water resource supply.(Ben & Dam n.d.). The table 2. shows the surface water distribution in Algeria, it is noticed

that the east of the country is enjoying more than the triple surface water amount existing in the west of Algeria.

Table 2. Surface water shade in Algeria(Drouiche, Ghaffour & Naceur 2012)

Water shade	Oranie Chott Chergui	Chéliff Zahrez	Algérois Soumam Hodna	Constantinois Seybouse Mellègue	South	Total
Mm^3/year	1,025	1,840	4,380	4,500	600	12,345
Percentage	8.7	15.7	37.3	38.3	0.48	100.0

5.2 Desalination plants

Due to the intermittency of precipitation, Algeria adopted sea water desalination strategy to achieve more water supply for the population. In 2019, 11 desalination plants were operational and one plant under construction, the total capacity of drinking water production of these desalination plants was 2.1million m^3 daily.(INTRA – AFRICA DESALINATION ROUND TABLE Seawater desalination in Algeria . Summary 2017).

Fig.8 shows the distribution of desalination plants on the Algerian coastline, it is remarked that most of the plants are concentrated on the western region of the country, this is due to the serious shortage of precipitation in this region, thus the desalination project will balance the water distribution between the east and the west of the country in a way that dams will be concentrated in the east of the country and desalination plants will be constructed in the west

Fig. 8. Desalination plants in Algeria(INTRA – AFRICA DESALINATION ROUND TABLE Seawater desalination in Algeria . Summary 2017)

5.3 Water treatment plants

Wastewater reuse is one of the Algerian strategies to harness the nonconventional water resources in the country. In 2014, 145 wastewater plants were operational in Algeria and 106 other plants were under construction ,this makes a total production of treated wastewater of 1.2 billion cubic meter per year.(Kherbache 2020) states that 177 wastewater purification plants were operational in 2016. Demineralisation of brackish water is also adopted in the country (Stambouli, Hamiche & Flazi 2016).

Table 3. Some wastewater plants and their capacity in Algeria(Drouiche, Ghaffour & Naceur 2012)

Name	Wilaya	Year of service	Capacity (m^3/d)	Treated volume
BBA	BBA	2008	2,500	30.000
Ibn Ziad	Constantine	2009	5,000	69.120
Ain Hout	Tlemcen	2009	9,300	30.000
Ghriss	Mascara	2012	1,000	3.700
Baraki	Alger	2013	76,712	150.000
Annaba	Annaba	2013		116.000
			554.512	648.820

- **Water uses in Algeria**

5.4 Water uses in Algeria

As mentioned before, Algeria gets its water from three sources, precipitation, groundwater, and desalination. These resources are divided between municipal use, agriculture, and industry. However, the agriculture sector gets more than 70% of Algerian water resources as it is mentioned in fig 9, this is due to the development of agricultural sector and strategies applied in Algeria to achieve the food self-sufficiency

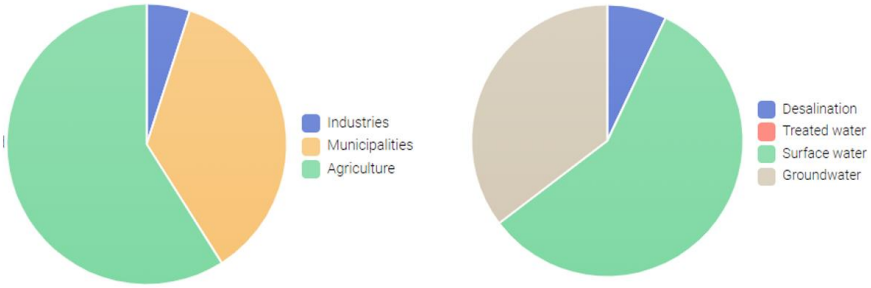


Fig. 9. Water use by sector and water withdrawals in Algeria(Fanack 2019).

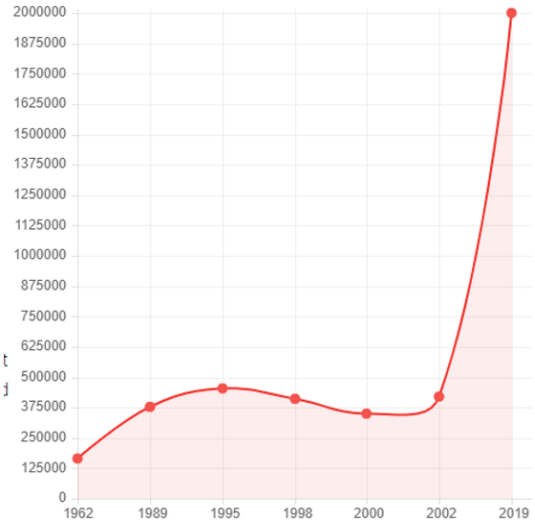


Fig.10. Evolution of irrigated perimeters in Algeria (Fanack 2019).

6 Water problems in Algeria

6.1 Water scarcity

Despite all the previous water potential, Algeria is considered as one of the most arid countries in Africa and the world with the supply of 400 cubic meter per capita daily(BOUCHENTOUF & BENABDELI 2021). Many factors affect the water resources in Algeria, the most important ones will be listed below.

RANK	NAME	ALL SECTORS
1	Bahrain	5.00
1	Kuwait	5.00
1	Qatar	5.00
1	San Marino	5.00
1	Singapore	5.00
1	United Arab Emirates	5.00
1	Palestine	5.00
8	Israel	5.00
9	Saudi Arabia	4.99
10	Oman	4.97
11	Lebanon	4.97
12	Kyrgyzstan	4.93
13	Iran	4.91
14	Jordan	4.86
15	Libya	4.77
16	Yemen	4.74
17	Macedonia	4.70

RANK	NAME	ALL SECTORS
18	Azerbaijan	4.69
19	Morocco	4.68
20	Kazakhstan	4.66
21	Iraq	4.66
22	Armenia	4.60
23	Pakistan	4.48
24	Chile	4.45
25	Syria	4.44
26	Turkmenistan	4.30
27	Turkey	4.27
28	Greece	4.23
29	Uzbekistan	4.19
30	Algeria	4.17
31	Afghanistan	4.12
32	Spain	4.07
33	Tunisia	4.06

Fig.11. Water stress by country by 2040(Fanack 2019).

Climate change: Climate change increases the temperature degree of the earth, as result the precipitation will decrease, and the need of water supply will increase. Rainfall in Algeria is very uneven, and the amount of precipitation decreased in a significant rate during the last decades, this led to the drought of many dams during summer, thus the water supply faces a serious deficit. In addition to that, climate change cause floods and incontrollable rainfall in winter and this led to water infrastructure damages and thus the decrease of water quality.

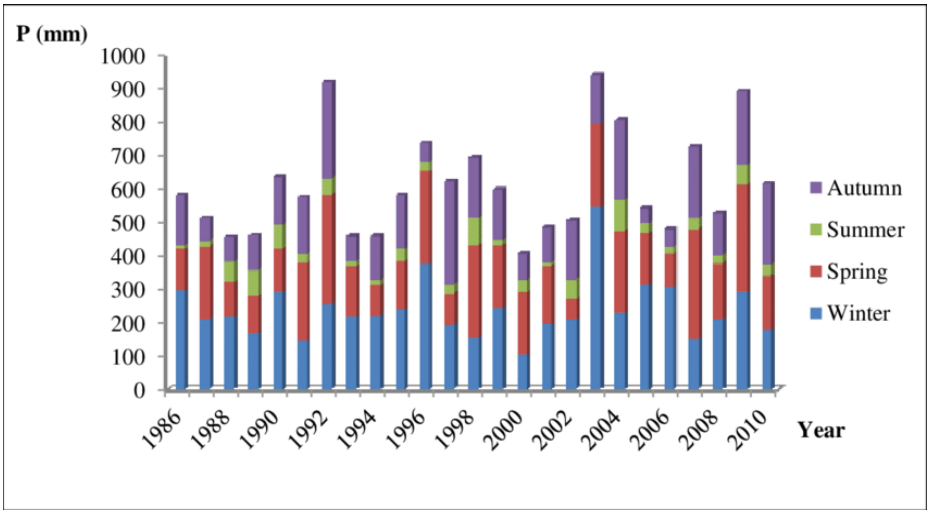


Fig.12. The intermittency in annual precipitation in Algeria(Fanack 2019).

Supply/demand: Another result of climate change is the perturbation between the water supply and water demand because the temperature increases the evaporation level increase and the water storage level decrease and the water demand level increase**.** The growth of population and its irregular distribution in the country worsen

the situation of water. Fig13 shows that mostly in the north of Algeria the water demand per capita is higher than the water supply, this is due to the concentration of 80% of Algerian population in the northern provinces, but also the precipitation in the western regions is limited compared to the eastern ones as shown before in table 2

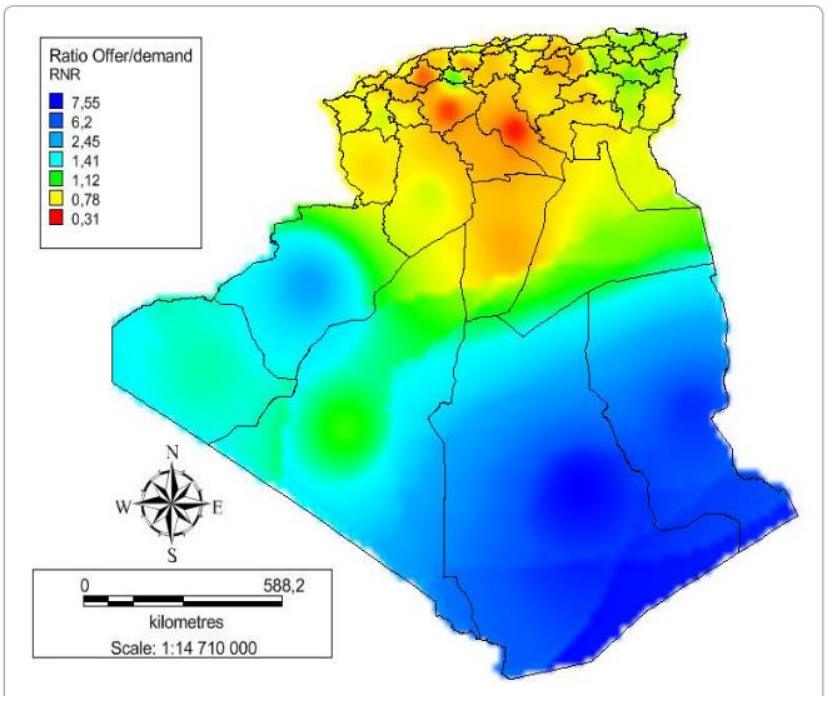


Fig.13. the ratio offer/demand of water supply simulation for 2020(Rahmani, Eddine & Boumediene 2020)

Water leakage: Algeria water supply and sanitation infrastructures are very old, some of the installations remains to the French colonialism period in the country and some roman terms are operational till now ,moreover the new installed networks are with low quality , all this consequent a significant amount of fresh water leakage that reaches 30 % of distributed water through these infrastructures.(Kherbache 2020)

Bad water governance: In Algeria, water is an important element in different sectors such as environment, agriculture, industry, energy, food, health, and household. Considering that water supply in Algeria is based on precipitation, ground water and desalination, it needs three different ministerial bodies for each source type, these ministerial bodies are under water resource ministry control, however they rely heavily on energy, this makes them under ministry of energy supervision at the same time because desalination and ground water extraction need a lot of energy while dams could be a source of energy production. Algeria relies heavily on oil and gas in energy production, this present a serious environmental issue that should be studied and controlled by ministry of environment in the country .As agriculture consumes more than 70% of water resources in Algeria , the ministry of agriculture is considered as an important factor in water resource management operations , moreover , food sector is linked directly to water resources as they are the bigger participant in food production, in the same way health , fishing, wastewater management and household sectors are influenced by water resources sector , consequently the water governance occurs under interlinked and complicated operations which are included under multisectoral institutions in the country .However , if these multi sectorial institutions are managed by qualified human resources , the coordination between

involved sectors will not present an issue as it will produce very efficient strategies that increase water production, decrease energy consumption and improve environmental conditions in the country. Unfortunately, this is not the case in Algeria because of migration of its high qualified population due to the socioeconomic situation in the country.

6.2 Water pollution:

Water pollution presents a serious challenge to the Algerian state because it is caused by different factors that are increasing and interconnecting. The population growth is one of the factors in water pollution, the government is not able to develop its water structure to satisfy the population needs which are fare more than the existing supply amount of water .This growing population is worsening the water pollution situation with its low level of awareness about environmental issues and water valorization as a natural resource, however the bad governance is the most significant factor in this catastrophic situation of water pollution ,factories were disposing their waste in the rivers which means to the seawater and pollute the surface water of Algeria. Authorities were allowing the construction of factories on the limit of rivers, moreover most of these factories were built by the government itself. One example of bad governance and protection of water resources is the contamination of Oued Elharrach in Algiers. Mercury and heavy metals pollution was discovered in the river after a monitoring study which was done in 2001, the fig13 shows the connection of two rivers which are Oued Elharrach and Oued Smar in Algiers and flow of their water into the bay of Algiers in the Mediterranean sea , unfortunately most of the regions around the two rivers are considered as industrial areas due to the concentration of many factories on their limits, moreover these factories dispose their waste directly in the rivers .A significant level of mercury contamination was detected in the river ,its origin was a chlorine factory that contains a chlor-alkali mercury electrode plant , it is situated in Baba Ali fig14 and has a chlorine production capacity of 4,000 ton per year. This factory was discharging its waste into the river directly. In addition to that, a high concentration of heavy metals was found after analysis, such as (Cu, Zn, Pb, As, Ni, Cd, and Cr).

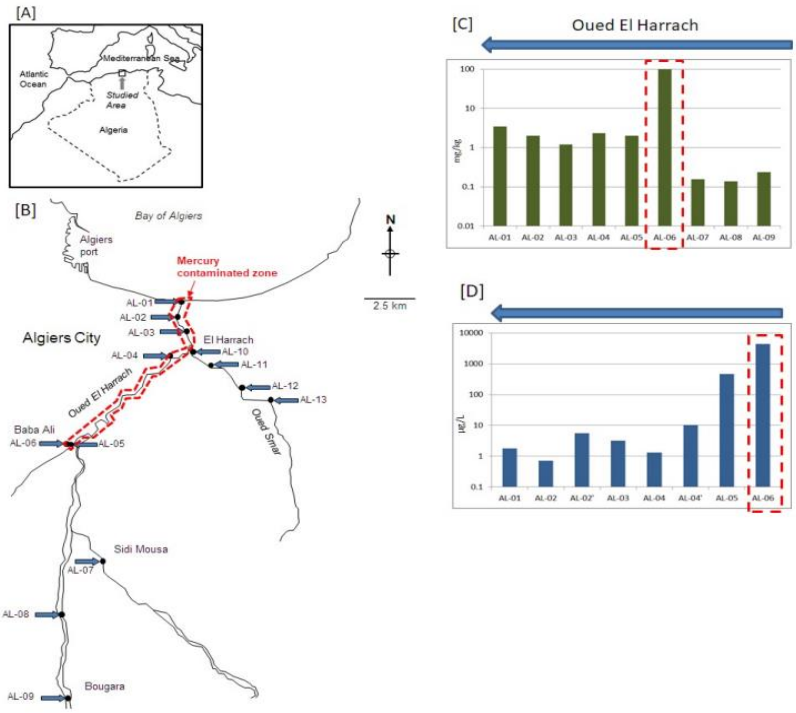


Fig.14. Oued Alharrach and Oued Smar contamination with mercury and heavy metals(Yoshida 2018)

This type of water pollution causes a significant danger as it has multidimensional effects. Fig15 shows how could the mercury and heavy metals contamination of Oued elharrach affect the sea food and thus cause the public health crisis in Algeria ,moreover the water contamination itself can lead to environmental issues such as water quality and soil degradation ,toxification , extermination of ecosystems and contamination of agricultural products.(Yoshida 2018).

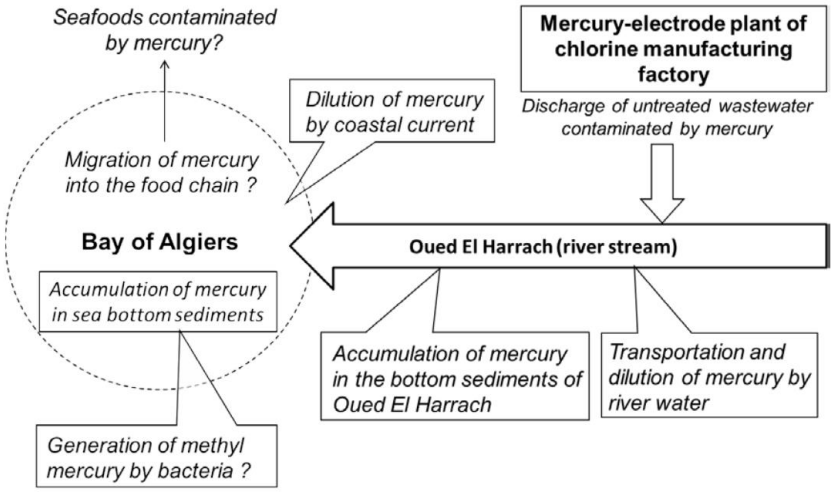


Fig.15. Water contamination effects on sea food production and public health (Yoshida 2018)

In addition to the significant impact of Industry on water pollution, agriculture sector participates in water pollution significantly as it consumes more than 70% of fresh water in Algeria. This water will be mixed with fertilizers in irrigation, thus a first step of pollution, on the other side fertilizers solutes are solved in irrigation water and transported into the groundwater which will be polluted in a second step. Fig16 shows the distribution of some agriculture areas that are supplied with the northwestern Sahara

aquifer which is shared by Algeria, Tunisia and Libya, the map explains the serious pollution impact of fertilizers in agriculture sector , if the toxic substances of fertilizers rich the groundwater of the two aquifers there, the pollution issue will be transmitted from a national scale into a regional scale that affect neighbor countries.(Nations, Commission & Europe n.d.)

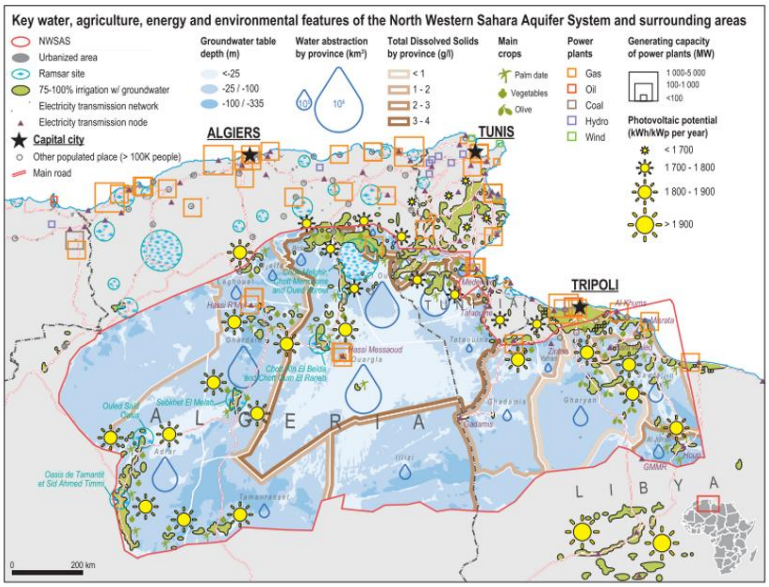


Fig.16. The North-Western Sahara Aquifer (Nations, Commission & Europe n.d.)

Another factor that causes water pollution in Algeria Is the degradation of sanitation, water supply and water transfer infrastructures. The country is dotted with old water supply and water sanitation networks, this causes the leakage of water from both networks and moreover, in some region the mixture of clean and sewage water consequent freshwater pollution in Algeria

7 Impact of water problems in Algeria

The vulnerability of water resources to climate change is a global major issue, Algeria is not an exception, water is the most important raw material in the country as it is important for human consumption, food production and other industries. Climate change increases the temperature in Algeria from 0.6º to 1.1º, thus the drought periods will be longer in the country and ground water reservoirs will dry, the rainfall will decrease and floods will be more frequent ,thus the agriculture lands will decrease and lead to food scarcity, the water infrastructures will be eroded and degraded .However , climate change is not the only factor in water vulnerability ,population growth , economy , water management and users behavior have a significant impact on water vulnerability in Algeria .Water supply will decrease because of the climate change and the water demand will increase due to the population growth and the irrational use of water resources in addition to the degradation of water infrastructures will wornness the situation of water scarcity in Algeria.(Mohammed & Al-amin 2018).

On the other side public health and sanitation will be highly affected by water resources vulnerability in Algeria , (Mellahi, Zerdoumi & Chaib 2021) stated that proportional relationship exists between the number of leaks in sanitation network and the number of cases of waterborne diseases as shown in fig 17 . Table 4 shows some of the famous waterborne diseases in Algeria.

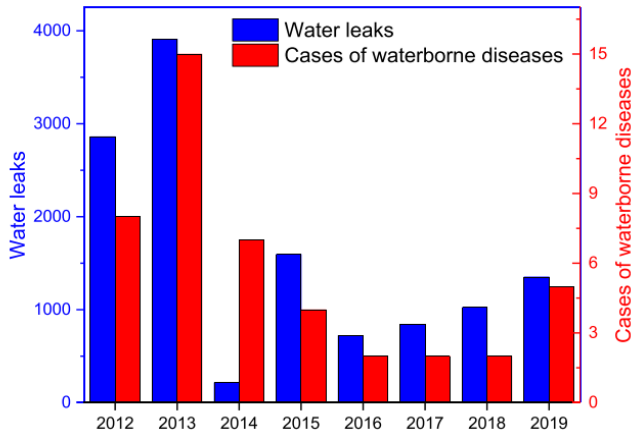


Fig.17. Relationship between waterborne diseases and leaks in sanitation networks(Mellahi, Zerdoumi & Chaib 2021)

Table4. Some microorganisms responsible for waterborne diseases in Algeria

Diseases	Causes
Typhoid fever	Salmonella Typhi bacteria
Diarrhoea	Viruses, bacteria and parasites from fecally contaminated water
Cholera	Bacterium Vibrio Cholerae
Dysentery	Bacillary dysentery: caused by bacteria. Amoebic dysentery: caused by amoebae.

8 Algerian strategies against water vulnerability

The government of Algeria and its policy makers made significant efforts against water scarcity and drought in the country, two basic strategies were implemented in the reform project:

8.1 Mobilizing conventional resources

Which aims to:

- Increase rainfall water storage capacity by constructing more dams.
- Improve and extend water transfer network.
- Maximize the exploitation of ground water by drilling more wells and boreholes.

8.2 Mobilizing non-conventional resources

Which aims to:

- Increase the number of seawater desalination plants and wastewater purification stations.
- Rehabilitation and Extension of Systems of Sanitation and protection against Floods
- Groundwater aquifers recharge recovery

Many organizations and institutions were implemented in water management strategy in Algeria such as:

Algerian Energy Company: which forms joint ventures with external companies to implement desalination projects.

National Agency of Dams and Large Transmission Mains: Implements surface water resources and projects of water transfer.

Algeria Water Company: To distribute drinkable water and provide water services.

Office of National Sanitation: Provides wastewater services and waste- water treatment.

Office of National Irrigation and Drainage and National Agency of Water Resources: Work on water resource planning.(Drouiche, Ghaffour & Naceur 2012)

9 Water management challenges in Algeria.

Despite the significant improvement in water resources supply and management in Algeria, the sector is facing some important difficulties such as:

- The multi-level governance gaps and absence of institutional inter-coordination.
- dependence on foreign countries concerning implementation of technological and engineering strategies.
- Increase of energy consumption by desalination plants and wastewater station and groundwater pumping facilities, thus the emission of more CO2 and its negative impact on the environment.
- Lake of qualified national human resources and companies in water resource management.

Algeria made great efforts to ensure a safe water resource management and achieved significant improvement in water infrastructure construction and management. However, the government strategies focused on increasing water resource supply and storage and neglected working on reducing population consumption of water and developing the individual's awareness regarding water resource consumption and conservation.

10 Sustainability package for water resource management in Algeria.

Due to the importance of water for life on the planet and its correspondence to different sectors that affect humans significantly, it is crucial to think about water resource management strategies as part of a total package of different strategies that aims to improve all interconnected sectors with water such as agriculture, energy, food, environment, and public health. Sustainability should be the major criteria for evaluation of different implemented strategies in water resource management sector. Basic goals could be:

- Increase water supply and storage in a rate that satisfy the population growth speed.
- Decrease water resources consumption in all sectors.
- Decrease energy consumption in water resource management sector.
- Diversify food production to achieve food self- sufficiency.

- Preserve natural resources, biodiversity and improve environmental conditions.
- Ensure a good quality of public health by providing good quality of water supply.

10.1 Who is involved?

All concerned actors should be involved to achieve the sustainability goals of water resource management, the state, local authorities, private sectors, and the civil society are invited to communicate and share responsibilities and experiences to apply the most viable strategies in sustainable water resources management.

10.2 How it works?

It is very important to set a coherent and well organized and interconnected structures and authority bodies which will be directed to work and achieve the sustainable development goals. As suggestion, a sustainable development council which will be under direct supervision of the government is an ideal establishment that could study, plane, and apply a sustainability package strategy with the coordination between all ministries and authority bodies that are involved on strategies application, this council should be at the top of all ministries that are interconnected in applying the sustainability development agenda including water resources management strategies. Which means that all decisions should come from it and all suggestions are to be approved from it. Fig 18 shows the proposed hierarchy of different institutions, ministries and authority bodies that are involved in the sustainability package application for different sectors including water resource management.

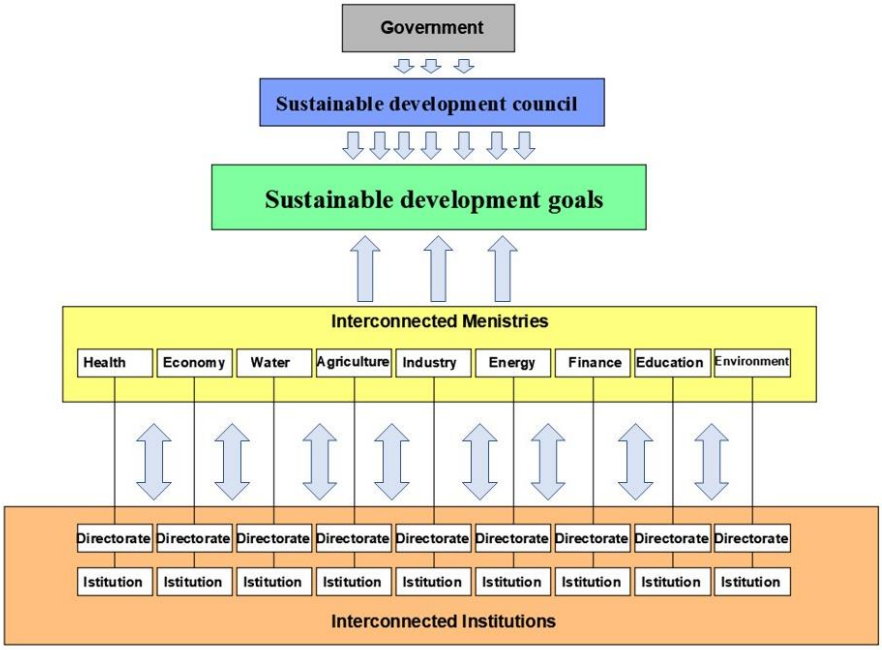


Fig.18. Typical hierarchy of different ministries and authority bodies in sustainability package (Author).

10.3 Strategies

Strategies to Increase water supply and storage in a rate that satisfy the population growth speed: This could be achieved by**:**

- Construction of more storage infrastructures (dams and reservoirs).
- Increasing the number of desalination plants and wastewater treatment.
- Drilling more wells and boreholes.
- Extend water transfer and sanitation networks.
- Groundwater aquifers recharging recovery using rainwater.

Strategies to Decrease water resources consumption in all sectors: This could be achieved by**:**

- Rehabilitation of water transfer networks to avoid water leakage and loses.
- Use smart and economic irrigation system that consume less amount of water.
- Integration of metering systems to detect loses and leakage.
- Rise population awareness regarding water consumption and saving.

Strategies to Decrease energy consumption in water resource management sector: This could be achieved by**:**

- Harness dams to produce clean energy to be used in desalination operations.
- Use the modern wastewater treatment techniques which allow to extract the methane gas from organic substances to be used for the generation of energy needed to run the process of wastewater treatment.
- Shift renewable energy in wastewater treatment operations.

Strategies to Diversify food production to achieve food self- sufficiency: This could be achieved by**:**

- Increase number of agricultural lands and irrigated areas.
- Increase the volume of treated wastewater to be used in the irrigation
- Rely on modern agricultural research and techniques in agriculture to enhance land productivity and avoid land degradation.
- Diversifying agricultural production to satisfy the population needs, decrease the amount of food products importation, and thus save the importation budgets for more investment in the country.

Strategies to Ensure a good quality of public health by providing good quality of water supply: This could be achieved by**:**

- Rehabilitation of the existing sanitation network to mitigate leakage of sewage water and the contamination of freshwater and soil degradation.
- Installation of new sanitation and water transfer networks using ecofriendly materials.
- Rely on technology to enhance drinking water in water treatment of dams and desalination.
- Using drainage of agricultural irrigation water to avoid the transfer of pollutant matters of fertilizers into surface water and groundwater.

Strategies Preserve natural resources, biodiversity and improve environmental conditions: This could be achieved by**:**

- Diversifying agricultural production to increase land performance and avoid land degradation.
- Use of technology in wastewater treatment to mitigate toxic gases emissions.
- Rational distribution of water resources to increase green areas in different regions of the country.
- Green urban planning which mitigates CO2 emission and increase the efficiency of urban water networks.
- The use of clean energy in desalination, wastewater treatment and groundwater extraction.

11 Challenges.

It seems that it is easy to meet with all involved actors in the sustainability package project, studying situation, searching for solutions, and discussing strategies. However, leading a developing country of its economy into sustainable development is very complicated process which faces many challenges:

11.1 Socioeconomic challenges:

Algerian population is growing with the rate of 2 %(Nations, Affairs & Division 2020), its growth is accompanied with poverty, unemployment , lack of awareness and many other problems .All this makes sustainable development goals achievement a very difficult target and this is applicable on sustainable management of water resources.

11.2 Financial challenges:

Algerian economy relies on oil and gas with 97%, consequently, all the country`s income depends on the oil and gas prices, unfortunately, the price of these resources is very fluctuant, thus the country`s budget is not content e and the economic situation is not stable sufficiently to apply a serious sustainability development in the country.

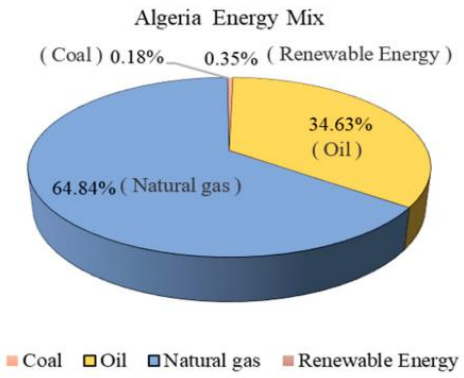


Fig.19. Fossil generation mix in Algeria (Profile 2019)

11.3 Environmental challenges:

Principal source of energy in Algeria is fossil fuels which provide the country with 99% of the energy(Zahraoui et al. 2021), this increases the CO2 emissions which reached 535 t/kwh in 2019 (Profile 2019). On another hand seawater desalination and wastewater treatment and extraction of groundwater need a significant amount of energy, consequently the water resource supply will increase the CO2emmissions and the environmental issues in the country.

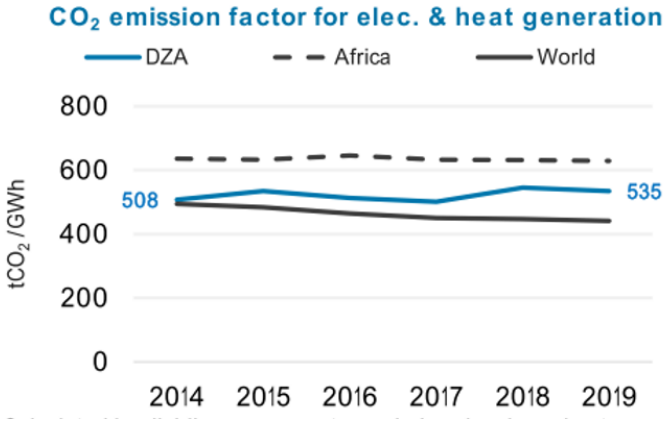


Fig.20. Co2 Emission factor for Elec& heat generation.(Profile 2019)

11.4 Technological challenges:

Algerian infrastructures still relying to traditional systems in their management, thus they are fare from controlling a multidimensional strategies project with the scale of the sustainability package proposed in this study. the absence of smart systems which allow the multi-control operations that could be done remotely and instantly will be a serious obstacle for the sustainability development strategies.

11.5 Human resources challenges:

Sustainability was not a priority in Algeria; thus, the institutions didn't produce a qualified human resource category which is trained to participate efficiently in a sustainability project. Fortunately the government is giving now more importance to environmental problems in the country , and a serious efforts are made to shift to clean energy sources in the future.

11.6 Civil society challenges:

Population in Algeria has been suffering from civil war for most than 10 years , as result a lot of instructed people migrated to Europe and Canada .in that time the government was not able to control the institutions of the country , educational institutions didn't make enough efforts to produce a good quality education that participate in increasing people awareness about environmental issues and natural resources conservation, moreover , this population is complaining about bad quality services provided from the government instead of trying to participate in the country development.

12 Policies.

While trying to find solutions to any type of problems on a national scale, policies are the key-element that should be taken in consideration, because they present the transitional step between problems and solutions. Recently, Algeria is giving a significant interest to the environmental issues. The government is engaged in many international agreements regarding climate change and renewable energy. Water is one of the important aspects that the country is working on to satisfy its population needs and achieve food self-sufficiency. Between 1999 and 2019, series of important official reforms supporting values of Integrated Water Resource Management such as:

- Law No. 05-12 concerning water.
- Creating the Ministry of Water Resources and Environment in 1999 after the improvement in 2015 and the return of the Ministry of Water Resources on May 2017.
- Creating the Integrated Water Resources Management Agency in 2011 and its installation in December 2014
- Establishment the River Basin Committees (RBC) and the National Advisory Council on Water Resources (NACWR).

In his analysis , (Kherbache 2020) says that Algerian policies and strategies regarding the water resources supply and management were successful, as results show that the water absorption rate in Algeria decreased from 114% in 2004 to reach 38% in 2012.However this rate increased after that to reach 81% in 2018.This was due to:

• The complication of processes without the serious application of policy texts.

• The law budget assigned to projects because of the inadequate project studies.

• The continuous stopping of project realization during the bad weather.

• Interconnexion between sectors such as transport, industry, energy, and housing with the inefficient coordination sometimes.

• Absence of qualified compagnies that take water projects in charge.

Algeria`s policies succeeded in to achieve the goals 6 and 7 of management development goals between the years 2000 and 2019 before 2015 which was the fixed deadlines by the UN (Kherbache 2020).However, these policies were focusing on increasing the water supply to satisfy the need of population which continues to grow and its water consumption is increasing .Algeria`s challenge now is to achieve the SDG number 6 which “Ensuring availability and sustainable management of water and sanitation for all”. What is needed now is to focus on implementing policies that aim to decrease the water consumption per capita, this could be done by limiting the individual consumption of water and companies then applying fine for those who exceed the limits decided by the government.

13 Conclusion

Despite classifying it as a country with high scarcity of water, Algeria has a great potential in water resource storage and supply, however it needs to develop its transfer and swage infrastructure network. The country is doing great job regarding water storage reservoir construction, desalination plants building and ground water extraction. However, a national and sustainable strategy that aims to reach the 17 sustainable development goals is a must to achieve water, food, and renewable energy safety. This research comes up with the Algerian potential to apply a sustainability package which include sustainable water resources management with efficiency of all other sectors related to water resources, at the same time it is crucial to ensure a strong base by eliminating the challenges that was discussed previously such as implementing smart system on the national scale to allow the multi-control action , remote coordination and instant metering of resource, moreover the shift into renewable energy production and the diversification of the country income is very important for the environment preservation and the food self-sufficiency .Fortunately , the Algerian authorities are highly interested to the climate change fighting strategies , recently the new strategies regarding climate change and renewable energy shift are announced by the Algerian president himself , this gives a glimmer of hope to see a sustainable future for Algeria .

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