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## Impacts of Population On Water Resources in Libya

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### Abstract

This article deals with water situation in Libya generally in order to show the effect of population on water resources which included population growth and geographical distribution of population. The study describe the current water situation in Libya including “water resources, water supply and water demand” based on data collected from different resources such as literature, books, reports and journals. The study revealed that the population growth rate is the most important factor affecting water resources. Libya will be facing extreme deficit in water resources, among highly populated cities because of increase in consumption of drinkable water and in domestic purposes. The country’s population has tripled since the 1950s. It was 1,888,730 in the first census in Libya in 1954 and it became 5,657,632 in the last census 2006. As a result of the population growth and the improvement of living standard, the country is facing a severe lack of water resources. Water shortages of about 1154 to 4339 Mm<sup>3</sup> have been estimated for the years 1998 and 2025, respectively. In respect to population distribution, the concentration of population in the north has led to increased demand for water, which in turn has led to the low level of water in some areas and vulnerability to pollution in other regions, while because of lack of population in the south part; these areas do not suffer from problems of water shortage or contamination.

Keywords: *water resources, water supply, water demand, population growth, distribution of population.*

## 1. Introduction

The world is entering a period of intense competition over limited supplies of water for multi uses in agriculture, industry, recreation, domestic, and environmental protection. The appearance of this competition and our present incapability to deal with it can be observed in many parts of the world. Gradually, water problem is extending universally but in some parts of the world it is turning out to be a major issue.

Most of the Arab countries are located in arid and semi-arid zones well-known for their slight annual rainfall, very high rates of evaporation due to high temperatures around the year and therefore highly inadequate renewable water resources. Water scarcity is becoming more and more of a constraint in development, slowing down the economic growth of many countries in the region. Agriculture is the greatest single worldwide consumer of water (70%), followed by industry (20%) and homes (10%) (Wheida, E. 2004), Considerable efforts have been made to reduce consumption in industry and homes; but much remains to be done in improving the efficiency of irrigation. The proportion of water used in these three sectors varies region to region, and between levels of economic development. In Europe and North America, water is used primarily by industry. In Asia and Africa, agricultural irrigation is the primary consumer. In many semi-arid and arid regions about 30% of groundwater is extracted for irrigation, and the trend is increasing. The demand for fresh water in the mostly desert country of Libya to keep up its economy, especially in agriculture sector, go beyond its conventional supplies.

Algeria, Tunisia and Libya share the consumption of the groundwater of the North Sahara Aquifer System, which over recent decades have seen their use increase from 0.6 to 2.2 billion m<sup>3</sup> per annum. Libya, which has very limited water resources, has been in a situation of imbalance between water resources and water needs. To equalize this imbalance, Libya has an alternative to non-conventional water and to mining as a means of making use of its underground water resources, which are non-renewable.

In the 1950s and 1960s the search for new oilfields in the deserts of southern Libya led to the discovery of major oil reserves as well as of aquifers containing huge quantities of fresh groundwater. Most of this fossil water was collected over 35,000 years ago (Loucks, D. 2004), this article discusses the impacts of population increased and distribution of population on water resources in Libya

## 2. Study area and methodology

Libya is located on the northern coast of the continent of Africa; bounded by the Mediterranean to the north. Tunisia and Algeria to the west, Egypt and Sudan to the east and south-east, and by Chad and Niger to the south as shown in Figure 1, it occupies vast area of 1,750,000 m<sup>2</sup>(Hamdan, J. 1993), so it ranks as the third Arab country in terms of area after Algeria and Saudi Arabia. It is also ranked third amongst African countries in terms of area after Algeria and Zaire (Congo), The geographical and astronomical location of Libya has a significant impact on water resources, as Libya is located between 19°-32`N latitude and 9°-25°E longitude. This means that most of the country lies within the tropical environment, with the exception of some parts of the north which lie within the temperate zone. This means that there are desert conditions of high temperatures and severe drought and there is also a spread of the manifestations of desertification across around 90% of the country; the Mediterranean climate has limited impact: this is restricted to the coastal parts only. However, it should be noted that even the coastal portions of these areas do not escape the negative impacts of the desert climate; those parts are also exposed to climatic conditions very similar to those prevailing in the desert in the summer, such as severe high temperature and seasonal warm winds.

The data was collected from different resources which include report and other locally exchanged documents, related studies in other areas, books and study journals. These collected from the nearby government offices, Libyan universities and from electronically available documents. In general the data sources can be divided as following

### a. Documents

Documents viewed included books, reports of National Body for Information and Documentation, Libya. Libyan Statistic Agency, census 1973, 1984, 1995 and 2006.

### b. Literature review

The literature review includes the studies that already done by other authors on water issue that includes “water resources, water supply, and water demand”.

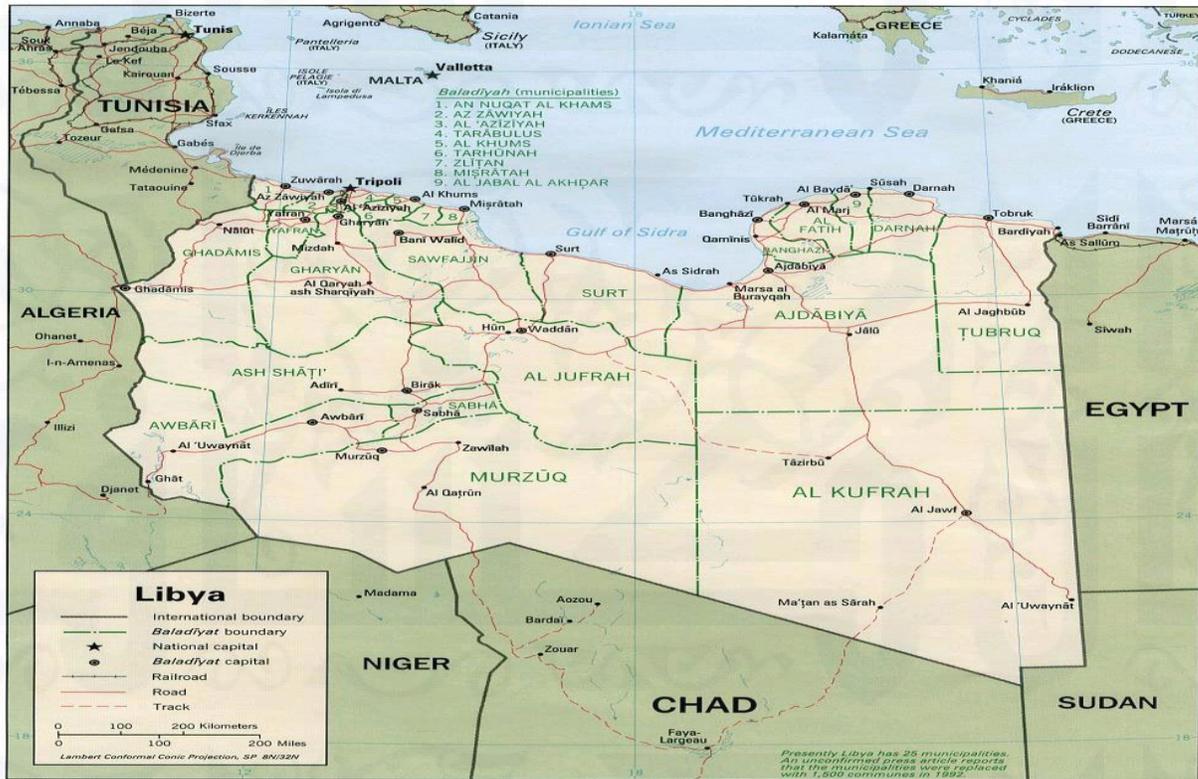


Figure 1 location of Libya

Source: [www.libyanlocation.com](http://www.libyanlocation.com)

### 3. Water resources

Libya is considered among the countries which suffer from limited natural water resources availability because the majority parts of the country are either semi-arid or arid. This part of the world is located among the driest regions in the earth, with yearly average rainfall ranging from just ten millimeters to 500 mm. Just five per cent of the entire area of Libya exceeds 100 mm annually. Evaporation rates are also high due to high temperatures. Range of evaporation rates is estimated from 1,700 mm in the north to 6,000 mm in the south. Prevailing water conditions do not provide sustainable alternative to surface water development, thus create immense pressures on ground water resources. Much of the ground water resource is used in agriculture, which represents almost 80 % of the total consumption (Abdelrhem M., et al., 2008),

Groundwater represents the main source of water supply in Libya. It is extracted through wells that vary in depth from few meters to more than 1,000 m. Groundwater is stored in aquifers that are either renewable or non-renewable. The renewable aquifers are those located in the northern zones and fall within areas under high precipitation rates. They contribute more than 2,400

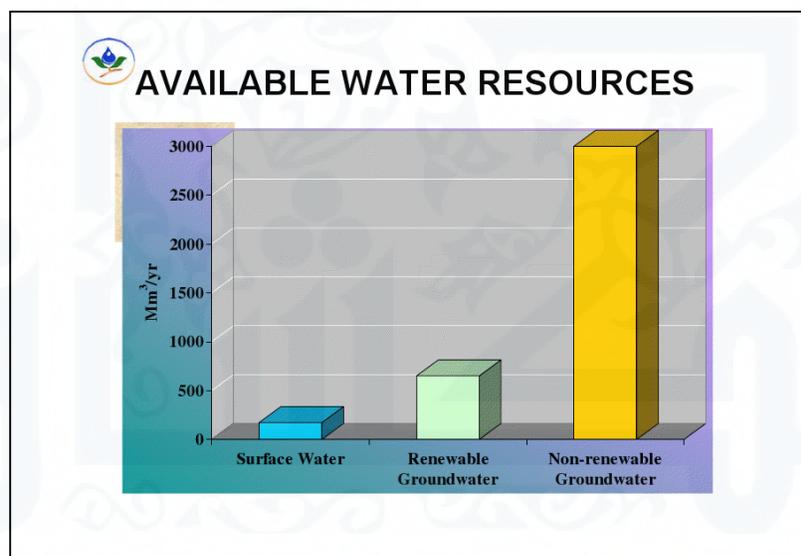
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million  $m^3$  of water reserves per year against an annual recharge of less than 6.5 million  $m^3$  per year. This imbalance has resulted in a continuous lowering of groundwater levels accompanied by deterioration in water quality due to mixing of seawater and addition of saline water from adjacent aquifers (Salem, O. 2007)

The water researches indicate that Libya will be facing extreme deficit in water resources, among highly populated cities because of increase in consumption of drinkable water and in domestic purposes. Due to the shortage of feeding water and renewable resources to the ground water reservoirs different techniques are considered Man-Made River Project to save all the water demands in Libya.

### 4. Water supply

Libya, as many other countries in the arid region, is heavily dependent on groundwater resources. The available groundwater supply is estimated at 2557.62  $mm^3$ , which represents 95% of the total supply. Surface water supply is 2.3%, whereas the desalination of seawater and the re-use of waste water are minor resources with very small shares of 1.8% and 0.9%, respectively. Thus, the total water supply capacity equals 3843.21  $Mm^3$ . The agricultural sector has the highest consumption quantity which is 85%. The domestic sector consume only 11.5%, and the industrial sector use only 3.5%, representing the lowest portion of the total water withdrawal.



**Figure 2** Available Water Resources in Libya

Source: Salem (2007)

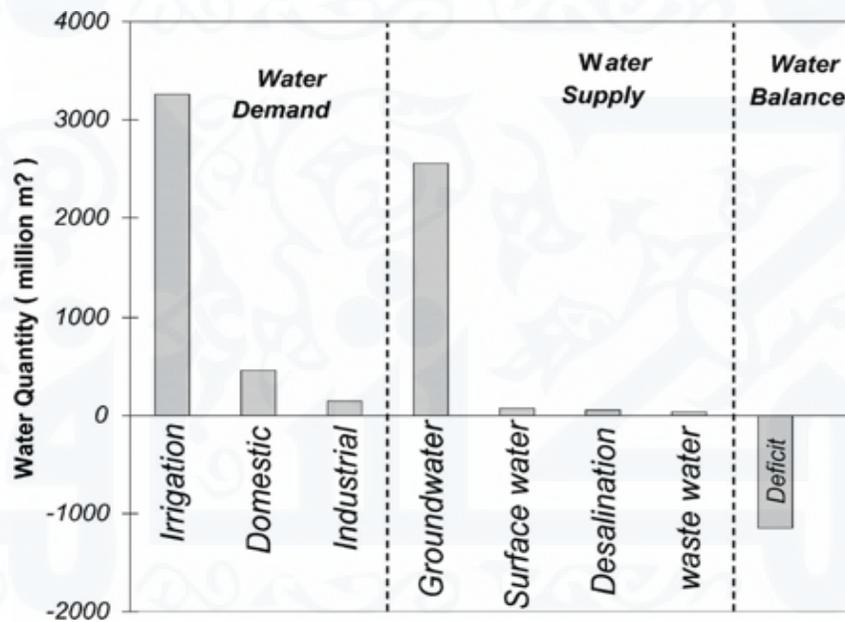
Figure 2 gives an overview of available water compared to current consumption. The quantities show a disproportion between the total withdrawal and the annual available volume of

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local water resources. Clearly there is a deficit, leading to deterioration of both water quantity and quality due to seawater intrusion.

The state of Libya without any doubt is in front of a serious water shortage due to an imbalance between limited water resources and its demands. The country's population has tripled since the 1950s. As a result of the population growth and the improvement of living standard, the country is facing a severe lack of water resources. Water shortages of about 1154 to 4339 Mm<sup>3</sup> have been estimated for the years 1998 and 2025, respectively. There is a vital need to focus on this problem properly to avoid serious impact on the economic development of the country (Wheida, E. 2004)

According to the reports published by the water resources institute (WRI), nine countries around the world are considered in water crisis as these countries are consuming water more than it can be replaced. Libya is the one of this country. In Libya rainfall (56 mm) generates an annual average flow of 98,000 Mm<sup>3</sup>, but only small proportion of this rainfall is transformed into renewable water resources (Calzadilla, A., et al., 2005)



**Figure 3** Situation of water resources in Libya

Source: Wheida (2004)

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The underground water basins whose water is renewable are located at the north of Libya, Jifarah basin ( $200 \text{ mm}^3$ , with an annual withdrawal of  $1200 \text{ mm}^3$ ), Jabal Akhdar basin ( $200 \text{ mm}^3$  with a withdrawal of  $600 \text{ mm}^3$ ), Hamada basin ( $475 \text{ mm}^3$  with a withdrawal of  $150 \text{ mm}^3$ ) and three other basins (Murzuk, Sarir, and Kufra) contain substantial amount of water, but it is non-renewable (Salem, O. 2007), The above statistics clearly shows that water demand in Libya far exceeds the amount of available ground water resources. Agriculture is the biggest water consuming sector but this consumption would decrease because of water scarcity in the region. That is why the Libyan government is looking forward on the Man-Made River Project for at least preserving the areas which are irrigated at the moment with a hope to extend them.

### 5. Water demand

Libya has two choices to carry out its water demands: the Mediterranean Sea and groundwater from the Sahara Desert. Libya, neighboring the Mediterranean Sea in Northern Africa, is mostly desert. Large amounts of water and energy underlie much of that desert sand, that is, the groundwater accumulated from hydrological events that took place many thousands of years ago. Today Libya is making use of this water for the benefits of its people. Along the Mediterranean coast is the densely populated area and to enable the people of Libya to use the water, Libyan government has planned, designed, and implemented the world's largest and groundwater pumping and supply project. It is the Man-made River Project (Geriani, et al. 1998), Construction began in the mid -1980s and still continues.

In Libya, the Man-Made River Project provides about 75% of Libya's annual water demand (agriculture) from 1,000 wells, with some surface water reservoirs for temporary water storage. Man-Made River Project's first aquifer, the Kufra Basin in southeast Libya, has an estimated groundwater storage capacity of nearly  $21,000 \text{ km}^3$  in the Libyan sector alone. Man-Made River Project's first stage supplies Benghazi and fills coastal reservoirs. Tripoli has been supplied since 1997. Ultimately Man-Made River Project is expected to provide  $3,000 \text{ Mm}^3$  annually from its  $30,000 \text{ km}^3$  aquifers. The goal is to supply  $6 \text{ Mm}^3$  per day to coastal populations. Although two-thirds of Man-Made River Project water was originally allocated to irrigation, but due to increasing demand in domestic sector it is consumed in households. Pessimists believe that the Man-Made River Project has one century of function; optimists claim five centuries. (Super-optimists mention 4,000 years.) Man-Made River Project officials say it will last 50 years (Goodland, R. 2008), In fact, the Man-Made River Project aquifers are huge and much in number but are still finite. The aquifers contain fossil water many thousands of years old and are not being recharged.

Water demand for irrigation is estimated at a volume of  $4300 \text{ Mm}^3$  in 2005. This volume would increase to  $6300 \text{ Mm}^3$  by 2025. Industry uses 4% of the Libyan water resources. Today the volume of water used by industries is  $214 \text{ Mm}^3$ , but it is expected that the demand will increase by the rate of 4%, which increases water demand for industry to  $470 \text{ Mm}^3$  in 2025. Excessive extractions in ground water basins disturb salt levels, especially, when the basins are situated on

coast. It is a natural phenomenon which is likely to happen in the majority of the coastal basins of the countries.

## 6. Population and water resources in Libya

### 6.1. Population Growth

The human factor is of great importance in terms of impact on water resources in Libya. Moreover, it can be said that the human factor is fundamental and comes in first place, because of the people who live in this land and invest in and use all of its resources to their benefit (NBID, 2000).

This part of the study discusses population growth and distribution of population and its effect on water resources. Table 1 shows the evolution of population growth in Libya from the first official census in 1954 to the census of 1984. It can be seen that the population growth rate has increased from one census to another. It reached the rate of 3.70% in the period between 1954 to 1964, but that rate is not sufficiently accurate, because of the circumstances and conditions that surrounded the census in 1954; it was conducted during a bad economic situation and also when there was a lack of awareness among population, who were at the time mostly nomads. In addition, lack of mobility and rapid communication led to a large part of them not being covered by the census. However, it can be seen that the rate continued to rise during the period 1964-1973 when it reached 4.30%. Possibly, the rate of population growth increased during this period due to the relative stability experienced by the country after the discovery of major oil reserves in early sixties of the last century. The growth rate of the population in Libya achieved its maximum during the period between 1973-1984 reaching 4.48%. This is because it is during this period that the country began to invest oil revenues in the implementation of several development projects, and the population policy of the State in that period was designed to increase the population; the provision of housing for all citizens, many health facilities such as hospitals and polyclinics, added to the incentives that were given to families to encourage them to increase the number of children. There were also housing and family allowances, as well as free education and healthcare (NBID, 2000).

There is no doubt that the high rate of population growth in that period led to increased demand on water resources. This may led to the idea for a Man-Made River Project to transfer water from the water basins in the south of Libya to the centers of population concentration in the north of Libya which appears to have emerged in that period, and hence it can be deduced that there may be a high correlation between the population growth in that period and the emergence of the idea concerning the Man-Made River Project.

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During the period 1984-1995, the rate of population growth in Libya decreased (2.80%), but this rate reached its lowest level in the last census of the population in Libya in 2006, which covered the period from 1995 to 2006. The rate fell to 1.80% due to certain economic factors such as rising living standards and the difficulty of providing basic necessities of life, the most important of which is housing. Other factors include the high levels of education and cultural diversity of the population, and the entry of women in different areas of work which plays a role in the low birth rate, in addition to the tendency of some families to use birth control (GIA, Census 2006)

**Table 1** Population Growth for Libyan & Non-Libyan Population 1954–2006

Census	Libyan population	Non-Libyan population	Total population	%
1954	1,041,599	47,274	1,888,730	??
1964	1,515,501	48,868	1,564,369	3.70
1973	2,052,372	196,865	2,249,237	4.30
1984	3,231,059	411,517	3,642,576	4.48
1995	4,389,739	409,326	4,799,065	2.80
2006	5,298,152	359,540	5,657,692	1.80

Source: GIA Census 2006, p 40.

The country's population has tripled since the 1950s. As a result of the population growth and the improvement of living standard, the country is facing a severe lack of water resources. Water shortages of about 1154 to 4339 Mm<sup>3</sup> have been estimated for the years 1998 and 2025, respectively.

Wheida (2004) illustrates that the water deficit was amounting to about 1154 million cubic meters in 1998 and estimates that the deficit will undoubtedly increase in the future in response to continuous population growth and corresponding increase in water requirements for the domestic, agriculture and industrial sectors. Depending on population growth, industrial and agriculture, water demand between (8200) and (8840) million cubic meters have been forecasted

for the year 2025 with deficits of about 4339 million cubic meters assuming the present water use practices.

## 6.2. Distribution of Population and Water Resources in Libya

The distribution of population in Libya is characterized by the fact that is not equal over the country; the distribution of the population appears dispersed and chaotic, suggesting poor concentration and low population destiny. There are two distinct realms of population distribution, the first in the densely populated part in the north and the second is the low density part or the empty part in the south..

### 6.2.1 Densely populated part

The densely population density part in the far north of the country covering a coastal strip that along the Mediterranean Sea. This part contains most of Libya's population; more than 80% of the total population is concentrated here in spite of the area good for human habitation being limited, which represented not more than 10% of the country. the population of this part is around 4,083,822 according to the 2006 census and is distributed in several cities and villages, especially around major cities such as Tripoli, Benghazi, Misurata, al-Zawiah, and Darnah. The largest population in Libya is in the city of Tripoli; more than a million people are concentrated in this city, equivalent to about a quarter of Libya's population. The city of Benghazi is ranked second, where currently more than 674 951 people are located, which represents 13.8% of the total population. In addition to Tripoli and Benghazi, there are some other cities where the population is concentrated, such as Misurata which has 10.1% of the total population and the city of al-Zawiah where currently 7.95 of the total population of Libya is located (GIA, Census 2006), Chia-Lin Ban (1949) stated that over 90% of the Libyan population were living in the coastal region

It should be noted that the phenomenon of concentration of the population in the cities of Tripoli and Benghazi is not new, as is shown in the results of the population census in 1954, which was the first census in Libya. At that time, the proportion of population concentration in these two cities amounted to 34% of the total population (Alawar, A. 2002).

The concentration of population in the northern part of Libya has to lead to an increased amount of water being consumed in the cities. Perhaps the best example to illustrate the effect of concentration of population in the northern part of Libya on water resource is what has happened in the plain of Benghazi, where the population concentration in this region and increased demand for water in different uses has led to a low level of water in the aquifer. It was observed that there has been a lower level of underground water in the plain of Benghazi by a distance of more than a meter and a half rate of decline of water supply in the reservoir after 1977 is nearly five times the rate of compensation (El-Deeb, M. 1997).

### 6.2.2 Low density part

This range encompasses the greater part of Libya, as it represents about 90% of the total area. Although the area is vast, the population is limited; not exceeding about 20% of the total population, and the population density is low in this part reaching .084 inhabitants per 1 km<sup>2</sup>. The decrease in the proportion of people in this part is due to the ruling desert conditions. The Great African Desert covers most parts of this range, and it is one of the hottest deserts in the world, so being marked by harsh climatic conditions, it is not conducive to human settlement. The temperature rises during the day, rain is almost non-existent, and the soil in this part of the desert is poor, inadequate for agriculture. All these conditions have made this region's environment unsuitable for the population which has migrated and increased the concentration of population in the north of the country. Thus the rest of the country's total area is left virtually uninhabited except for some populations in small scattered areas of oases, where these populations live on ground water from these oases. Because of the low population in the south of Libya, these areas have not been exposed to the problems of pressure on water resources as has happened in the north (Hamdan, J. 1993).

## 7. Discussion

The above overview discovered that the population growth rate is the most important factor affecting water resources; the more the population growth rate the greater the demand for water. Libya's population growth rates are among the highest in the world. In recent years however, a gradual decrease in the growth rates from over 4% to less than 3% was noticed. Accordingly, projection of future population based on past and present trends in growth rates could be generated as shown in Table 2

**Table 2** Population Growth

Year	1995	2000	2005	2010	2015	2020	2025
Population (10 <sup>6</sup> )	4.8	5.7	6.7	7.8	9.0	10.3	11.7

Source: Miludi 1995

Table 3 shows the available water resources which amounts to 3,820 Mm<sup>3</sup>/yr of which 170 Mm<sup>3</sup> is in the form of surface water, 650 Mm<sup>3</sup> is the annual recharge to groundwater and 3000 Mm<sup>3</sup> is the acceptable reduction rate of the non-renewable aquifers. The latter is independently determined for each basin on the basis of its hydro geological characteristics

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**Table 3** Available Water Resources

Source	Potentially available water(Mm <sup>3</sup> /yr)
-Surface water	170
-Renewable groundwater	650
-Non-renewable groundwater	
Gefara Plain	25
Jabal Akhdar	25
Kufra & Sarir	1300
Hamada	150
Murzuk	1500
<b>TOTAL</b>	<b>3820</b>

Source: Miludi 1995

**Table 4** The Overall Water Balance Projected for the Year 2025

Year	1995	2000	2005	2010	2015	2020	2025
Supply (Mm <sup>3</sup> )	3820	3820	3820	3820	3820	3820	3820
Demand(Mm <sup>3</sup> )	3885	4493	5128	5794	6495	7236	8022
Balance (Mm <sup>3</sup> )	-65	-673	-1308	-1974	-2675	-3416	-4202

Source: Miludi 1995

When calculated for each of the five regional water basins, the deficit in the water is more pronounced in the highly populated northern plains, namely Gefara, and Jabal Akhdar for the year 1995.

Elhassadi (2007) estimated that if available resources remain constant at 2005 level the deficit will increase from around 76% of the total demand to about 86% by the year 2025.

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With respect to the distribution of population in Libya, there are two ranges of main population; the first one is located in northern Libya, which is characterized by the overcrowding population, the same time bringing about a negative impact on water resources in northern Libya. The concentration of population in those areas has led to increased demand for water, which in turn has led to the low level of water in some areas and vulnerability to pollution in other regions. The second is in the central and southern parts of Libya, the uninhabited range, where there is a lack of population, and therefore these areas do not suffer from problems of water shortage or contamination. Therefore based on this study it is found that the population distribution in Libya tends to have a negative impact on water resources.

### 8. Conclusion

This article almost clearly explains the deficiency of water that Libya is and will be facing in future. The data collected leave no doubt in understanding the overall dearth in water resource and water supply in Libya. The population growth and population distribution of Libya further explains the current insufficiency of water supply and demand.

Most of the available water is consumed in agriculture; very less is available for industry and domestic use. Moreover, availability of water in Libya is mostly not subject to water reuse because most of the water sinks to river basins and flows to other countries. Existing condition of water do not provide sustainable alternative to surface water development, thus create enormous pressures on ground water resources. Groundwater represents the main source of water supply in Libya. population growth rate is the most important factor affecting water resources. In respect to population distribution, the concentration of population in the north has led to increased demand for water, which in turn has led to the low level of water in some areas and vulnerability to pollution in other regions, while because of lack of population in the south part; these areas do not suffer from problems of water shortage or contamination

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