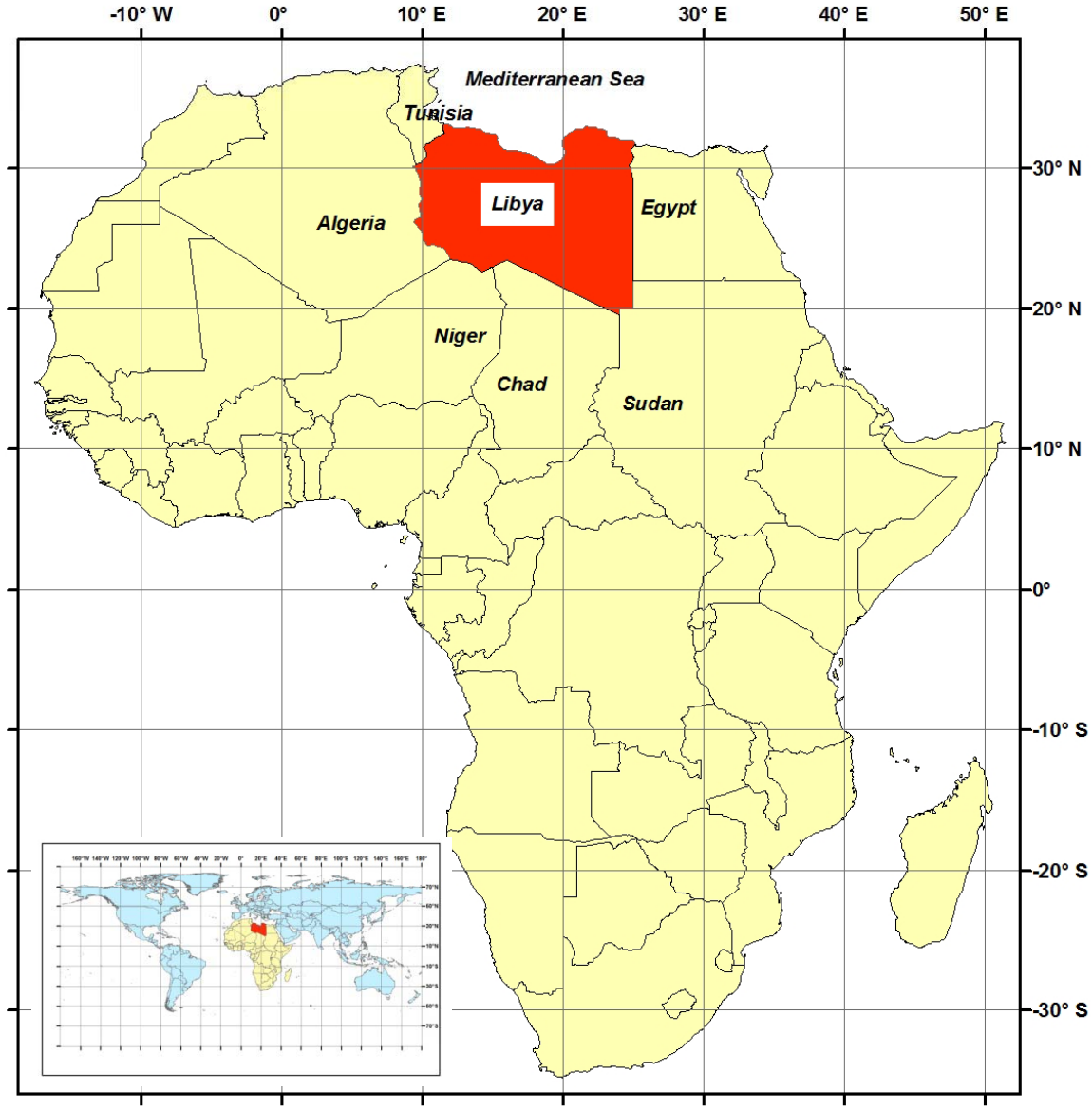
Libya is located in the north of Africa between longitude 9^{o} - 25^{o} east and latitude 18^{o} - 33^{o} north. It extends from the Mediterranean coast in the north to the Sahara desert in the south, with a total surface area of approximately 1.750 million km^2. It is bounded on the east by Egypt, on the west by Tunisia and Algeria and on the south by Chad, Niger and Sudan.

According to 2006 census, the total population of Libya amounted to about 5.658 millions (5.298 Libyans and 0.360 non-Libyans)

The population density varies widely from one area to another. About 70% of Libyan population lives in the coastal cities, where more than 45% live in Tripoli, Benghazi, Misrātah and AzZawayah, with a population density of about 45 person per km^2. This density does not exceed 0.3 person per km^2 in the interior regions.



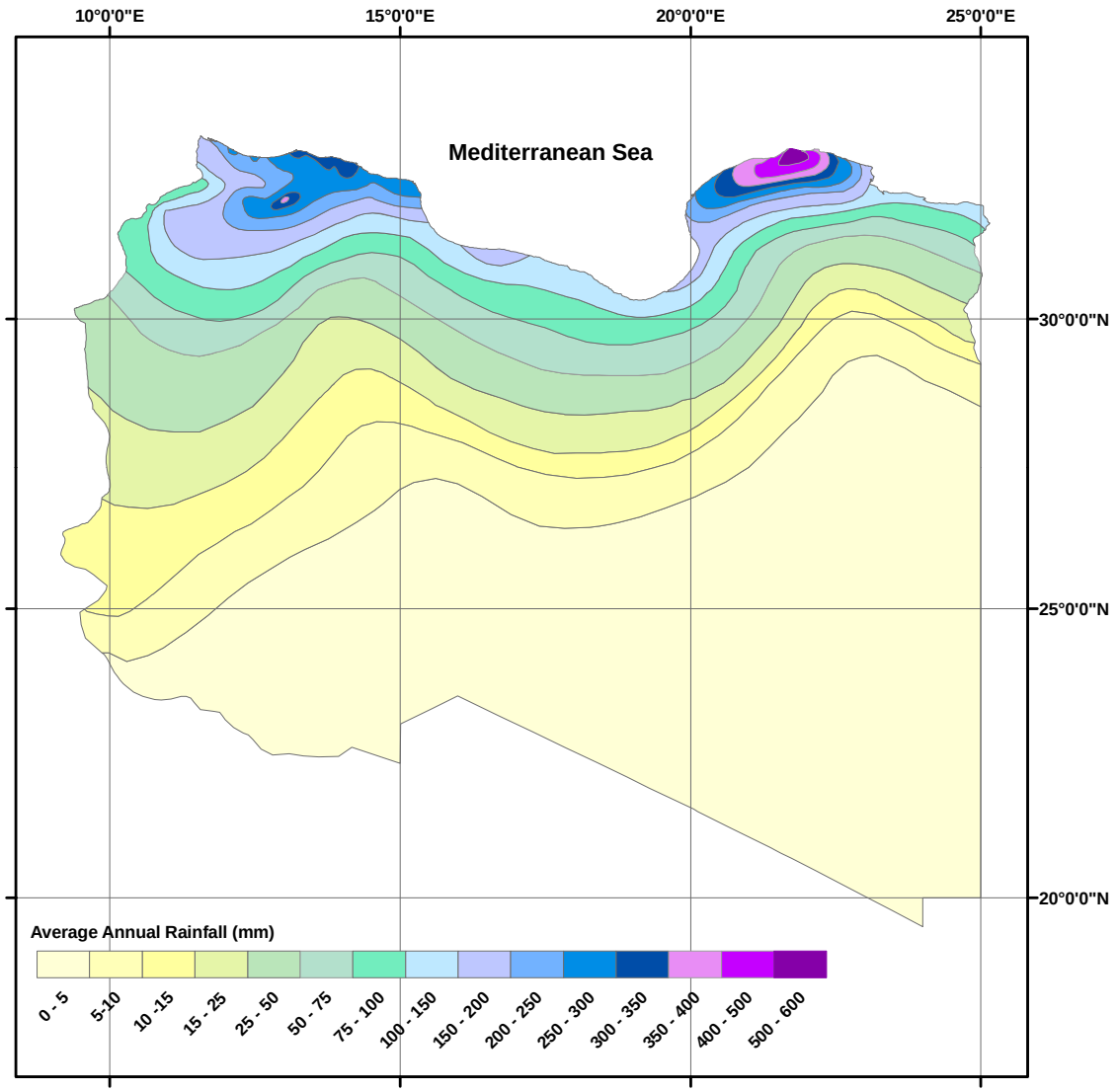
Location map

Rainfall in Libya is characterized by its inconsistency as a result of the contrary effects of the Sahara from one side and the Mediterranean from the other. Intensive thunderstorms of short duration are fairly common.

About 96% of Libyan land surface receives annual rainfall of less than 100 mm. The heaviest rainfall occurs in the northeastern region (Jabal al Akhdar) from 300 to 600mm and in the northwestern region (Jabal Nafūsah and Jifārah plain) from 250 to 370mm.

There is no perennial surface runoff in Libya, a part of the precipitation falling on the Jabal Nafūsah and Jabal al Akhdar cause a surface runoff trough many seasonal wadis. Wadis in a desert environment generally are dry during the whole year except after sudden heavy rainfall which often resulting a flash flood.

Several ephemeral wadis with limited catchment areas originated in the northern flanks of Jabal Nafūsah and of Jabal Akhdar.



Average annual rainfall 1956 - 2000

Water Resources

1- surface water resources

The surface water resources are very limited and contribute only a small amount (Less than 5%) to the total water consumption.

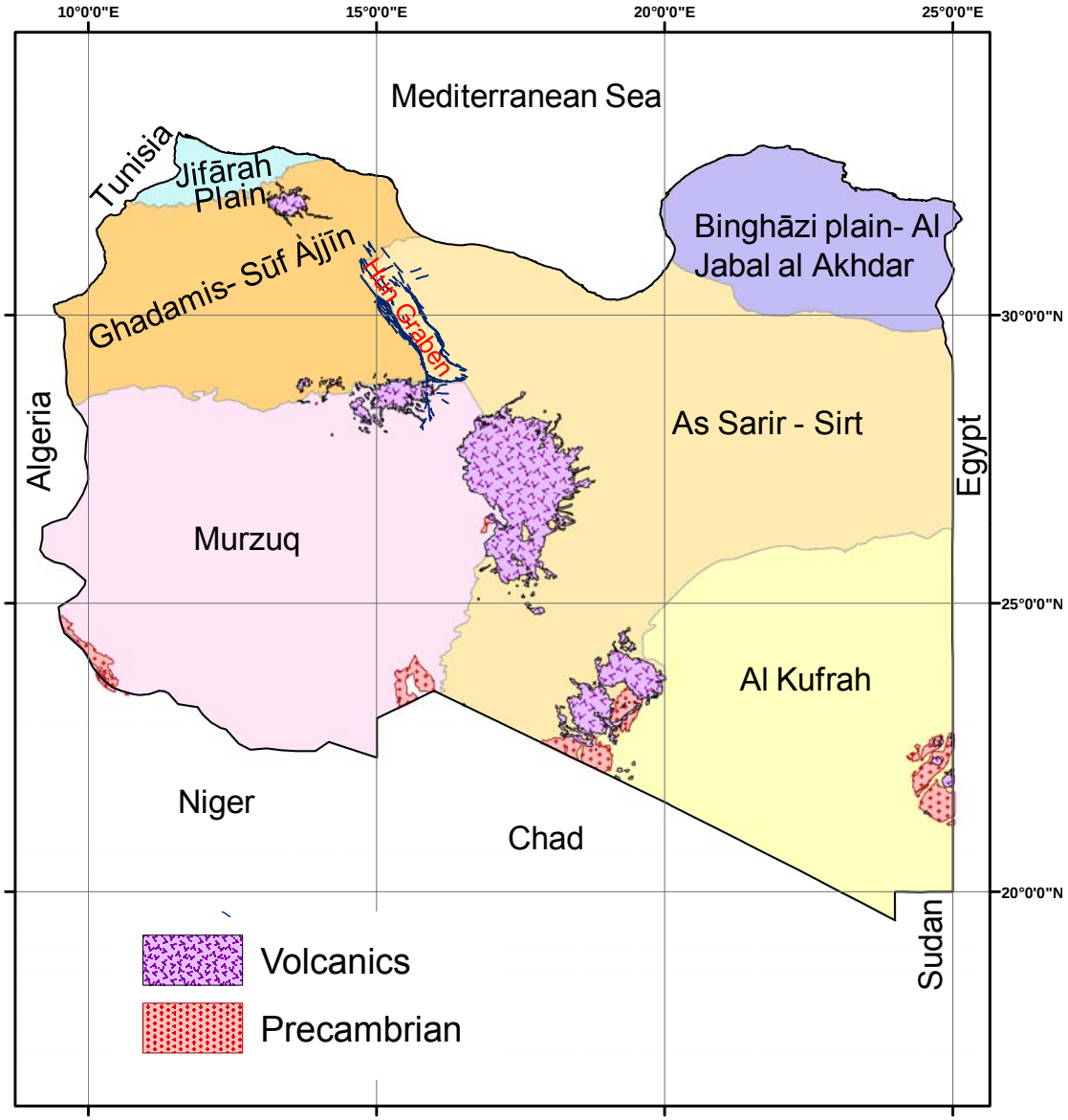
18 dams have been already constructed on the main wadis to control periodic floods, divert the retained water to irrigation projects and recharge locally the groundwater aquifers.

The total storage capacity of these dams is about 389 Mm^3 with an average annual volume of water retained behind these dams is about 61 Mm^3.

2- Groundwater

Groundwater forms the only available source of potable, industrial and irrigation water supply covering more than 80% of the total water demand.

The groundwater occurs within 6 main groundwater basins. These basins are consisting of several groundwater aquifers which vary in their depth, thickness, geologic age, hydraulic and hydro-chemistry properties.



Groundwater basins in Libya

Characteristics of the groundwater basins in Libya

Groundwater Basin	Jifārah Plain	Jabal al Akhdar	Ghadamis- Sūf Ajjīn	Murzuk	Al Kufra & AsSarir
Area (k^2m)	20000	145000	215000	350000	760000
Water Bearing Formations	Quaternary & Miocene deposits and Triassic deposits (Azizyah dolomitic limestone & Abu Shaybah sandstone)	Miocene, Oligocene and Eocene deposits (Karstic phenomena)	Upper Cretaceous carbonate rocks and Kiklah sandstone	Lower Cretaceous, Triassic and Palaeozoic sandstone	Post Eocene in Sarir and Nubian sandstone and Palaeozoic sandstone in Kufra
Water Quality (mg/l)	500 - 4500	1000 - 5000	Less than 1000 to more than 5000	Less than 500 to more than 1500	200 -2000
Present and probable Pollution Sources	Sea water intrusion, Fertilizers and waste disposal	Sea water intrusion, and waste disposal	No pollution	Humans and Fertilizers	Humans and Fertilizers
Effect of Exploitation	Sharp water level decline and Sea water intrusion	Continuous water level decline and Sea water intrusion	Water level decline	Local drop in water level and local contaminations	Local drop in water level and local contaminations

3- Non-conventional Water Resources

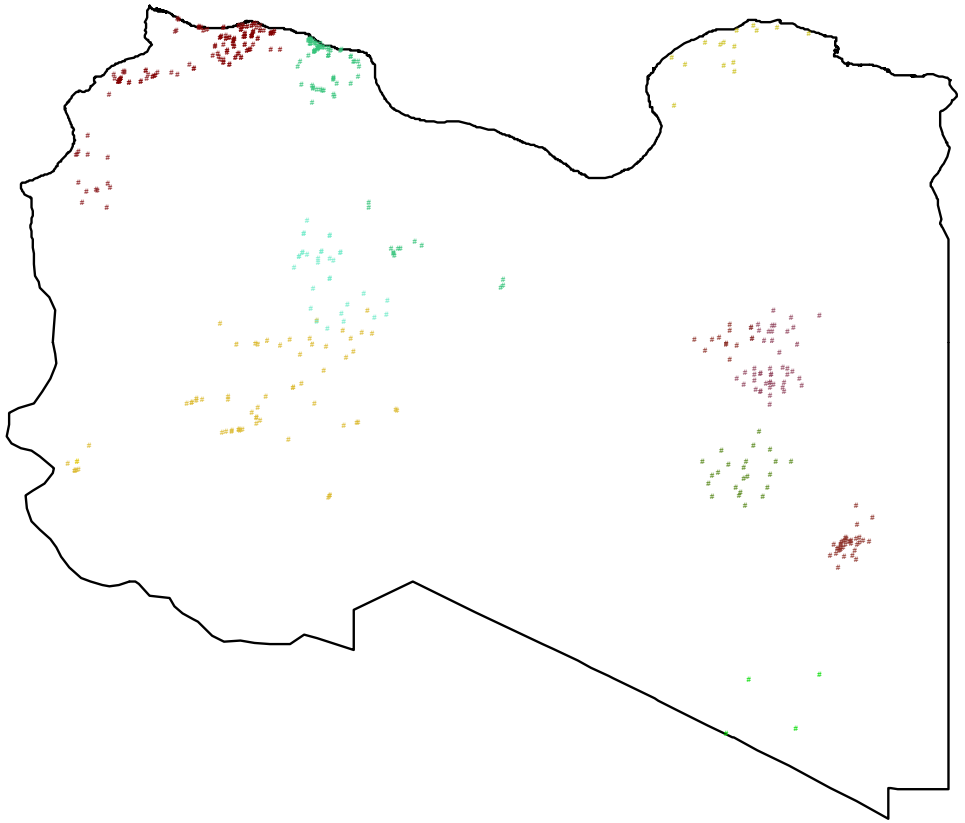
Due to the limited available conventional water resources to meet the increasing water demand in Libya as result of population growth, development activities and life standard, in addition to the pollution problems, the development of non-conventional water resources such as wastewater treatment and desalination of sea water are imperative as they represent additional water resources

The total amount of water which supposed to be treated by existing plants is 655950 m^3/day. The designed capacity of the operating plants is about 160000 m^3/day. The designed capacity after repairing the plants which need maintenance is about 451350 m^3/day. The actual amount of treated water produced by the operating plants is about 64000 m^3/day. The ratio of the actual amount of treated water to the total designed capacity of existing plants represents 10 %.

A report prepared by the General Company of Desalination shows that 8 desalination plants were operating in 2009. These plants produce about 52.6 Mm^3/year, where only 51.2 Mm^3/year of desalinated water supplied to be used by municipalities for domestic purposes. The production of operating plants represents 53% of their total design capacity.

Groundwater Monitoring

A systematic monitoring of groundwater levels in selected wells has started in the early seventies. A well-established network of piezometers was initiated immediately after the creation of the General Water Authority in 1972. Water level measurements are collected four times a year and piezometric maps along with individual well hydrographs are prepared.



Effects of the groundwater over-exploitation

Most of the population and its diverse economic activities are concentrated in the northern parts of the country. A rapid increase in groundwater consumption to meet the growing water demand caused the deficit in the water balance of the northern groundwater aquifers particularly in the Jifārah plain and the Binghāzi plain- Al Jabal al Akhdar aquifer systems.

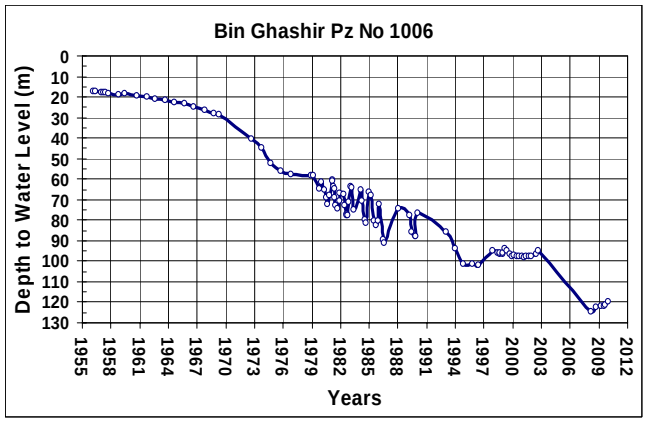
The effects of the groundwater over-exploitation are reflected by continuous water level decline accompanied by deterioration in water quality and seawater intrusion along the coast.

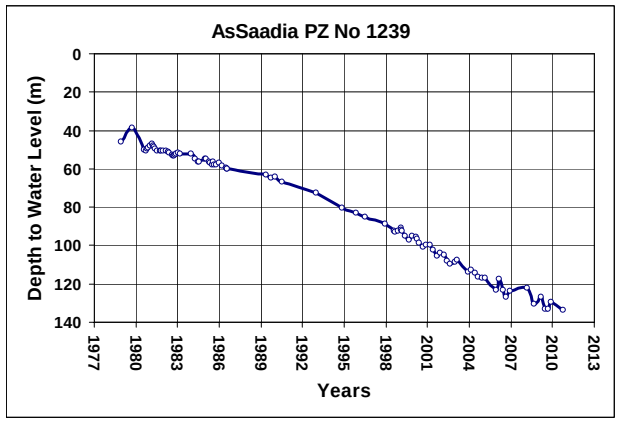
1 – Water Level Decline

Jifārah plain located in the northwestern part of Libya is representing the most affected area resulting from groundwater over-exploitation. Its population has increased significantly, mostly along the coast and contains the largest Libyan city, Tripoli. Although, it forms approximately 1% of Libya's total land surface, it has a great economic and social importance. Approximately 40% of Libyan population lives in the area and more than 50% of the agricultural production comes from this region.

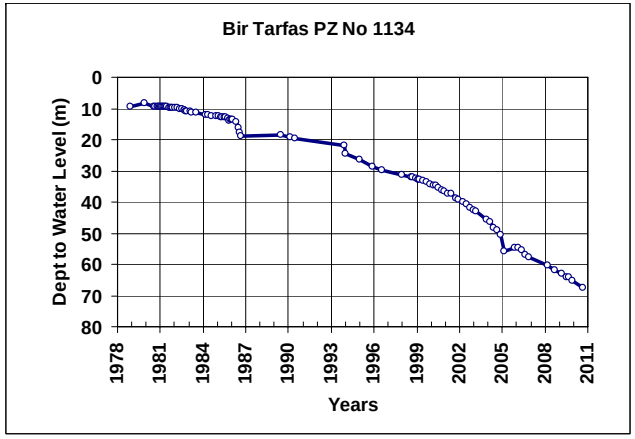
In the Jeffara plain, the hydrographs of piezometers located in the intensive groundwater extraction areas show continuous sharp water level declines.

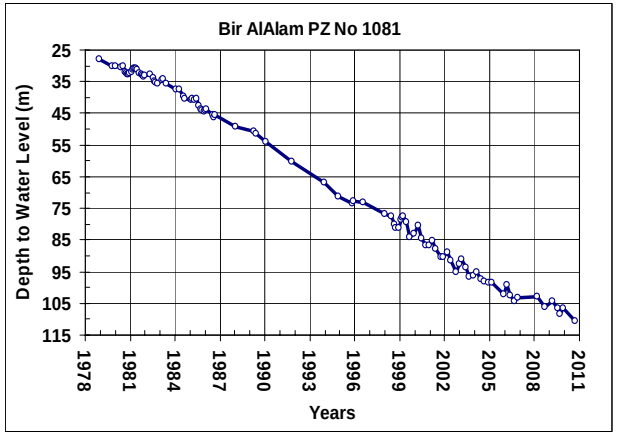
There are many other areas in Jabal al Akhdar, Ghadamis- Sūf Ajjīn and Murzuk basins suffering from intensive development of the groundwater aquifers which produce a continuous drop in water levels.





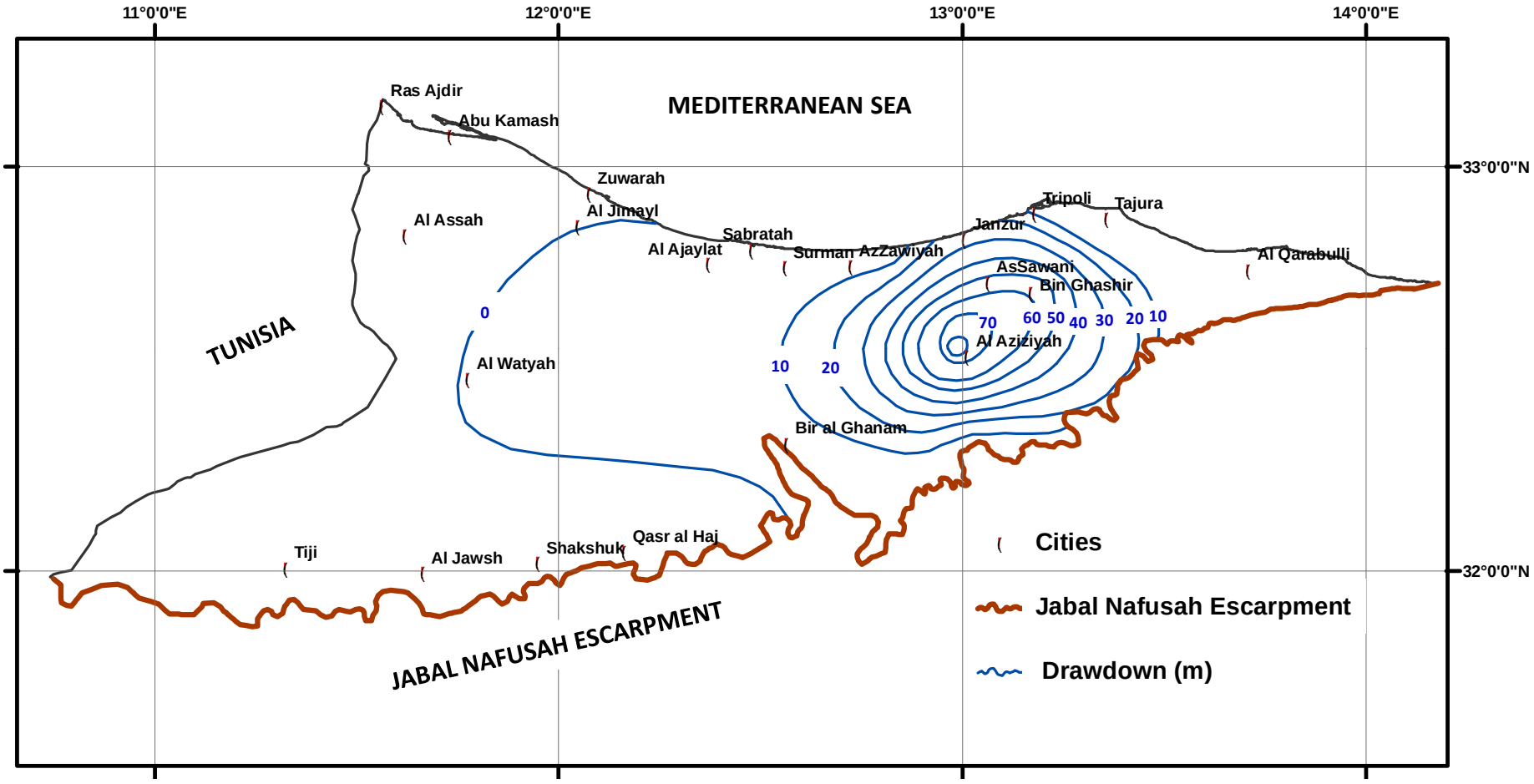
(a)- Shallow aquifer





(b) – Deep aquifers

Hydrographs of some selected piezometers in Jifārah plain



Water level decline map for upper aquifers in Jifārah plain

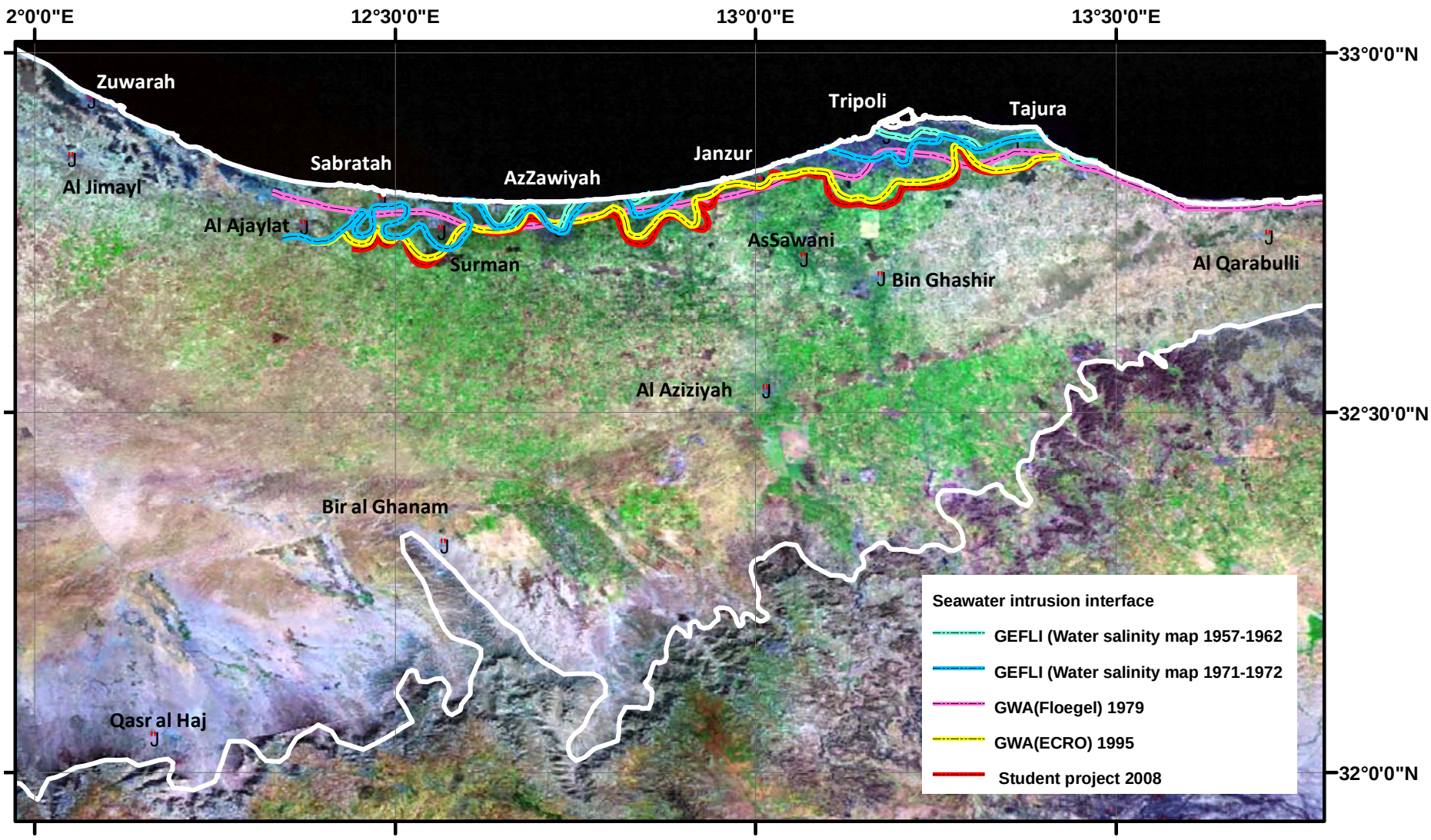
Water Quality Deterioration

Over-pumping of groundwater aquifers along the coastal belt caused seawater front moving inland along a strip of 2 to 10 km, this inflow induced a strong deterioration of water quality.

The intensive groundwater extraction of shallow aquifers in Jifārah plain NW Libya causes a rapid increase in the salinity of groundwater up to more than 3000mg/l during the last twenty years.

The most rapid advance has taken place in the vicinity of Tripoli. This is due to the cone of depression is most developed in the areas just to south of Tripoli and extends westwards towards Az Zawya, resulting in a reversed hydraulic gradient with water flowing in from the sea rather than fresh water discharging into the sea (see water level decline map).Groundwater salinity of more than 10000 mg/l has been observed in Tripoli.

In order to illustrate the advance of seawater front, a contour line of 1.5g/l in the salinity maps prepared in 1957/62, 1971/72, 1979, 1995 and 2008 were collected in one map.



Seawater intrusion front (1957-2008)

Water quality deterioration also observed in areas influenced by Sebkha water which has similar chemical composition to seawater. Salinity of shallow groundwater aquifers in the western part of Jeffara plain exceeds 2000 mg/l due to deterioration laterally or vertically from Sebkha water.

In Murzuk basin, some agricultural project which implemented close to sebkha and saline groundwater shallow aquifer, the drop in water level created from the groundwater extraction of the upper and lower aquifer systems affected the natural equilibrium in the area. The gradient and consequently groundwater flow direction were inverted locally and caused the contamination of originally fresh water bearing formation from the adjacent saline water.

Over-exploitation impacts

As a consequence of the groundwater abstraction growth, a number of environmental and economical problems have occurred and can be summarized as following:-

1- Water level decline caused by groundwater withdrawal:
- Increases the Water production costs which include the expenses of power, lowering the pump, deepening the well or drilling a deeper replacement well especially in the Jifārah plain area.
- Can cause destruction of the environment, desertification and may cause land subsidence (eg. AsSarir area).
- Loss of wildlife habitat and reduction in biodiversity.

2- Lowering the water table of the upper Nubian sandstone aquifer affected the palm trees and vegetation cover in Murzuq area.

3- As a result of groundwater quality deterioration along the coastal areas due to seawater intrusion:

- Municipal water supply is affected by the abandonment of production saline wells.
- Most of the citrus crops are affected by saline water.
- Soil gradually mineralized due to irrigation with saline water and may cause changes in soil structure, permeability and aeration.
- Corrosion problems cause damage to the metallic materials used in water distribution and consumer systems such as pipes, taps, water heaters, washing machines … etc.

These problems reduce the economic life of the materials and increase compromise maintenance expenses; in addition, they pose possible health hazards and change water taste making it undesirable for consumption.

4- Yield reduction or depletion of some springs (eg. Ayn ash Sharshara in Tarhuna and Ayn ArRomia in Yafren).

MEASURES TO REMEDY WATER SHORTAGES

Serious measures have been implemented in order to minimize the effects of the groundwater over-exploitation and to secure additional water resources in order to cover the current and future water needs. These measures have also taken into consideration the conservation and protection of the available water resources. Remedial measures include:

1- Achievement of the maximum use of available surface water resources by the construction of dams and ground reservoirs in order to collect and preserve rainfall and surface runoff. The maximum volume of surface water that can be retained behind these dams reached to about 61Mm^3/year. Additional dams are planned to be constructed with an average annual volume of water, 120Mm^3 to be retained.

2- Implementation of the Man-made River Project ,which aims through its phases to convey about 6.1Mm^3 of water daily from the groundwater aquifers located in the southern areas to northern coastal areas where the population centers and major economics activities are located .

3- Areas suffering from over-exploitation and deterioration of groundwater have been put under restrictive water use or complete ban of groundwater extraction. No new wells are allowed to be drilled except for the replacing or rehabilitation of existing ones in the cultivated areas.

4- Water Legislations

The legislation concerning the water sector contains a number of laws. These laws are well developed. The most important laws are:

- Law no. 3 (1982) in regard to the regulation of water resources utilization

The law sets out the general principles to regulate the utilization of water resources and defines controls preservation and protection operations

- Law no. 7 (1982) for environmental safety and protection

Chapter 4 deals with the protection of water resources. This chapter contains eleven articles starts from article 40. These articles defined the uses of water, its provision, distribution, purification, protection, treatment, quality control, safety, and how to dispose solid, liquid and gaseous wastes that may cause pollution to the water resources in a direct or indirect manner.

- Law no. 106 (1973) regarding health

The law explained in details all the aspects of environment and environmental protection. The preamble dealt with problems of water and its protection from pollution, demonstration of the pertinent risks, the necessary procedure and measures to manage water pollution. It is showing types of water resources, methods of treatment and how to take samples and relevant standards.

5- National Strategy for the Water Resources Management in Libya

The national strategy for water in Libya has been prepared including the assessment of the available water sources used for various purposes for the year 1998 and estimating the future water needs until the year 2025. The available water resources are scarce and large efforts need to be made during this planning period.

Objective of the strategy

The main objective of the strategy is to develop an integrated national plan aims to:

- *Minimize the water deficit which increased with time.*
- *Limit the deterioration of water quality and protect and preserve the water by reorganization of the water consumption patterns taking in consideration the constrains imposed by the nature.*
- *To achieve sustainable development of these resources to improve standards of living, maintain the economical and social activities and to ensure the water rights for the coming generations.*
- *Sound management of available water resources to ensure sustainable development.*
- *Optimum use of available water resources to ensure that agricultural production can achieve greater economic return.*
- *Provision of clean drinking water and sanitation for all people.*
- *Facing the possible impacts of climate change on water resources and agricultural production.*
- *Implementation of the principles of integrated management of available water resources as a method in water policy.*
- *Building capacity by training and educating the technical staff using the latest techniques in water resources assessment, development and management.*
- *Raising public awareness in the field of optimum utilization and protection of the available water resources.*