



المؤسسة الوطنية للموارد المائية دولة  
ليبيا

# Evaluation of the Nubian Sandstone Aquifer System (NSAS) in Al Kufra Oasis, Southeast Libya

**Salah Hamad**

**Lecturer**

Faculty of Natural resources and Environmental science  
Omar Al Mukhtar University, Al Baydah, Libya

**Consultant**

**National Water Resources Establishment**

Msc GIS Science & Systems  
IWRM postgraduate diploma

# Overview

- Introduction
- Geology of Al Kufra
- Groundwater Resources of Al Kufra
  - The Aquifers
  - Current situation of the water use
  - Water levels
  - Water Quality
  - Water managements
- Conclusions

# Introduction

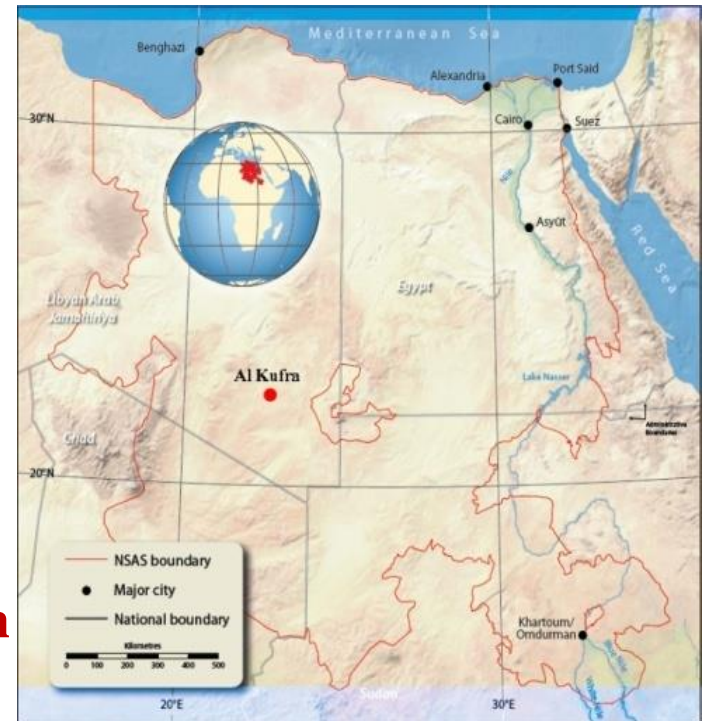
- The majority of the Libyan land is categorized as arid to hyper-arid.
- About **90%** of the land is desert characterized by low rainfall rates, diurnal temperature variations, poor soils, and seasonal winds.
- Groundwater accounts for **97%** of total water abstracted for different uses.
- The available figures indicate that the country total water abstraction is about **6.5 billion cubic meters per year** (GWA, 2006) and (NWRE,2017).
- The dependence on the Nubian Sandstone Aquifer System (NSAS) mostly occurs in the **middle and eastern parts** of the country, while other regions of the country depend on the other groundwater basins.

## Cont., Introduction

- The country's **political conflict and uprising** have led to a disruption of the water management system and to a difficulty in monitoring and managing water resources.
- This research will discuss the current situation of the NSAS aquifer in Al Kufra Oasis.

## Cont., Introduction

- The NSAS (Figure 1) is the world's largest known fossil water aquifer system.
- It is located in the eastern end of the Sahara Desert and spans the political boundaries of four countries in north-eastern Africa.
- The **NSAS** covers a land area spanning over **2.2 million Sq. Km**
- **North-western Sudan 376.000 Sq. Km**
- **North-Chad** with an extension of 235.000 **Sq. Km**
- **Libya** with an extension of 760.000 **Sq. Km**
- **Egypt** with approximately 80% and extension of 826.000 **Sq. Km**



# Geology of Al Kufra

<b>Age</b>	<b>Formations &amp; approximate max. thickness (m)</b>	<b>Lithology &amp; depositional environment</b>
<b>Recent/Pleistocene</b>	100 m	Sandstone and Sabkhat deposits
<b>Lower Cretaceous</b>	Nubian Sandstone (900 m)	x-bedded sandstone, shale and conglomerates
<b>Carboniferous</b>	800 m	Continental sandstones
<b>Devonian</b>	Tadrart Sandstones (100 m)	Massive, continental x-bedded sandstones with fossil plant marginal marine deposits
<b>Silurian</b>	Tanezzuft Shales Acacus Sandstones (90 m)	Sandstones, marine with fossils. dark shale and silty with fossils
<b>Ordovician</b>	Gargaf Group (700 m)	x-bedded sandstones with some silty shale (continental/marginal marine deposits)
<b>Pre-Cambrian</b>	Basement	Folded metamorphic and granitic igneous rocks

# Groundwater Resources of Al Kufra

## The Aquifers

- **First aquifer the Paleozoic**

It is composed of thick layers sandstone of the Cambro-Ordovician, Silurian, and Devonian ages, that intercalated with layers of clay due to its presence at deep depths.

- **Second aquifer the NSAS**

Consisting of layers of loose sand, silt, and mud, with fewer sandstones and some other sedimentary rocks and divided into:

- **Shallow Aquifer**

The water level of this aquifer extends from depths of **10-150** meters, and the total dissolved solids (TDS) ranges from **300-8000** ppm *due to the existence of an old sabkah.*

- **Deep Aquifer**

Starts from a depth of 400 to 800 meters, the TDS of this aquifer ranges from **300-4500** ppm *due to the existence of an old sabkah.*

## Cont., Groundwater Resources of Al Kufra

### Current situation of the water use

- The total abstraction from NSAS in Libya estimated at about **1020.7 Mm<sup>3</sup>** per year for all water uses (NWRE,2017).
- The increase in freshwater demands for domestic, agriculture and industrial purposes corresponds to the increase in population.
- Currently, about **96,4100 inhabitants** living in **74 human settlement** are dependent on the NSAS for domestic use and for agricultural production.
- The agriculture abstraction is estimated at about **504 Mm<sup>3</sup>** per year, utilized in about **7011 farms** with different crops
- for industrial use, the oil industry represents the main consumer which use water for oil production. Where amount of water abstracted for industrial purposes is estimated from the available data at about **130 Mm<sup>3</sup>** per year.



# Cont., Groundwater Resources of Al Kufra

## Current situation of the water use

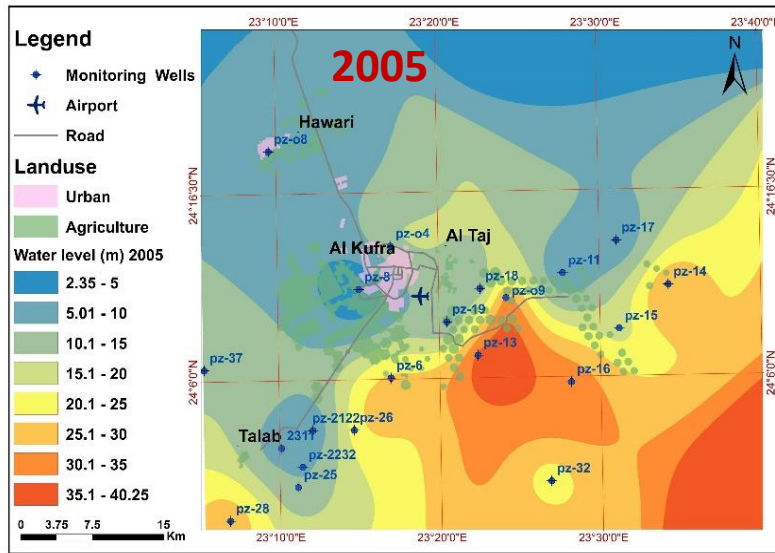
- The water use for agricultural purposes in Al Kufra Oasis is the largest compared to other uses
- The unaccounted for water in the water supply network is considered high, where remarkable frequent explosions noted in the main and secondary pipelines, due to the weakness of the current network.
- In addition, most of the main and secondary pipelines are being violated when passing through private farms by illegal connections, as well as by several new residential neighborhoods which are built randomly out of the main urban plan and do not have public facilities.

Use	Project name	Abstraction Mm <sup>3</sup> / year	Aquifer	Depth (meter)
Agriculture	Al kufra production project	١٧٦	Deep	٣٠٠-٢٥٠
	Al Kufra settlement project	٣٢	Deep	٤٥٠
	Palm Project	٣٣	Shallow	١٢٠-٥٠
Domestic and Industrial	Private farms	٧٥	Shallow	١٥٠-٥٠
	Domestic and water bottling industry	٢٦	Deep	٤٥٠-٢٥٠
Total		٣٤٢		

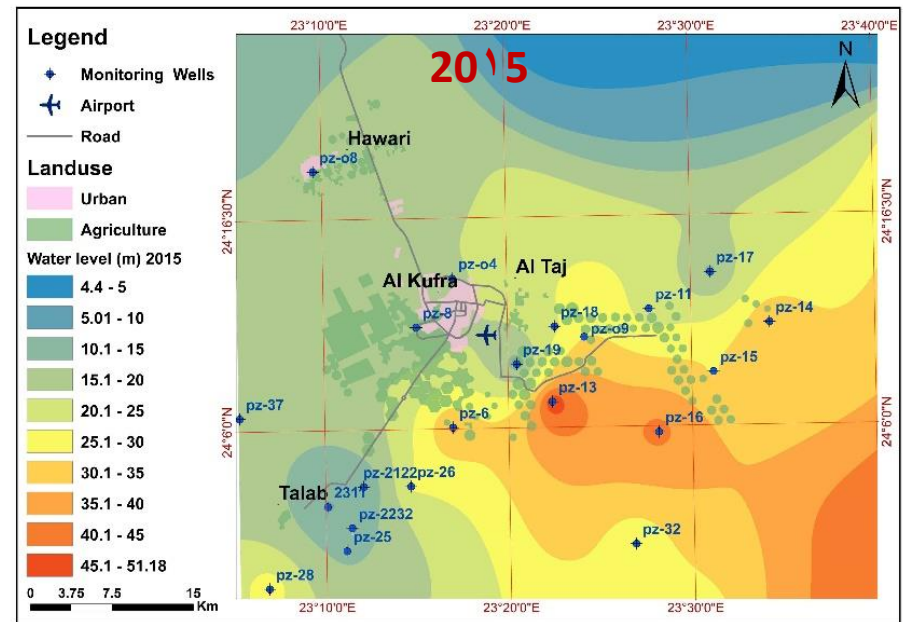
# Cont., Groundwater Resources of Al Kufra

## Groundwater levels

- the average depth to water level was **23.07** meters
- the lowest water level was **4.4** meters at the southwestern part of the oasis
- Urban area and the agriculture projects areas water level depth reach to **51.18** meters.



- Average depth to water level was about **17.55** meters,
- The lowest was **2.35** meters at the southwestern part of the oasis,
- Urban and agriculture projects areas the depth to water level reach to **40.25** meters

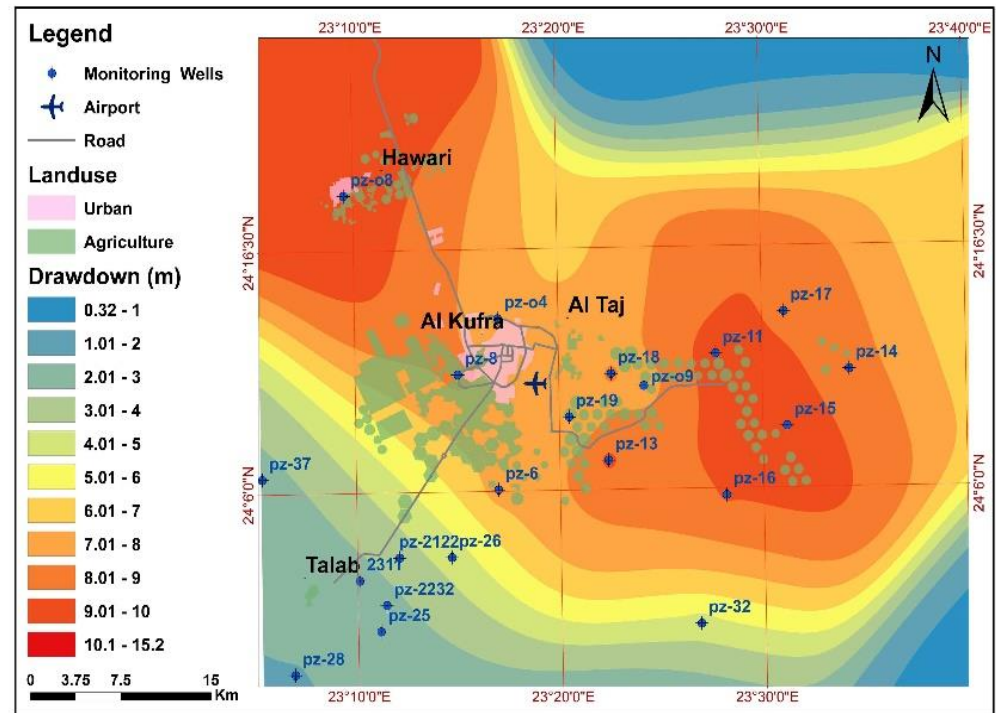


# Cont., Groundwater Resources of Al Kufra

## Groundwater levels

### Drawdown in groundwater level

- The drawdown in groundwater levels in Al Kufra area in 10 years
- Average drop of the water level about **5.54** meters
- Significant decline in the water level at the urban area and Al Kufra agricultural production project
- The highest value of drawdown, estimated at **15.2** meters

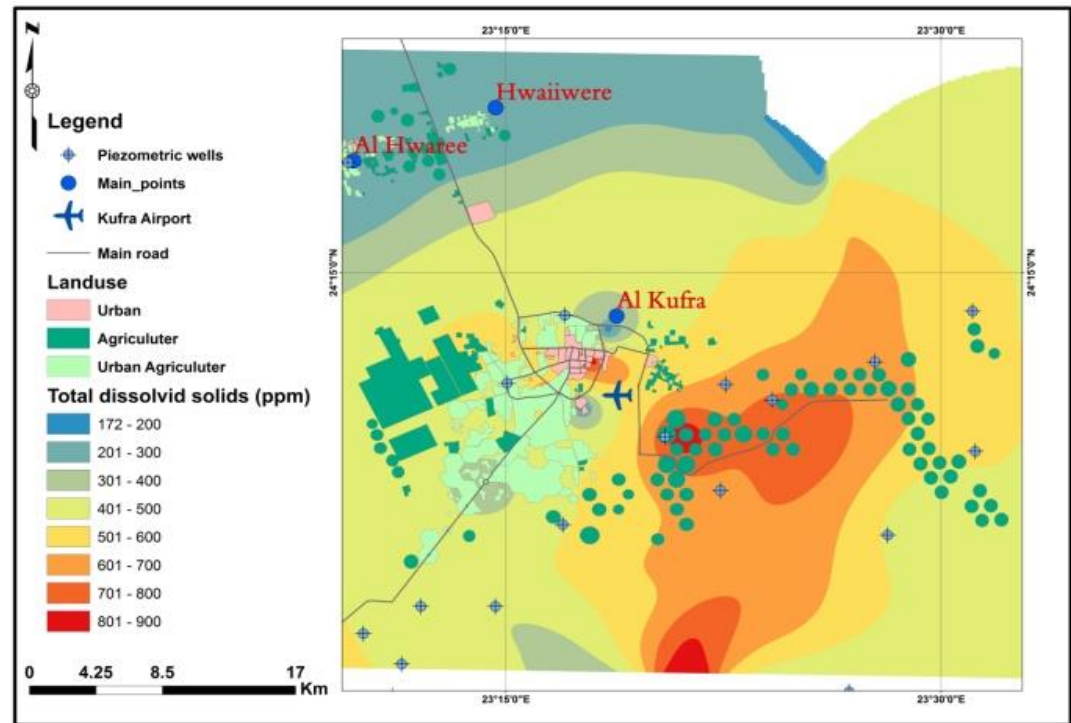


# Cont., Groundwater Resources of Al Kufra

## Groundwater quality

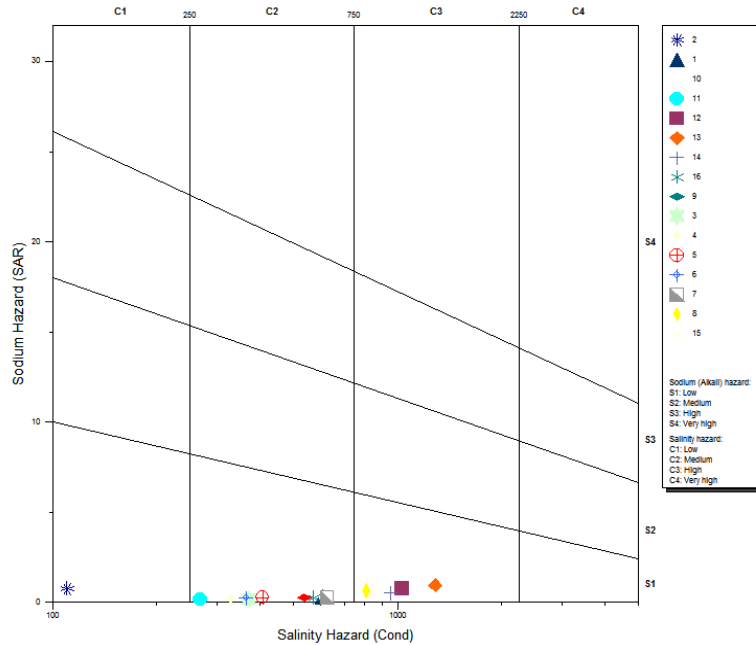
According to the results of the chemical analysis of water samples in the region

- The total dissolved solids of the groundwater aquifer ranged from **172** to **900** ppm.
- The map of total dissolved salts (TDS) shows increasing values in urban area and the agriculture projects areas in comparison to other areas of the oasis.
- There are two possible interpretations for this salinity increase:
  - The first is that the increase in salinity is due to saltwater migration due to heavy abstraction.
  - The second is that increased salinity is a result of anthropogenic surface activities represented in irrigation return flow and wastewater return flows (most of the city's neighborhoods and suburbs do not have sewage collection networks) to groundwater. .

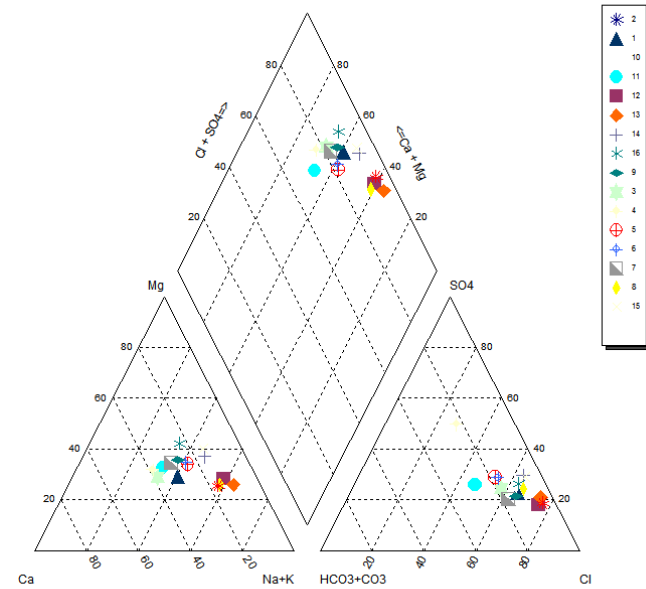


# Cont., Groundwater Resources of Al Kufra

## Groundwater quality



Wilcox Diagram



Piper's diagram

There are no major changes in the suitability of groundwater to agriculture  
Piper's and Wilcox diagram

# Groundwater management

- Most of the government water institutions in Libya were established through decisions from the Ex-Ministerial Council.
- After the political change in 2011, the government in 2012 established the Ministry of Water Resource to be the highest water resources authority responsible in Libya to supervise and administrate all the water institutions. After two years, the Ministry of Water Resource' name was changed to the National Water Resources Establishment with the same tasks. Water institutions were characterized by **administrative instability**, and **overlaps in responsibilities**, in addition to the **centralized approach in the management**.

- The responsibilities and tasks of the water institutions in Al Kufra

- **The General Water Authority (GWA)**

formed in **1972** and responsible mainly for ground water resources exploration, monitoring, supervisor on the drilling of the water, and ground water regulation.

- **The General Company for Water and Wastewater (GCWW)**

Established in **1996** responsible mainly for water supply; construction, operation, maintenance of transmission, distribution networks, water pumping stations, and control centers, to ensure the provision of better services to the users of them. In addition to the construction, operation, and maintenance of drainage systems and related treatment plants, filtration, pumping, and monitoring.

- **The Joint Authority for NSAS (JA) 1989**

An authority has been established in 1989 under the name "Joint Authority between the signed countries of Libya, Egypt, Sudan and Chad for the Study and Development of the Nubian Sandstone Aquifer Waters" The Authority has been established to carry out Study, development and investment of water resources in the Nubian Sandstone Aquifer System and strengthen the regional corporation between member states.

# Groundwater management

- Enabling environmental indicators and institutional arrangement

Indicator	Unit	Year : ٢٠١٨
Water resources policies based on IWRM principles	Yes/No	No
Water institutions	Number	٣
Inter-institutional integration	Yes/No	No
Stakeholder participation	Yes/No	No
The existence of a supreme national authority	Yes/No	Yes
Application of laws to violators of the Water Law	Yes/No	No
Academies that provide training in the field of water in the region	Number	٠
Awareness and water awareness activities per year	Number/YEA R	٠

# Conclusions

**The results of the assessment of the current water management system in Al Kufra Oasis can be summarized as follows:**

- Centralized planning and financing and limited financial resources.
- Tasks overlap of water institutions, lack of coordination, and organizational instability.
- Inadequate institutional capacity at regional and local levels and limited experience in integrated
- water resource management (e.g., insufficient consideration of the socio-economic dimensions).
- Inadequate stakeholders participation.
- socio-economic dimensions are not involved in the current scheme of the management
- Limited capacities in water management and lack of skilled labour to cope with future challenges.
- Lack of organized approach of awareness.
- limited Monitoring system and lack of data quality.