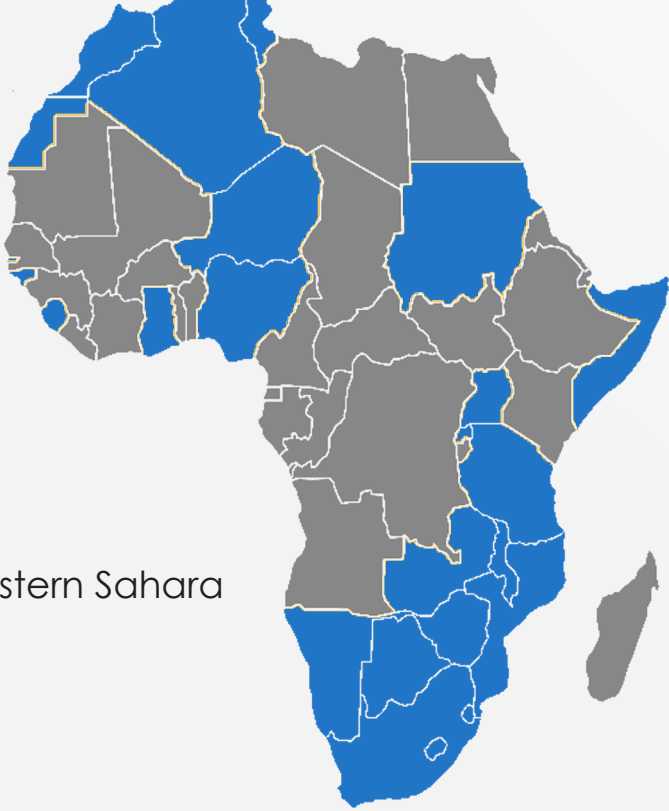


# NATIONAL GROUNDWATER MONITORING PROGRAMMES

## AFRICA

- 
- 2 Algeria
  - 3 Botswana
  - 4 Eswatini
  - 5 Ghana
  - 6 Guinea-Bissau
  - 7 Lesotho
  - 8 Malawi
  - 9 Mauritius
  - 10 Morocco & Western Sahara
  - 11 Mozambique
  - 12 Namibia
  - 13 Niger
  - 14 Nigeria
  - 15 Rwanda
  - 16 Sierra Leone
  - 17 Somalia
  - 18 South Africa
  - 19 Sudan
  - 20 Tanzania
  - 21 The Gambia
  - 22 Tunisia
  - 23 Uganda
  - 24 Zambia
  - 25 Zimbabwe



## INSTITUTIONAL SETTING AND PURPOSE

The Ministry of Water Resources (MRE) is responsible for creating the institutional conditions to improve the management of public water services. Institutional consultation with the sectors is ensured by an advisory body called National Water Council (CNL).

The National Agency for Hydraulic Resources (ANRH) is the national agency in charge of decision-making for groundwater resources in Algeria and conducting scientific and technical ac-

tivities. ANRH with the Agency of Hydrographic Basins (ABH) are in charge of quantity and quality groundwater monitoring, including the collection, processing and updating of data and information on groundwater resources.

ANRH ensures the update of the water points inventory, the piezometric monitoring of groundwater, prospection, and mathematical model to facilitate the management of the resource.

## CHARACTERISTICS OF THE NETWORK

The monitoring network maintained by ANRH is comprised of 500 observation points. Monitoring campaigns are done twice a year, at low and high water-level points.

North Western Sahara Aquifer System (NWSAS) consultation mechanism established 11,166 water points of the monitoring system in Algeria, Tunisia and Libya by 2008 where the data on piezometric heads, water abstraction, drawdown, water quality was collected to manage shared groundwater resources.

## PROCESSING AND DISSEMINATION

In this area, ANRH regularly publishes yearly reports of geophysical studies, directories of hydrogeological studies, inventories of water points, and inventory of piezometers. The collected information supports specific hydrogeological studies and the development of thematic maps such as: hydrogeological maps, piezometric maps, vulnerability maps of groundwater resources, aquifer systems maps, etc.

Data from the NWSAS consultation mechanism is included in the Algeria Water Sector M&E Rapid Assessment Report.

## Sources

- **Agence Nationale des Ressources Hydrauliques (ANRH)** - <http://www.anrh.dz>;
- **CEDARE, 2014. Algeria Water Sector M&E Rapid Assessment Report. Monitoring & Evaluation for Water in North Africa (MEWINA) Project, Water Resources Management Program, CEDARE** - <http://web.cedare.org/wp-content/uploads/2005/05/Algeria-Water-Sector-Monitoring-and-Evaluation-Rapid-Assessment-Report.pdf>;
- **Chabour, N, Mebrouk, N, Hassani, I H, Upton, K, Ó Dochartaigh, B É and Bellwood-Howard, I. 2018. Africa Groundwater Atlas: Hydrogeology of Algeria. British Geological Survey. Accessed 02-07-2019** - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Algeria](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Algeria); and
- **Guyomard, 2011. Concerted management of transboundary groundwater (In French)** - [https://www.oieau.fr/eaudoc/system/files/Guyomard\\_synthese\\_finale-1\\_0.pdf](https://www.oieau.fr/eaudoc/system/files/Guyomard_synthese_finale-1_0.pdf).

# Botswana

**Capital city:** Gaborone  
**Inhabitants:** 2 Million



## INSTITUTIONAL SETTING AND PURPOSE

Groundwater level monitoring in Botswana is carried out by the Ministry of Land Management, Water and Sanitation Services (MLMWS, formerly the remit of the Ministry of Minerals, Energy and Water Resources, MMEWR).

The Department of Water and Sanitation monitors both natural (undisturbed) areas and pumping (disturbed) areas. Formerly, the natural areas were monitored by the Department of Geological Survey (DGS), which has been transformed into Botswana Geoscience Institute. The objectives of monitoring are (i) to observe long-term groundwater level behaviour under natural conditions and to collect data for future economic development and resources management, and (ii) to observe long-term groundwater level behaviour under pumping conditions to analyse changes and aquifers' responses to stresses.

DWS also advises the Water Apportionment Board for licenses of large water users. Large water users have to report annually, although without the obligation to submit the relevant data to the Department of Water Affairs (DWA).

Furthermore, the Ministry of Agriculture oversees the livestock watering and large-scale irrigation, and the Water Utilities Company (WUC, parastatal) is the drinking water supply authority responsible for abstraction, distribution, and monitoring of pumped wellfields.

WUC is responsible for compliance monitoring in and around wellfields and monitoring the performance of boreholes. Large water users carry out compliance monitoring as well.

## CHARACTERISTICS OF THE NETWORK

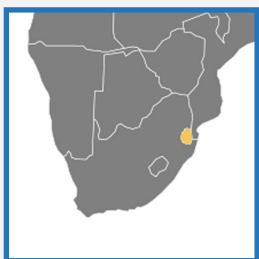
The national groundwater monitoring network has approximately 1000 piezometers, and in general the measurements are taken manually and monthly. In addition, WUC has approximately 100 data loggers installed in about 10 wellfields.

## PROCESSING AND DISSEMINATION

The Department of Water and Sanitation uses its web-based Integrated Groundwater Resource Data Management System (IG-WRMS) for storage and dissemination of borehole completion certificates, dams, river draw offs, and monitoring data (levels, quality and quantity) and information.

## Sources

- **Feedback from the Department of Water and Sanitation Botswana** - received on 06-10-2020;
- **IGRAC, 2013. Groundwater Monitoring in the SADC Region, 2013. Overview prepared for the Stockholm World Water Week** - [https://www.un-igrac.org/sites/default/files/resources/files/Report\\_Groundwater%20Monitoring%20in%20SADC%20region.pdf](https://www.un-igrac.org/sites/default/files/resources/files/Report_Groundwater%20Monitoring%20in%20SADC%20region.pdf);
- **Farr, J.L. 2017. Groundwater Monitoring Assessment Study Botswana. World Bank GFDRR Final Report** - Report prepared as a collective contribution from DWS (DWA) and WUC as main stakeholders and other stakeholders as Department of Meteorological Services (DMS), Botswana geoscience Institute (BGI), National Disaster Management Office (NDMO), Universities (UB and BUIST), private sector (Debswana, mining companies, industrial enterprises, parastatals), and government ministries and departments;
- **Upton, K, Ó Dochartaigh, B É, Key, R, Farr J and Bellwood-Howard, I. 2018. Africa Groundwater Atlas: Hydrogeology of Botswana. British Geological Survey. Accessed 02-07-2019** - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Botswana](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Botswana); and
- **SADC country visits** - 2017.



Capital city: Mbabane and Lobamba  
Inhabitants: 1 Million

## INSTITUTIONAL SETTING AND PURPOSE

Groundwater resources are monitored and managed by the Ministry of Natural Resources and Energy through The Department of Water Affairs. As secondary task the Ministry is obliged to supply and manage water in the rural areas of the country. The country has approximately 6,000 boreholes dug for groundwater exploration, the bulk of them for domestic water supply particularly in water stressed areas. Exploration wells are intended for the monitoring of groundwater levels and quality.

Groundwater monitoring is coordinated from the headquarters in Mbabane. A groundwater monitoring plan existed but was curtailed to enable the use of the groundwater boreholes to provide potable water to communities affected by the drought that has been observed over the years. However, groundwater monitoring is being revised through support from the SADC Groundwater Management Institute. A groundwater monitoring project is being piloted with the aim of rolling out to a national scale subject to availability of funds. Considered parameters are water levels, major ions (Ca, Mg, K, Na, Cl, NO<sub>3</sub>, SO<sub>4</sub>, HCO<sub>3</sub> and CO<sub>3</sub>), EC, pH, just to name a few.

## PROCESSING AND DISSEMINATION

Groundwater levels are supposed to be measured monthly, but they are currently measured only once after the borehole has been drilled. Afterwards, it is the responsibility of the user to monitor the water level, but these values are not communicated to the Ministry in a systematic and harmonised manner.

There is no database to store groundwater monitoring data, however, this would soon be a thing of the past post the ongoing pilot groundwater monitoring project implementation. Data are stored in Excel files and is accessed by staff within the Department with no access to external users.



Figure 1 – Field visit in Eswatini for SADC project

## Sources

- Feedback from the Department of Water Affairs - received on 22-10-2020; and
- SADC country visits - 2017.

# Ghana

**Capital city:** Accra  
**Inhabitants:** 30 Million



## INSTITUTIONAL SETTING AND PURPOSE

In Ghana, the Ministry of Sanitation and Water Resources (MSWR) established in January 2017, through its Water Directorate, coordinates policies, programmes and projects on water resources management, drinking water and water-related sanitation sector. Before 2017, the water sector was part of the Ministry of Water Resources, Works and Housing, and the sanitation sector was part of the Ministry of Local Government and Rural Development.

The Water Directorate collaborates with the Water Resources Commission (WRC), the body mandated to regulate and manage water resources (including groundwater) and to coordinate government policies in relation to them. The WRC mandates data collection institutions such as the Ghana Atomic Ener-

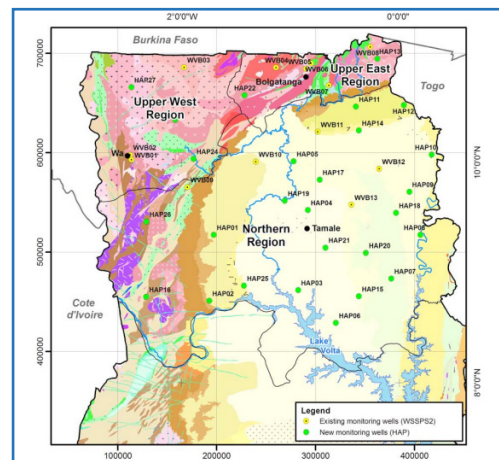
gy Commission (GAEC) and the Groundwater Division of the Council for Scientific and Industrial Research – Water Research Institute (CSIR-WRI) to undertake groundwater monitoring programs. Data and information on groundwater level and recently, data on physico-chemical parameters as well as isotopic composition of the monitoring wells in the Volta basin are collected.

The Groundwater Division of the CSIR-WRI had a number of monitoring wells in the Accra Plains which were monitored monthly for several years until it was discontinued in the late nineties due to urbanization and land disputes rendered most of the well locations inaccessible.

## CHARACTERISTICS OF THE NETWORK

With the support of the CIDA-funded Hydrogeological Assessment Project of the Northern Regions of Ghana (in the Volta river basin), the Water Resources Commission has achieved the establishment of a groundwater monitoring network and information management system. Other funded projects by the Danish Development Cooperation (DANIDA) and the European Union (EU) installed groundwater monitoring wells in the Tano, Ankobra, Pra and Densu river basins. In all, a total of about seventy (70) wells are installed in the above river basins, thirty-seven (37) of which are located in the Volta basin which are currently being monitored by GAEC on behalf of the WRC.

*Figure 2 – Location of the 37 new and existing monitoring wells*



## PROCESSING AND DISSEMINATION

The raw data of time-series groundwater level of monitoring wells are stored in Water Resources Commission hydrogeological database and are available to the general public usually by request. However, there are yearly reports for each groundwater monitoring campaign which are available at WRC. Data are also stored at CSIR-WRI.

## Sources

- **Bibliographic reference:** Obuobie, E., Agyekum, W., Appiah-Adjei, E.K., Upton, K., Ó Dochartaigh, B.É. and Bellwood-Howard, I. 2018. **Africa Groundwater Atlas: Hydrogeology of Ghana.** British Geological Survey. Accessed 02-07-2019 - [http://earthwise.bgs.ac.uk/index.php/Hydrogeologyof\\_Ghana](http://earthwise.bgs.ac.uk/index.php/Hydrogeologyof_Ghana);
- **Feedback from the Groundwater Division of the CSIR WRI** - received on 16-03-2020;
- **Feedback from WRC, Ghana** - received on 07-05-2020;
- **Ministry of Sanitation & Water Resources, Republic of Ghana** - <http://mswr.gov.gh/about-us/>; and
- **Water Resources Commission of Ghana** - <http://www.wrc-gh.org/about-us/>.



## INSTITUTIONAL SETTING AND PURPOSE

The Directorate General of Water Resources (DGRH) under the Ministry of Energy, Industry and Natural Resources (MEIRN) is the main entity responsible for water supply and sanitation in Guinea Bissau. Other state agencies with responsibilities for water resources are the Ministry of Public Health, the Public

Enterprise for Electricity and Water Supply (EAGB), the General Directorate of Energy (DGE), the Inter-ministerial Council for Water Resources (CIMA), the Water Technical Committee, and the Ministry of Agriculture, Forestry, Hunting and Livestock with its Directorate of Rural Engineering Services (DSER).

## PROCESSING AND DISSEMINATION

Groundwater data are stored in a national database hosted by the DGRH and visualized with mWater Portal including drilling logs, groundwater levels and groundwater quality, Figure 1. The development of this database has been supported by UNICEF.

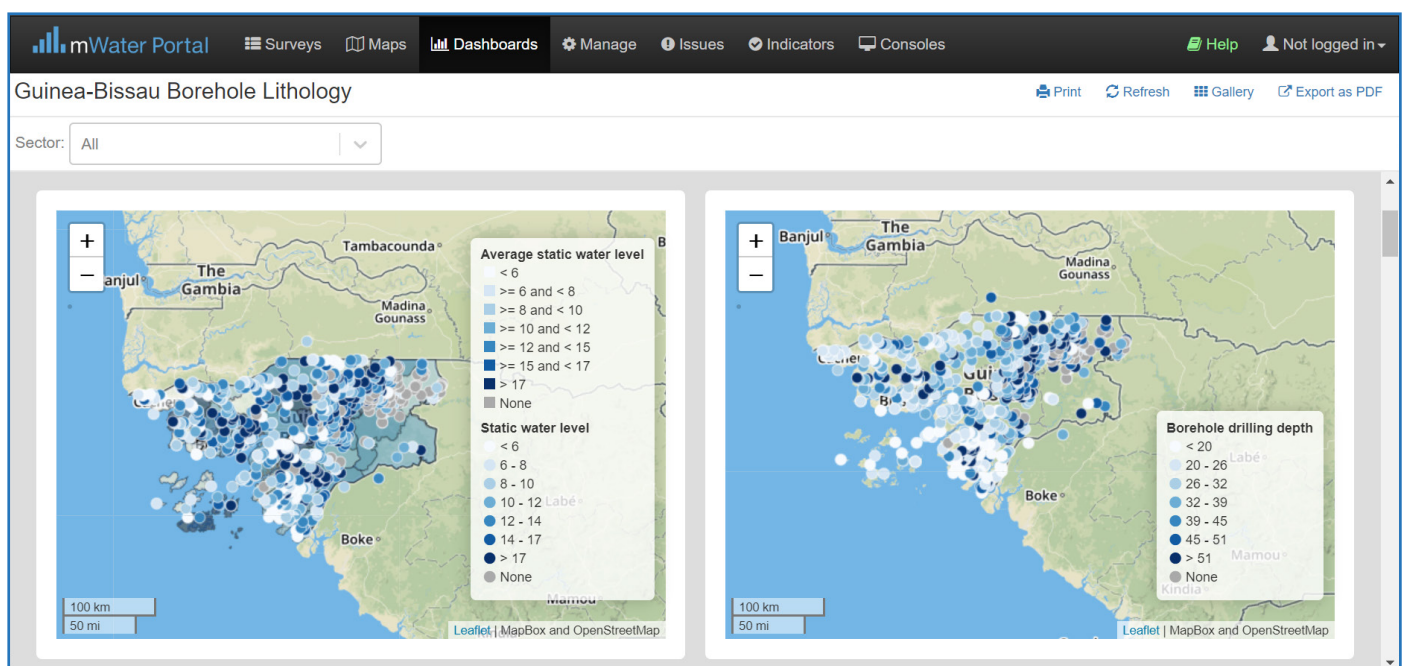


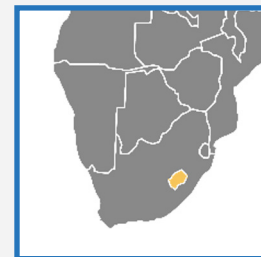
Figure 3 – Guinea Bissau borehole lithology with static groundwater level information, mWater Portal

## Sources

- **Bibliographic reference:** Upton, K, Ó Dochartaigh, B É and Bellwood-Howard, I. 2018. **Africa Groundwater Atlas: Hydrogeology of Guinea Bissau.** British Geological Survey. Accessed 02-07-2019 - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Guinea\\_Bissau](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Guinea_Bissau); and
- **Guinea-Bissau Borehole lithology** - <https://portal.mwater.co/#/dashboards/9c20165c8763489b85baf898bda1d-ca3?share=2bb0050028d540298277e50208717545>.

# Lesotho

**Capital city:** Maseru  
**Inhabitants:** 2.1 Million



## INSTITUTIONAL SETTING AND PURPOSE

The Department of Water Affairs (DWA) in the Ministry of Water is responsible for groundwater monitoring including groundwater levels and groundwater quality. Groundwater monitoring started in the early 1990's as a result of an Italian (funded and executed) project that produced a Lesotho Hydrogeological Map. Boreholes drilled for the purpose of that project became the groundwater monitoring network, without a concrete monitoring plan and specific objectives.

Lesotho is in a process of decentralisation where the monitoring responsibility will be transferred to local communities and where DWA takes the primarily advisory role. Also, Lesotho is implementing the project under SADC-GMI on Expansion of National Groundwater Monitoring network that ends December 2020. This project is aimed at improving what has been done in the 90's with a clear plan of what is being monitored for best quality data on groundwater resources.

## CHARACTERISTICS OF THE NETWORK

The network includes officially 130 springs and 60 observation wells, but it is not fully operational, Figure 1. In reality, only 30 springs (distributed in 10 districts) and 20 wells (approx. 3 per district) are being regularly monitored.

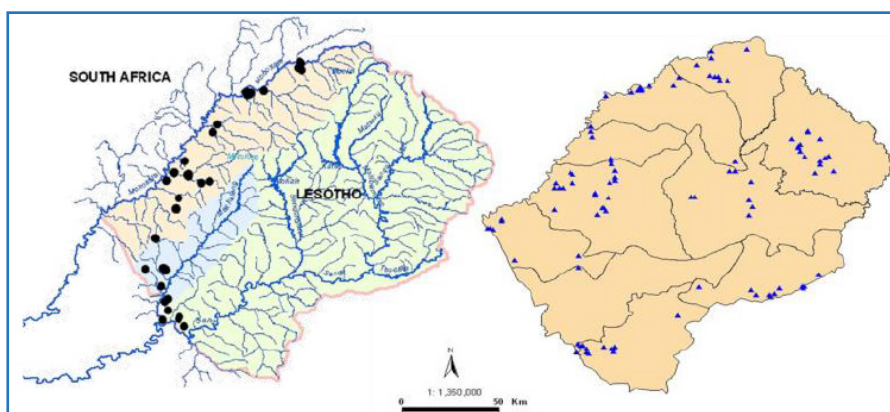
Both observation wells and springs are monitored every three months. Piezometric levels are measured manually with water level dippers (no data loggers are used).

Monitoring of springs, which are numerous and the main source for rural water supply, is done by regional offices in mountainous areas, and by DWA in lowlands. DWA makes use of data from the Ministry of Health to prioritise springs for sampling. Prioritising is based on 1) population depending on the source, 2) age of water at the source (both data from DWA and regional offices in mountainous areas for rural water supply) and 3) disease trends in population using the source (data from the Ministry of Health).

## PROCESSING AND DISSEMINATION

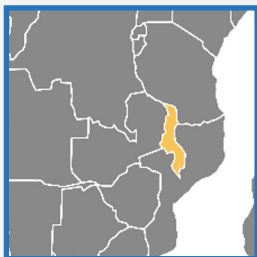
Data of groundwater levels is stored in simple spreadsheets per district. Data are not compiled in a central database.

*Figure 4 – Location of boreholes (black dots, left), location of monitoring springs (blue triangles, right)*



## Sources

- Department of Water Affairs (DWA), Ministry of Water of Lesotho - [www.water.org.ls/dwa/](http://www.water.org.ls/dwa/);
- Feedback from Department of Water Affairs, Groundwater Division, Ministry of Water of Lesotho - received on 16-09-20;
- IGRAC, 2013. Groundwater Monitoring in the SADC Region, 2013. Overview prepared for Stockholm World Water Week - [https://www.un-igrac.org/sites/default/files/resources/files/Report\\_Groundwater%20Monitoring%20in%20SADC%20region.pdf](https://www.un-igrac.org/sites/default/files/resources/files/Report_Groundwater%20Monitoring%20in%20SADC%20region.pdf); and
- SADC country visits - 2017.



## INSTITUTIONAL SETTING AND PURPOSE

The monitoring of groundwater levels is responsibility of the Groundwater Division at the Department of Water Resources (DWR) under the Ministry of Forestry and Natural Resources. The National Water Resources Authority (NWRA), established by the Water Resources Act 2013, will take over this responsibility when it is adequately operationalised.

The national groundwater monitoring network was established in 2009. The objective of the network is to monitor groundwater quality and quantity in Malawi to enable informed decision-making for the development and protection of groundwater resources. The National Water Resources Master Plan, 2017 includes an Annex on Groundwater that describes the hydrogeology of the country, groundwater monitoring and groundwater development.

## CHARACTERISTICS OF THE NETWORK

The network includes 75 wells with automatic data loggers. 30 of them were drilled in 2009-2010 and started recorded data automatically in 2013. In total, 36 of the wells were drilled in 2015 and had data loggers installed in 2017. Data for these 66 monitoring wells is recorded every 15 minutes. Groundwater monitoring data downloading from the loggers is ad hoc due to resource constraints. Another 10 monitoring wells were drilled in 2017 and data loggers were installed in 2018 for automatic readings at 9 of them (one was vandalised before installation). The loggers for the latter 9 wells record data every hour.

Groundwater levels are firstly stored into Excel which allows easy processing and visualisation. The Ministry uses Windows Interpretation System for Hydrogeologists (WISH) database developed by the Institute for Groundwater Studies (IGS) and the Water Research Commission (WRC) as a groundwater as-

essment tool. The data are also stored in Hydstra (which is the main software used for hydrological data analysis in the Ministry) including groundwater level time-series, but there are challenges in using drilling data in Hydstra. Also, challenges with licence requirements for Hydstra and compatibility with drilling data affect its use.

Data are for Ministry's internal use as well as for external use as requested.

Groundwater level time series are analysed via plotting and identification of outliers, trends and gaps, combining precipitation and surface water data.

## Sources

- **Departments of the Ministry of Irrigation and Water Development** - [http://www.malawi.gov.mw/index.php?option=com\\_content&view=article&id=13&Itemid=99](http://www.malawi.gov.mw/index.php?option=com_content&view=article&id=13&Itemid=99);
- **Feedback from the Groundwater Division at the Department of Water Resources (DWR), Ministry of Forestry and Natural Resources of Malawi** - received on 22-09-20;
- **Government of Malawi, Department of Water Resources, Transboundary Water Resources Management Unit. National Water Resources Authority (NWRA)** - <http://malawi-twrmu.hatfieldgroup.com/en/institutions/national-water-resources-authority>; and
- **SADC country visits** - 2017.



# Mauritius

**Capital city:** Port Louis  
**Inhabitants:** 1 Million



## INSTITUTIONAL SETTING AND PURPOSE

The Water Resources Unit (WRU) under the Ministry of Energy and Public Utilities is responsible for the assessment, development, management and conservation of water resources in the Republic of Mauritius. On the other hand, the Central Water

Authority (CWA) of the Ministry of Energy and Public Utilities has the mission of securing and providing a sustainable water supply service of appropriate quality and at affordable price.

## CHARACTERISTICS OF THE NETWORK

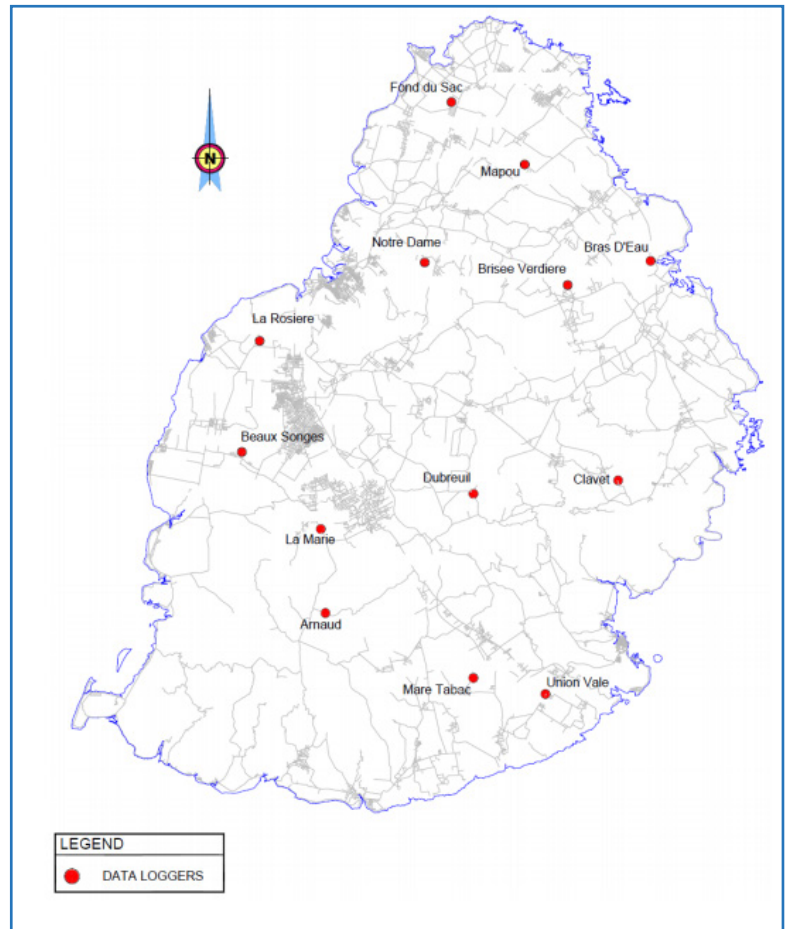
Groundwater monitoring consists of 300 wells managed by the WRU and 400 abstraction wells controlled by the CWA.

The frequency of monitoring used to be every month, but currently it has been reduced to once every four months depending on the priority degree. The measurements are mostly manual. Only 13 sites are equipped with data loggers.

The quality of data are checked by senior/experienced personnel without a specific procedure.

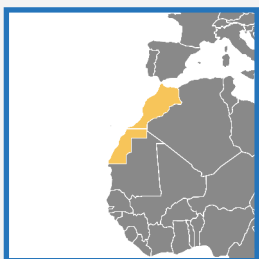
There is no database available. However, the groundwater level data can be accessed via reports, and they are available to the public.

**Figure 5 - Location of data loggers in Mauritius**



## Sources

- **Hydrology data book** - <http://publicutilities.govmu.org/English/Pages/Hydrology-Data-Book-2006---2010.aspx>;
- **SADC Project** - Country visits (2017).



# Morocco & Western Sahara (Moroccan Sahara)

Capital city: Rabat  
Inhabitants: 36 Million

## INSTITUTIONAL SETTING AND PURPOSE

The Department of Water under the Ministry of Energy and Mines, Water and Environment (MEM) is responsible for developing and ensuring the implementation of policies in terms of mobilisation, management, preservation and protection of water resources. This is done through nine Basin Hydraulic Agen-

cies (Oum Er Rbia, Moulouya, Loukkos, Sebou, Bou Regreg and Chaouia, Tensift, Souss-Massa-Draa, Guir-Ziz-Rh ris and Sakia El Hamra-Oued Eddahab) and the National Office of Electricity and Drinking Water (ONEE). The Basin Agencies carry out groundwater level and quality monitoring.

## PROCESSING AND DISSEMINATION

Groundwater level monitoring is carried out monthly in important and overexploited aquifers, and twice per year in other aquifers. The data are stored in databases of the Hydraulic Department of the MEM and the Basin Agencies. Other important background data are stored in universities and research institutes.



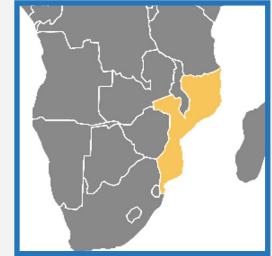
Figure 6 - Well along the Tensift River (right bank), near Marrakech, by: Water Alternatives

## Sources

- Upton, K.,   Dochartaigh, B. . and Bellwood-Howard, I. 2018. Africa Groundwater Atlas: Hydrogeology of Morocco & Western Sahara. British Geological Survey. Accessed 02-07-2019 - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Morocco\\_%26\\_Western\\_Sahara\\_\(Moroccan\\_Sahara\)](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Morocco_%26_Western_Sahara_(Moroccan_Sahara)).

# Mozambique

**Capital city:** Maputo  
**Inhabitants:** 29.5 Million



## INSTITUTIONAL SETTING AND PURPOSE

The National Water Directorate (DNA) under the Ministry of Public Works and Housing and Water Resources (MOPHRH) is in charge of water resources planning and development in Mozambique.

Groundwater monitoring has been decentralised in Mozambique. The country used to be divided in five Regional Water Administrations (ARAs), but due to reforms in the water resources sector, there are now three ARAs. The capital city, Maputo, is located in the most southern ARA called ARA-Sul.

There is no national groundwater monitoring plan but apparently all the ARAs have monitoring networks. ARAs measure water levels (monthly) and groundwater quality (every six months).

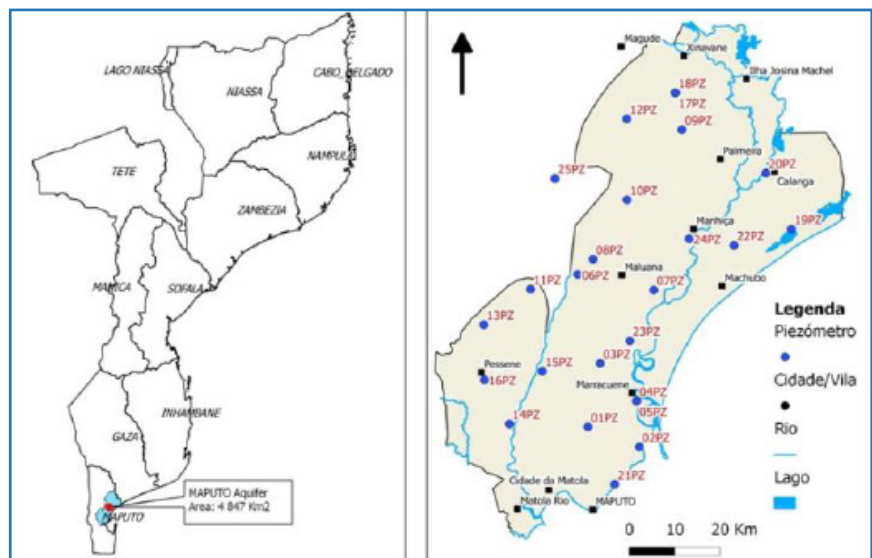
Different departments have different databases. The department of water affairs does not support the data handling. When they require data, it is requested from the ARAs. The ARAs do the borehole registration, including geophysical and geological information from the borehole logs, pumping test data, and the coordinates without the elevation.

Access to the data are restricted to the ARAs, but external access can be granted on written request. The main users of the groundwater data are the ARAs, the MOPHRH, universities and consultants.

## CHARACTERISTICS OF THE NETWORK

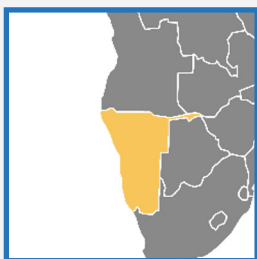
The water agency ARA-Sul has an operational network that consists of 45 groundwater monitoring wells in and around Maputo, Figure 63. The network was established to monitor the Greater Maputo Aquifer. Data collection includes groundwater levels, electro-conductivity (EC) and chemical parameters.

**Figure 7 - Provinces of Mozambique and location of the Maputo Aquifer (left), location of monitoring points part of the ARA-Sul**



## Sources

- Chairuca, L., Naafs, A., van Haren, I., Upton, K., Ó Dochartaigh, B.É. and Bellwood-Howard, I. 2018. **Africa Groundwater Atlas: Hydrogeology of Mozambique.** British Geological Survey. Accessed 02-07-2019 - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Mozambique](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Mozambique);
- **Feedback from the Ministry of Public Works, Housing and Water Resources (MOPHRH)** - received on 23-09-20;
- **SADC country visits - 2017;** and
- **IGRAC, 2013. Groundwater Monitoring in the SADC Region, 2013. Overview prepared for the Stockholm World Water Week** - [https://www.un-igrac.org/sites/default/files/resources/files/Report\\_Groundwater%20Monitoring%20in%20SADC%20region.pdf](https://www.un-igrac.org/sites/default/files/resources/files/Report_Groundwater%20Monitoring%20in%20SADC%20region.pdf).



## INSTITUTIONAL SETTING AND PURPOSE

The Ministry of Agriculture, Water and Land Reform (MAWLR) through the Directorate of Water Resources Management (DWRM) is responsible for the groundwater monitoring in Namibia. Even though groundwater level monitoring started in Namibia in the 1960s, no formal groundwater monitoring plan at the national level is in place. The ongoing groundwater monitoring in the country is based on MAWF annual plans, the availability of resources and sometimes ad-hoc decisions.

The nation-wide groundwater monitoring has an overall aim of keeping uninterrupted record for possible future evaluation, data collection for dissemination and decision making.

The monitoring network also aims to identify areas of extensive groundwater use and areas of a transboundary significance.

## CHARACTERISTICS OF THE NETWORK

Currently, 629 monitoring wells are present in the system. The design of the monitoring network took into account areas with high potential of groundwater resources to monitor and protect them for a sustainable use. The data are collected manually and automatically. The collected data include groundwater levels, groundwater quality sampling and abstraction.

Automatic water level loggers transmit data on daily basis, water level loggers without telemetric connection are read

quarterly. Initial borehole installations are also recorded and displayed for easy reference, but changes to the installation are not recorded.

The equipment used in the field is calibrated on every field visit and/or inspection and correlated to the manual measurement in site. Likewise, equipment for the monitoring of groundwater quality are calibrated for use before every collection of samples.

## PROCESSING AND DISSEMINATION

Analyses and interpretation is performed through trend analysis and correlation is performed to time-series of piezometric levels. Monitoring data are stored in the National Groundwater Database (GROWAS). Digital records are firstly retrieved in excel spreadsheets and subsequently in GROWAS2.

Data collected is checked and verified by the Geohydrology Division of the Department of Water Affairs before entering into the database.

Data are available internally for all relevant staff working and verifying the databases. Overall, data are accessible upon request, depending on the nature of the request. The user must fill a data use disclaimer form, stating the use of the data and confirming that the data will be used for that purpose only. It is not allowed to share data internationally unless it is stated so in the disclaimer form.

## Sources

- **Feedback from the Geohydrology Division of the Ministry of Agriculture, Water and Land Reform of Namibia** - received on 15-09-20;
- **Geohydrology Division of the Department of Water Affairs. Groundwater in Namibia: an explanation to the Hydrogeological Map. Unrevised second edition January 2011. ISBN No. 0-86976-571-X** - [https://www.bgr.bund.de/EN/Themen/Wasser/Projekte/abgeschlossen/TZ/Namibia/groundwater\\_namibia.pdf?\\_\\_blob=publicationFile&v=3](https://www.bgr.bund.de/EN/Themen/Wasser/Projekte/abgeschlossen/TZ/Namibia/groundwater_namibia.pdf?__blob=publicationFile&v=3);
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- **SADC Country visit** - 2017.

# Niger

Capital city: Niamey  
Inhabitants: 22.4 Million



## INSTITUTIONAL SETTING AND PURPOSE

The Ministry of Hydraulics and Sanitation is responsible for providing access to drinking water and sanitation. One of five sub-programs covers monitoring and protection of water resources.

The institution in charge groundwater resources is the Agency for Groundwater Exploitation (Office d'Exploitation des Eaux Souterraines), a public institution under the Ministry of Hydraulics and Sanitation.

## CHARACTERISTICS OF THE NETWORK

Piezometric network of Niger is composed of 308 observation points, operated by the regional services of the Ministry of Hydraulics. Frequency of water level measurements is highly variable with 2-3 times per month to 1-2 per year.

## PROCESSING AND DISSEMINATION

Two governmental databases store information on boreholes and hand dug wells: for the central region and for encompassing the whole country, although there is not much information from the north and east parts of the country.

The Ministry of Water (currently the Ministry of Hydraulics and Sanitation) has identified more than 24,000 wells and boreholes in the country, and a UNICEF study of 2010 compiled information of around 11,000 wells, many of them include info on water levels.

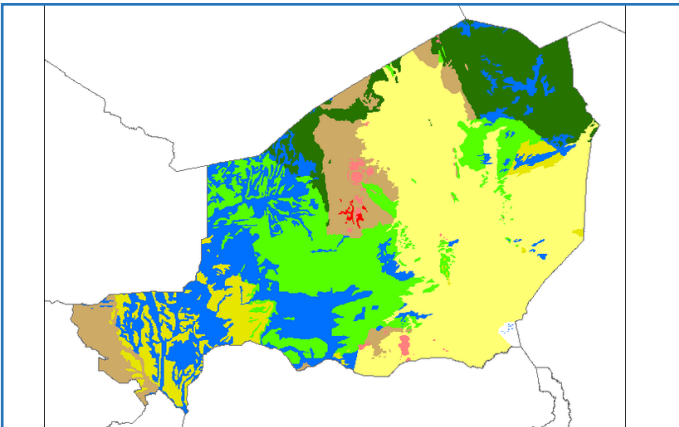


Figure 8 - Geology map Niger, source: [Earthwise.bgs.ac.uk](http://earthwise.bgs.ac.uk)

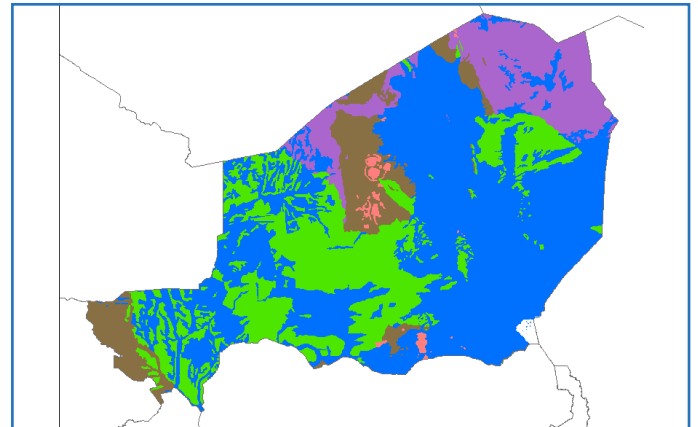
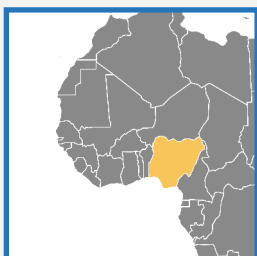


Figure 9 - Hydrogeology map Niger, source: [Earthwise.bgs.ac.uk](http://earthwise.bgs.ac.uk)

## Sources

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- **Observatory of Sahara and Sahel (2011): Monitoring and Assessment of Transboundary Aquifers – Mali, Niger and Nigeria; Guyomard (2011)** - Concerted management of transboundary groundwater;
- **UNICEF. 2010** - Etude de faisabilité des forages manuels: identification des zones potentiellement favorables. Republique du Niger Ministère de l'Eau, de l'Environnement et de la Lutte Contre Le Desertification; and
- **Upton, K., Ó Dochartaigh, B.É. and Bellwood-Howard, I. 2018. Africa Groundwater Atlas: Hydrogeology of Niger. British Geological Survey. Accessed 09-07-2019** - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Niger](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Niger).



# Nigeria

Capital city: Abuja  
Inhabitants: 195.9 Million

## INSTITUTIONAL SETTING AND PURPOSE

The Federal Ministry of Water Resources formulates the National Water Resources policies and coordinates their implementation. The Ministry is in charge of groundwater resources exploration and development. It also supports studies and research on surface and groundwater resources potential.

Nigeria Hydrological Services Agency (NIHSA) is an agency of the Federal Ministry of Water Resources that has the mandate of assessing the national water resources in terms of quantity, quality, availability and distribution in space and time. NIHSA is responsible for groundwater monitoring in Nigeria.

## CHARACTERISTICS OF THE NETWORK

The network managed by NIHSA has 43 monitoring points, among them 32 are equipped with data loggers that measure the groundwater levels daily or twice a day.

## PROCESSING AND DISSEMINATION

The data are stored at NIHSA headquarters in Abuja.

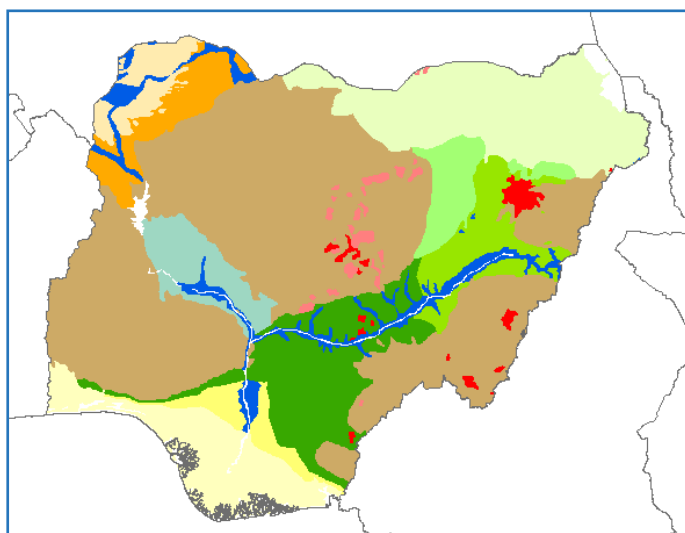


Figure 10 - Geology map Nigeria, source: Earthwise.bgs.ac.uk

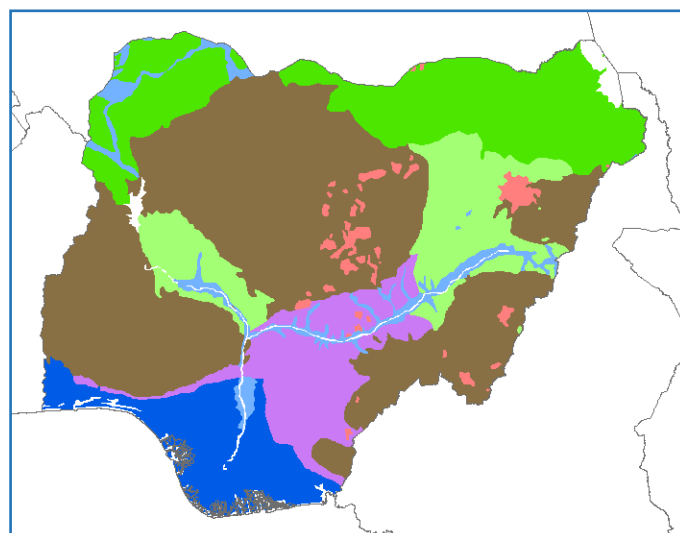


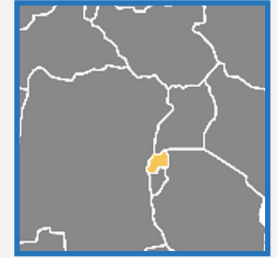
Figure 11 - Hydrogeology map Nigeria, source: Earthwise.bgs.ac.uk

## Sources

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- **Tijani, M., Crane, E., Upton, K., Ó Dochartaigh, B.É. and Bellwood-Howard, I. 2018.** Africa Groundwater Atlas: Hydrogeology of Nigeria. British Geological Survey. Accessed 09-07-2019 - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Nigeria](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Nigeria); and
- **Ministry Water Resources** - <https://www.facts.ng/nigerian-ministries/ministry-water-resources>.

# Rwanda

Capital city: Kigali  
Inhabitants: 12.3 Million



## INSTITUTIONAL SETTING AND PURPOSE

The Rwanda Water Resources Board (RWB) is an institution in charge of implementing policies and strategies related to management of natural water resources, comprising monitoring and coordination among the sectors. The water resources monitoring programme of Rwanda, having a groundwater compo-

nent, is designed to provide to stakeholders and decision makers with information to support the sustainable development and management of Rwanda's water resources, with particular attention to water productivity in agriculture and to adaptation to climate change.

## CHARACTERISTICS OF THE NETWORK

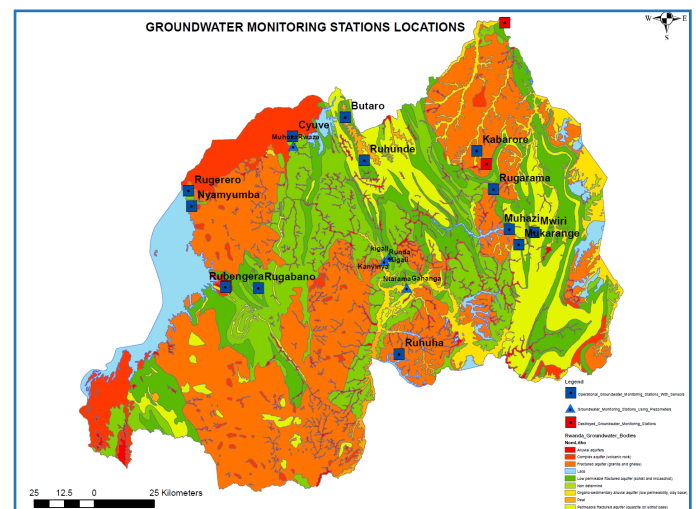
In 2016, groundwater levels were recorded from twelve groundwater monitoring stations, including four piezometers where data were collected manually, and eight monitoring stations equipped with sensors (divers and barometers) recording data

twice per day (at 6:00 and 18:00). The number of monitoring stations has been increasing with time, and currently, the monitoring network is composed by eight piezometers and thirteen groundwater monitoring stations equipped with sensors.

## PROCESSING AND DISSEMINATION

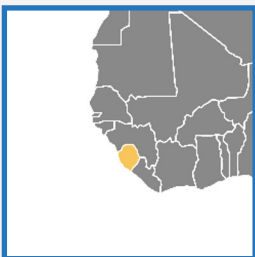
The RWB produces an Annual Water Status Report which is an overview of key parameters and locations indicative of the overall state of Rwanda's water resources. The report is concise and meant for a broad public; It is divided into four sections: surface water quantity, groundwater quantity, water quality and water use. The RWB also maintains the Rwanda Water Portal, which is a web platform that stores and facilitates access to water resources related information such as water quality, surface water monitoring results, groundwater monitoring results, water laws and policies. Data are presented in various formats and with various levels of detail/accessibility, according to the type of user. The groundwater section of the portal contains a map with the location of 21 groundwater monitoring stations, and time-series of groundwater levels for the existing stations having data.

Figure 12 - Groundwater Monitoring stations of Rwanda. Source: Rwanda Water Resources Board



## Sources

- **Annual Water Status Report for 2016-2017, Rwanda Water and Forestry Authority (RWFA)** - <https://waterportal.rwfa.rw/sites/default/files/2018-01/Annual%20Water%20Status%20Report.pdf>;
- **Annual Water Status Report for 2019-2020, RWB** - <https://waterportal.rwb.rw/sites/default/files/2018-01/Annual%20Water%20Status%20Report.pdf>;
- **Feedback from the Rwanda Water Resource Board (RWB)** - received on 05-10-2020;
- **IGRAC. Information collected during the regional training programme on Integrating Groundwater Management within River Basins held from 15-17 January 2019 in Nairobi, Kenya** - <https://www.un-igrac.org/news/integrating-groundwater-management-river-lake-basins-eastern-africa>;
- **Rwanda Water Resources Board (RWB)** - <http://rwb.rw/index.php?id=2>;
- **Rwanda Water Resource Portal** - <https://waterportal.rwb.rw/>; and
- **Rwanda Water Resource Portal, Groundwater monitoring network** - [https://waterportal.rwb.rw/data/ground\\_water](https://waterportal.rwb.rw/data/ground_water).



## INSTITUTIONAL SETTING AND PURPOSE

The Ministry of Water Resources (MWR) of Sierra Leone is responsible for managing and protecting the water resources at local, national and transboundary levels.

The Sierra Leone Water Security Project was funded by the Department for International Development (DFID) of the United Kingdom through its national WASH facility and had the overall aim of 'putting in place the foundations for water security in

Sierra Leone'. During this project, a groundwater monitoring network was installed, that measured groundwater levels from November 2012 onwards.

Currently, Sierra Leone does not have a national groundwater monitoring network.

## CHARACTERISTICS OF THE NETWORK

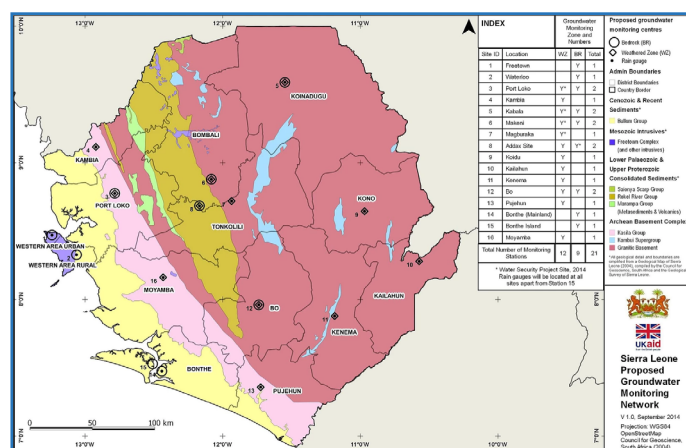
The network was equipped with automatic data loggers with barometric sensors in hand-dug wells and deep wells. Water levels were measured manually at the beginning and end of the monitoring period to validate readings.

## PROCESSING AND DISSEMINATION

The Salone Water Security portal, powered by the MWR, is the nation's focal point for national policies, strategies and regulation. It stores groundwater level data of the groundwater monitoring network of the Water Security Project (18 wells, available for download). Bumbuna Watershed Management Authority (BWMA) is in charge of data collection and storage.

The Salone portal also presents a map of 2014 with a proposed national groundwater monitoring network.

Figure 13 - Proposed groundwater monitoring network, source: Salone Water Security



## Sources

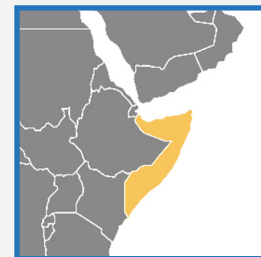
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# Somalia

Capital city: Mogadishu

Inhabitants: 15 Million



## INSTITUTIONAL SETTING AND PURPOSE

The Ministry of Water Resources in Mogadishu, the Ministry of Water Resources in Somaliland and the Puntland State Agency for Water, Energy and Natural Resources are institutions related to groundwater resources management in Somalia.

In Somalia there is no national groundwater monitoring network taking place. However, in 2012, FAO/SWALIM (Somalia Water and Land Information Management) established a groundwater monitoring network in the provinces of Somaliland and Puntland.

## CHARACTERISTICS OF THE NETWORK

The network is equipped with automatic water level data loggers. Currently, 4 monitoring stations are installed in Somaliland (Hargeisa, Borama, Berbera and Burco) and 4 in Puntland (Garoowe, Boosaaso, Gaalkacyo and Qardho).

## PROCESSING AND DISSEMINATION

The Live-Map in the SWALIM portal shows the status of water resources in Somalia, including information about boreholes and water points, Figure 1.

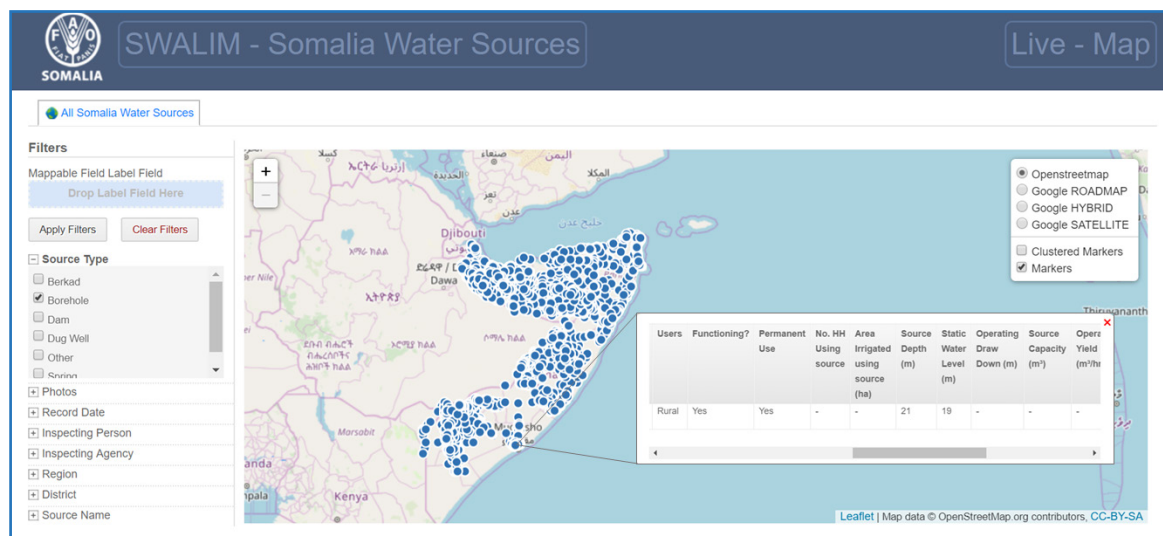
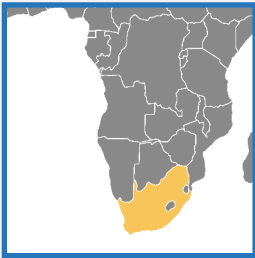


Figure 14 - Live-Map SWALIM

## Sources

- **IGRAC (2012). Information collected during GGMN Workshop in the IGAD Region** - <https://www.un-igrac.org/news/groundwater-monitoring-network-programme-africa>;
- **Gadain H, Stevanovic Z, Upton K. Ó Dochartaigh BÉ and Bellwood-Howard, I. 2018. Africa Groundwater Atlas: Hydrogeology of Somalia.** British Geological Survey. Accessed 09-07-2019 - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Somalia](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Somalia);
- **Somalia Water and Land Information Management (SWALIM)** - <https://www.faoswalim.org/water/water-resources/ground-water;and>
- **SWALIM – Somalia Water Sources – Live Map** - <http://fmt.faoso.net/imms/fmt/maps/website/227>.



**Capital city:** Cape Town (legislative) / Pretoria (administrative) / Bloemfontein (judicial)  
**Inhabitants:** 57.8 Million

## INSTITUTIONAL SETTING AND PURPOSE

The institution in charge of groundwater management in Republic of South Africa (RSA) is the Department of Water Affairs and Forestry (DWA). The DWA has delegated most of the monitoring tasks to its regional offices. Regional offices are set up in all the provinces of RSA, but some of them lack capacity to complete all the delegated tasks.

The objectives of the groundwater monitoring plan are to identify spatial and temporal trends, and to understand the causes and effects of groundwater changes in affected areas. The plan includes the monitoring of groundwater levels and its quality.

## CHARACTERISTICS OF THE NETWORK

Groundwater levels are monitored monthly at approximately 1,800 monitoring points. Piezometric levels are measured manually with water level dippers. The Department of Water and Sanitation (DWS) makes use of (detailed) field forms developed by an in-house Groundwater Field Monitoring Committee.

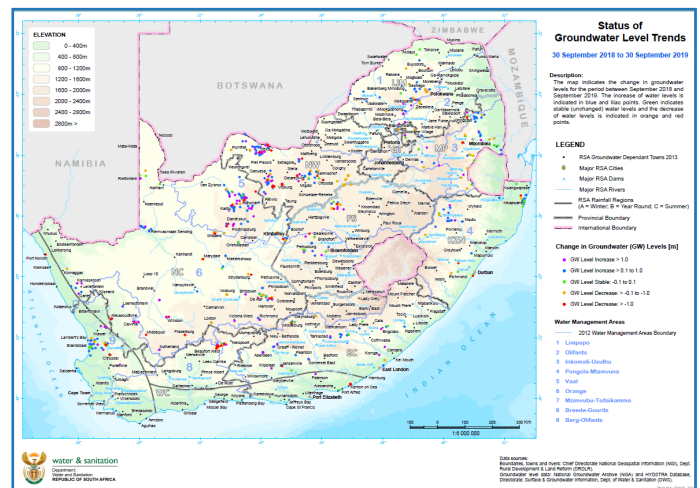
Standard operation procedures (SOP) are applied as a data quality control to ensure proper data collection. Two main procedures are: standard for Geosite description, and standards for capturing groundwater data.

## PROCESSING AND DISSEMINATION

DWS produces annual Groundwater Level Maps, Figure 1. Currently three maps are available on the website of the DWS indicating the difference of groundwater levels between Septembers of 2017 to 2018, of 2018 to 2019 and of 2017 to 2019.

Data are stored in the National Groundwater Archive (NGA), which is a centralized database with a web interface. Everyone with an interest in groundwater can register to search, capture and store data. Only one value of water level per month is stored in the NGA; larger time-series are stored separately in a Hydstra database.

The databases can be accessed from inside and outside the department and are accessible for registered users. However, not all data are online and detailed water level time series must be requested.



**Figure 15 - Difference in groundwater levels September 2018 to September 2019. Source: DWA**

## Sources

- **Department of Water and Sanitation (DWS). Groundwater level maps 2017-2019** - <http://www.dwa.gov.za/Groundwater/maps/gwlevelmaps.aspx>;
- **DWS. The National Groundwater Archive (NGA)** - <http://www.dwa.gov.za/groundwater/nga.aspx>;
- **Feedback from the Department of Water Affairs and Forestry** - received on 05-10-2020;
- **IGRAC, 2013. Groundwater Monitoring in the SADC Region, 2013. Overview prepared for the Stockholm World Water Week** - [https://www.un-igrac.org/sites/default/files/resources/files/Report\\_Groundwater%20Monitoring%20in%20SADC%20region.pdf](https://www.un-igrac.org/sites/default/files/resources/files/Report_Groundwater%20Monitoring%20in%20SADC%20region.pdf); and
- **SADC Country visits - 2017.**

# Sudan

**Capital city:** Khartoum  
**Inhabitants:** 41.8 Million



## INSTITUTIONAL SETTING AND PURPOSE

Several governmental institutions are responsible for groundwater in Sudan:

- The Ministry of Irrigation and Water Resources, responsible for all water resources, irrigation and domestic water supply;
- The Groundwater and Wadis Department, responsible for groundwater assessment, development and management; and
- State corporations (18 in total), responsible for rural and urban water supply (drinking water).

Monitoring networks for groundwater exist at regional and national scales but may be not covering all aquifers.

A regional network exists within the transboundary network of the Nubian Sandstone Aquifer System, which is monitored by the other three countries sharing the aquifer (Egypt-Libya-Chad) as well. Data collected is stored in a regional database named NARIS (Oracle), which is shared online among the four countries, with the server located in Tripoli, Libya. Eight monitoring wells are part of the network.

The Groundwater and Wadis Department monitors groundwater levels in the wadis Nyala and Gash and the Nubian Sandstone aquifer in the north of the country. Monitoring is carried out both manually and automatically. Telemetry technology was introduced in 11 wells in the Nubian Aquifer network and it is planned to use this technology in some other aquifers.

## CHARACTERISTICS OF THE NETWORK

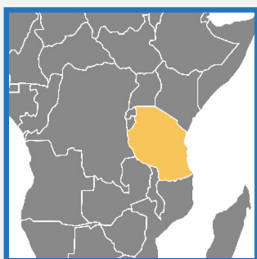
Monitoring data are stored in digital form in the Groundwater Directorate Database and in spreadsheets. Unpublished reports with results from groundwater quality monitoring are available at the ministries.



Figure 16 - Water tap in Sudan, by: Vitor Martinho

## Sources

- **Feedback from Secretary of Transboundary Groundwater Aquifers, Ministry of Irrigation and Water Resources of Sudan** - received on 17-09-20;
- **Gadelmula AH, Upton K, Ó Dochartaigh BÉ and Bellwood-Howard, I. 2018. Africa Groundwater Atlas: Hydrogeology of Sudan. British Geological Survey. Accessed 09-07-2019** - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Sudan](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Sudan);
- **IGRAC (2012). Information collected during GGMN Workshop in the IGAD Region** - <https://www.un-igrac.org/news/groundwater-monitoring-network-programme-africa>; and
- **IGRAC. Information collected during the regional training programme on Integrating Groundwater Management within River Basins held from 15-17 January 2019 in Nairobi, Kenya** - <https://www.un-igrac.org/news/integrating-groundwater-management-river-lake-basins-eastern-africa>.



## INSTITUTIONAL SETTING AND PURPOSE

Water resources in Tanzania are managed basin-wise; five river basins and four lake basins. Water monitoring is done by the Ministry of Water.

There is no national groundwater monitoring programme in Tanzania, but groundwater levels are monitored in several areas of the country.

## CHARACTERISTICS OF THE NETWORK

Groundwater monitoring in Tanzania started in 1955 with the Makutapora well field. In the early 2000, 12 monitoring wells were drilled in Rufiji basin with the assistance of the World Bank. In 2007, 30 boreholes were added in the Internal Drainage Basin, and 15 out of 35 planned boreholes were installed in the Pangani River Basin in 2010. 19 boreholes were drilled and installed with water level loggers by Japan International Cooperation Agency in Wami Ruvu Basin in 2011.

Currently, groundwater level monitoring is carried out in the Makutapora Basin in the Dodoma region by ten automatic data loggers, and in Arusha by the Arusha Urban Water Supply Authority and in TPC-Moshi. In Arusha groundwater levels are measured manually on a daily basis.

In 2017, a local groundwater monitoring network was installed in the Upper Great Ruaha Basin Observatory in southern highlands of Tanzania by the GroFutures team at Sokoine University of Agriculture (SUA, Tanzania).



Figure 17 - The Ruaha Basin in Tanzania

## Sources

- IGRAC, 2013. **Groundwater Monitoring in the SADC Region, 2013. Overview prepared for the Stockholm World Water Week** - [https://www.un-igrac.org/sites/default/files/resources/files/Report\\_Groundwater%20Monitoring%20in%20SADC%20region.pdf](https://www.un-igrac.org/sites/default/files/resources/files/Report_Groundwater%20Monitoring%20in%20SADC%20region.pdf);
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- GroFutures, 2017. **Groundwater monitoring established in the upper great Ruaha Basin of Tanzania** - <http://grofutures.org/article/groundwater-monitoring-established-in-the-upper-great-ruaha-basin-of-tanzania>; and
- Sangea H, Upton K, Ó Dochartaigh BÉ and Bellwood-Howard, I. 2018. **Africa Groundwater Atlas: Hydrogeology of Tanzania. British Geological Survey. Accessed 09-07-2019** - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Tanzania](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Tanzania).

# The Gambia

Capital city: Banjul  
Inhabitants: 2.3 Million



## INSTITUTIONAL SETTING AND PURPOSE

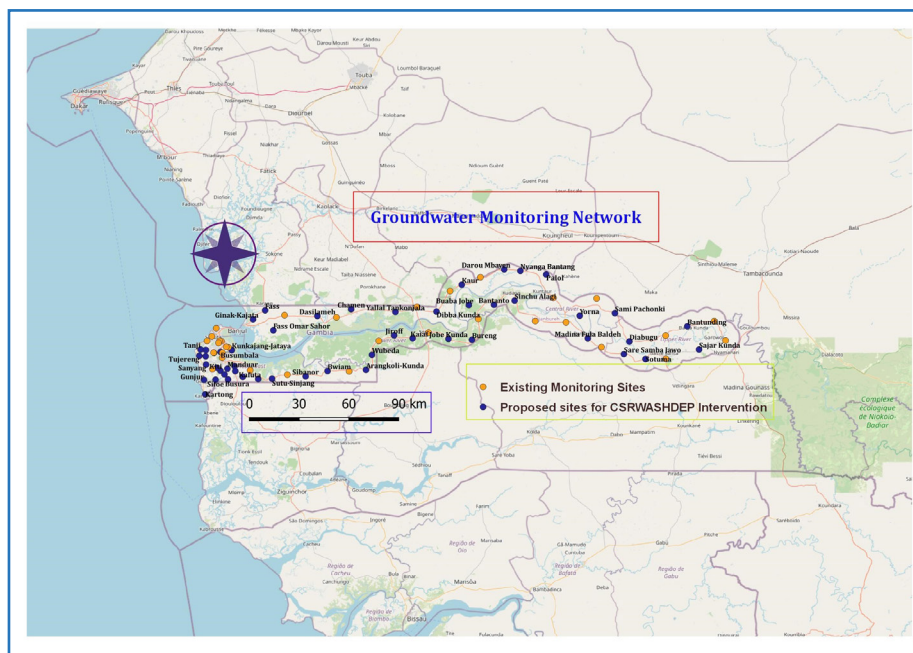
The Department of Water Resources (DWR) under the Ministry of Fisheries, Water Resources and National Assembly Matters is in charge of the development, use and protection of groundwater in the Gambia. The DWR maintains the national groundwater monitoring network. The network was established within the National Water Sector Reform Project (NWSRP) funded by the African Development Bank (AfDB) through the African Water Facility (AWF) from 2011 to 2015. The project aimed to

modernize the groundwater monitoring network to enhance the assessment of resources for sustainable groundwater management and development. However, due to high failure of the current groundwater data loggers, the department is also anticipating for further support from Climate Smart Rural WASH Development Project (CSRWASHDEP) with funding AfDB, to increase the number of monitoring sites and purchase more stable automatic data loggers.

## CHARACTERISTICS OF THE NETWORK

The Department presently operates a network of about 38 groundwater monitoring boreholes, installed with automatic data loggers, which are currently monitored manually. Around half of the monitoring points are spread in the Greater Banjul Area (GBA), the rest are equally distributed eastward at 35km distance throughout the north and south bank of the country. The loggers are designed to measure water level below ground surface (to be subsequently referenced to mean sea level) and groundwater temperature etc. The groundwater measuring devices were set at 6 hours interval, but the data was downloaded at a monthly basis or less frequently.

Figure 18 - Groundwater monitoring network of The Gambia



## Sources

- Bibliographic reference: Bojang L, Corr G, Upton K, Ó Dochartaigh BÉ and Bellwood-Howard, I. 2018. Africa Groundwater Atlas: Hydrogeology of the Gambia. British Geological Survey. Accessed 02-07-2019 - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Gambia](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Gambia);
- Feedback from the Department of Water Resources, Ministry of Fisheries, Water Resources and National Assembly Matters of The Gambia - received on 22-09-20; and
- GGMN People Network.



**Capital city:** Tunis  
**Inhabitants:** 11.6 Million

## INSTITUTIONAL SETTING AND PURPOSE

The General Directorate of Water Resources (DGRE) and the National Water Distribution Utility (SONEDE) are the key institutions in Tunisia involved in groundwater management.

## CHARACTERISTICS OF THE NETWORK

Monitoring of groundwater levels is done twice a year by 24 departments of the DGRE, through a network of more than 2,000 shallow wells and more than 1,100 deep wells.

## PROCESSING AND DISSEMINATION

DGRE publishes an annual report with the results of the monitoring of the deep aquifers, and every 5 years a report with the results of the monitoring of the shallow aquifers.

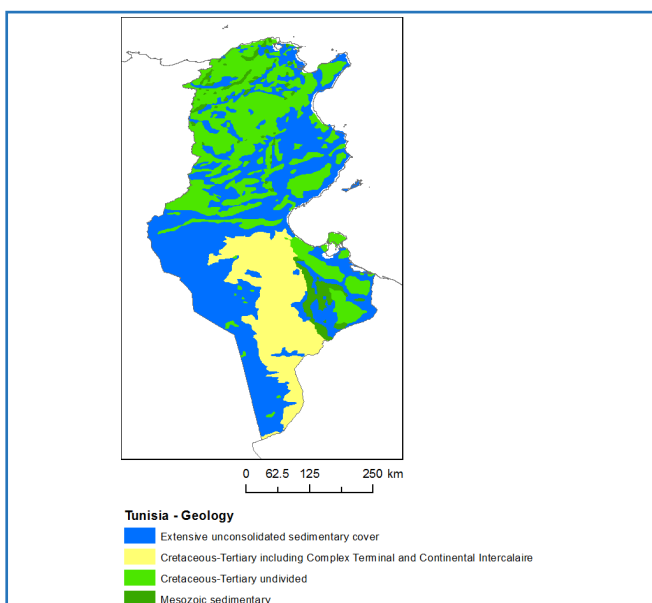


Figure 19 - Geology map Tunisia, source: Earthwise.bgs.ac.uk

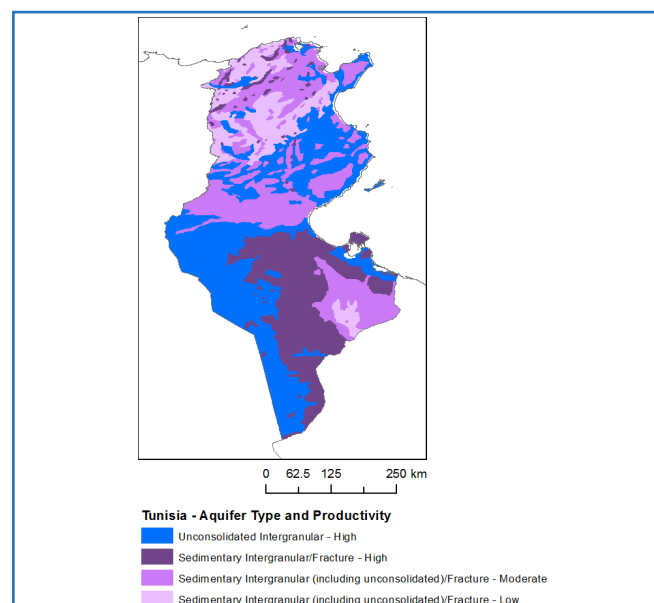


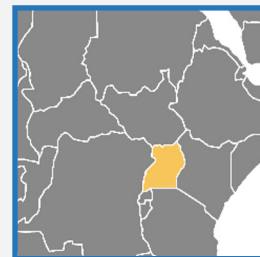
Figure 20 - Hydrogeology map Tunisia, source: Earthwise.bgs.ac.uk

## Sources

- Ben Ammar, S., Mekni, A., Upton, K., Ó Dochartaigh, B.É. and Bellwood-Howard, I. 2018. Africa Groundwater Atlas: Hydrogeology of Tunisia. British Geological Survey. Accessed 09-07-2019 - [http://earthwise.bgs.ac.uk/index.php/Hydrogeology\\_of\\_Tunisia](http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Tunisia);
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- Ministry of Agriculture, Hydraulic Resources and Fisheries. Water resources - <http://www.agridata.tn/fr/group/pluviometrie>; and
- Euro-Mediterranean Information System on know-how in the Water Sector - <http://www.semide.net/fr>.

# Uganda

Capital city: Kampala  
Inhabitants: 42.7 Million



## INSTITUTIONAL SETTING AND PURPOSE

The Directorate of Water Development and the Directorate of Water Resources Management (DWRM), both under the Ministry of Water and Environment (MWE), are responsible for implementing national legislation on the sustainable use of natural resources, including groundwater. Among others, DWRM is in charge of managing and monitoring groundwater resources.

## CHARACTERISTICS OF THE NETWORK

In 2017, the national groundwater monitoring network consisted of 55 boreholes, from which 23 were operational and 23 were newly drilled and waiting for instrumentation. Some of the monitoring wells are located close to abstractions boreholes to monitor the effects of abstraction, but most of them are far to monitor natural groundwater level fluctuations.

## PROCESSING AND DISSEMINATION

Groundwater monitoring started in 1998 and recordings of groundwater levels are available for 30 stations. The National Groundwater Database (NGWDB) managed by the DWRM contains key borehole information provided by drilling contractors, as they must return borehole completion forms quarterly to DWRM for each borehole drilled. Only boreholes deeper than 30 m are generally included in the database. The national moni-

toring database is Access-based but not user-friendly.

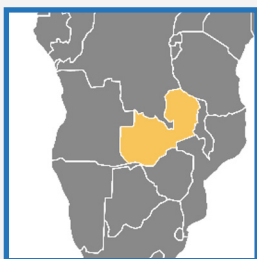
Groundwater maps and the report, results of the Mapping Groundwater Resources in Uganda Programme 2012, are publicly available. They present the location of shallow, deep boreholes and springs.



Figure 21 - A water well in Uganda, by: Dennis Wegewijs

## Sources

- **GGMN workshop IGAD - 2012;**
- **Ministry of Water and Environment. Directorate of Water Resources Management. Kibaale District Groundwater Report, 2012. Mapping of Groundwater Resources in Uganda - <https://www.mwe.go.ug/sites/default/files/library/Kibaale%20Ground%20Water%20Map%20Report.pdf>; and**
- **Ministry of Water and Environment, Republic of Uganda. Kibaale Groundwater Maps - <https://www.mwe.go.ug/library/kibaale-ground-water-maps-0>.**



## INSTITUTIONAL SETTING AND PURPOSE

The Department of Water Resources Development (DWRD) under the Ministry of Water Development, Sanitation and Environmental Protection is responsible for the water policy, transboundary groundwater resources management and development. DWRD is also in charge of aquifer mapping, well field development and groundwater exploration. The Water Resources Management Authority (WARMA), which is an autonomous body established by the Water Resources Management Act, is responsible for the implementation of the Act, the allocation and management of all water resources of Zambia, including groundwater monitoring.

Only a part of monitoring is carried out by the institutions mandated to do so because of budget limitations. Groundwater monitoring is partly performed by organizations and industries within their areas of operations such as the Zambezi River Authority (Lake Kariba and parts of the Zambezi River), Zambia Electricity Supply Cooperation (on Kafue River) and various mining companies. Some of these monitoring data are reported monthly to WARMA.

## CHARACTERISTICS OF THE NETWORK

The central groundwater monitoring network consists of 100 piezometers, of which 44 are located around Lusaka, where groundwater levels are monitored 4 times per year.

## PROCESSING AND DISSEMINATION

The Ground Water Management Information System (GRIMS) is used to store and analyse data and produce information. GeoDin is another software used at WARMA. The data are available to the WARMA and the Ministry, and external users can access it upon written request. Data from 1970 onwards are present in the files.

The main users of the data are the WARMA, the Ministry, universities and consultants.

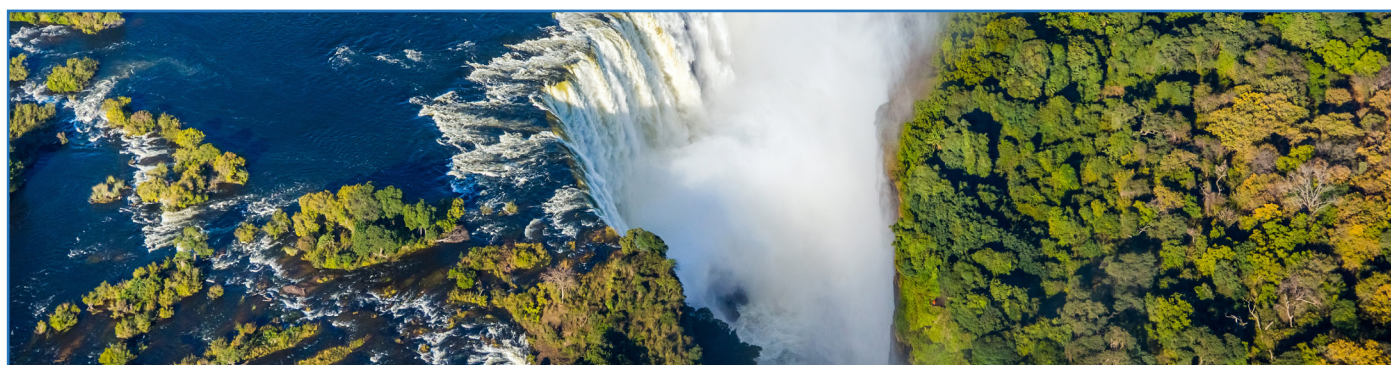


Figure 22 - Bird eye view of the Victoria falls waterfall on Zambezi river

## Sources

- GGMN workshop SADC - 2013; and
- Country visits SADC - 2017.



# Zimbabwe

**Capital city:** Harare  
**Inhabitants:** 14.4 Million



## INSTITUTIONAL SETTING AND PURPOSE

The Groundwater Division of the Zimbabwe National Water Authority (ZINWA) is a parastatal entity under the Ministry of Lands, Agriculture, Water and Rural Resettlement. ZINWA is responsible for monitoring groundwater quality and levels. Furthermore, the Catchment Councils, through the sub-catchment councils, are responsible for water allocation and groundwater monitoring in the context of a catchment scale.

There is no national groundwater monitoring plan in Zimbabwe, but groundwater levels are measured by ZINWA in three major aquifers: the Lomagundi Dolomite Aquifer (in the north west of Zimbabwe), the Nyamadlovu Sandstone Aquifer (in the south west of Zimbabwe) and the Save Alluvial Aquifer (in the south east of Zimbabwe). The objective is to perform resource monitoring for the development of well fields.

## CHARACTERISTICS OF THE NETWORK

Water levels are measured manually once per month. There are routine checks to assure the quality of the data, but no standard protocol is employed. During data collection, no specific procedures for quality control are applied.

Considering the number of authorities collecting various groundwater data, it is expected that quality control procedures or protocols vary depending on the type of data being collected.

## PROCESSING AND DISSEMINATION

For the well fields, the monitored groundwater level data are stored in Excel files in internal hard drives, and in some external drives for backing up. Hard copies of field measurements are also stored. The data can be accessed through a formal written request indicating the purpose of the data.

The external access to the data can be challenging since there is no national database. This means that the data are found in different departments or stakeholders, which must be approached separately to make a request. Moreover, in most cases it is not possible to know beforehand what kind of data are available and in which department.

*Figure 23 - Aerial view of cultivated fields in the countryside of Zimbabwe-by Soldo76*



## Sources

- **Country visits SADC - 2017;**
- **Feedback from the Department of Water Resources Planning and Management; Ministry of Lands, Agriculture, Water and Rural Resettlement** - received on 22-09-20; and
- **GGMN workshop SADC - 2013.**

# NATIONAL GROUNDWATER MONITORING PROGRAMMES

## A GLOBAL OVERVIEW OF QUANTITATIVE GROUNDWATER MONITORING NETWORKS

Groundwater is a vital natural resource, being increasingly under pressure of climate change and human activities. We need to monitor the invisible groundwater in order to use and protect it properly.

This document provides an overview of quantitative groundwater monitoring networks at national scale. It is prepared to encourage sharing of monitoring experience, assist in improvement of monitoring and data processing and increase awareness of a general lack of groundwater monitoring.

The full report, including analyses and country profiles of other regions is available on the IGRAC website:

**[www.un-igrac.org/global-monitoring-overview](http://www.un-igrac.org/global-monitoring-overview)**



International Groundwater Resources Assessment Centre