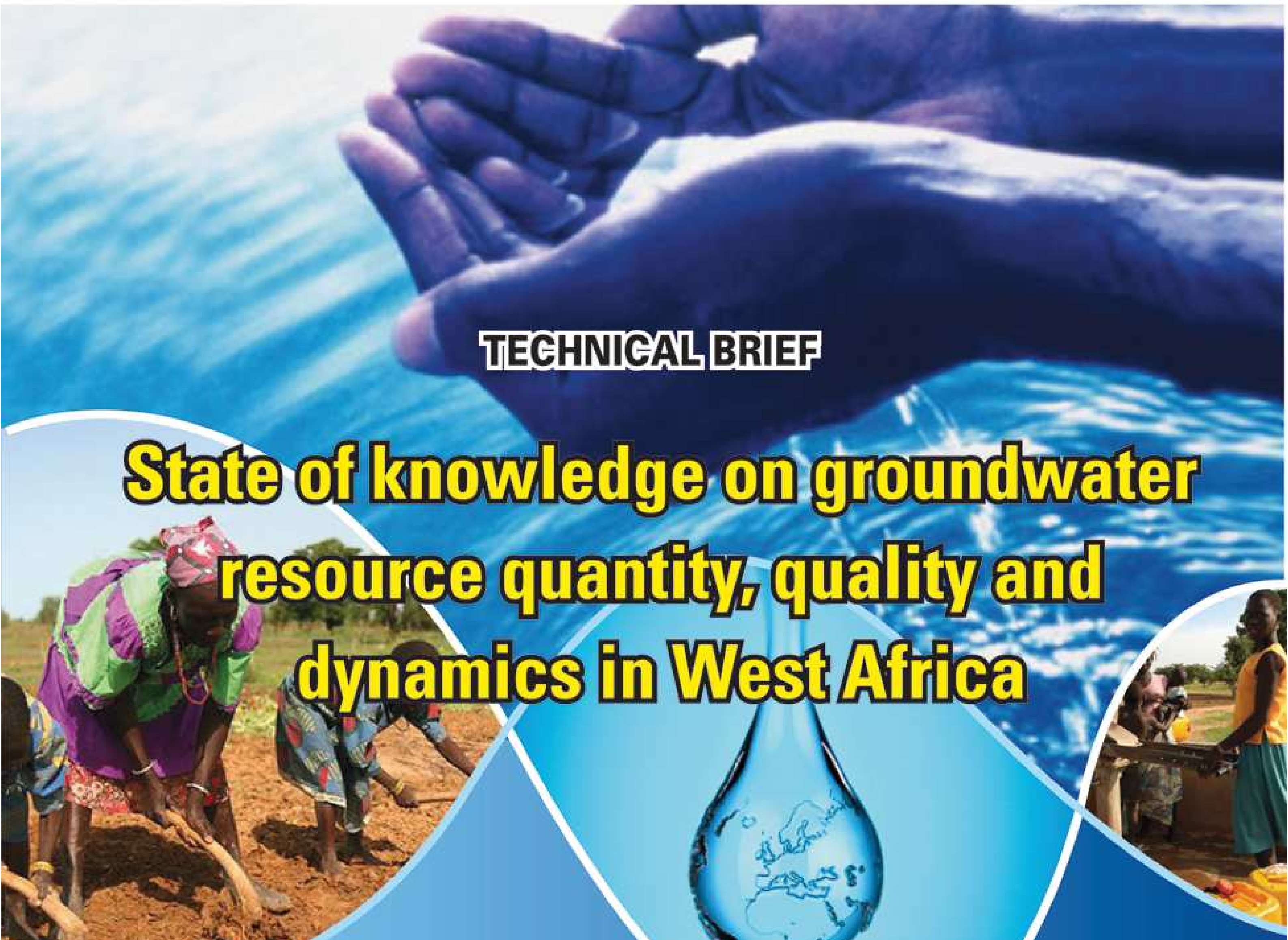
ACPC African Climate Policy Centre

Economic Commission for Africa

Global Water Partnership West Africa



TECHNICAL BRIEF

State of knowledge on groundwater resource quantity, quality and dynamics in West Africa

INTRODUCTION

Groundwater is the world's largest, accessible store of freshwater. Groundwater is also the primary source of drinking water to nearly half of the world's population and, as the dominant source of water to irrigated land, is critical to global food security. Heightened variability in precipitation brought about by climate change will intensify pressure upon groundwater resources to meet rapidly growing, global demand for freshwater. Despite this dependence, both the Third (2001) and Fourth (2007) Assessment Reports of the Inter-governmental Panel on Climate Change (IPCC) note: *"groundwater is the major source of drinking water across much of the world…but there has been very little research on the potential effects of climate change".*

Groundwater represents a key element of food security, and, therefore contributes to poverty reduction. Moreover, groundwater is climate sensitive resource and is a very important resource for West Africa, notably for the Sahelian countries (UNECA/ACPC 2011). Poor knowledge of the groundwater resources in both quantity and quality for the current, short and long-term periods further exacerbates the resource vulnerability to anthropogenic pressure and climate related impacts. The water tables recharge mechanisms remain little known and studied to date. The insufficiency of available long observation data sets does not also facilitate the analysis of the impacts of the climate on groundwater

The state of knowledge and management of West Africa groundwater resources is not well known for most of the trans-boundary aquifers resources. In general, there is limited knowledge on aquifers and not many initiatives exist to change dearth of knowledge of these vital resources. Like its surface waters, West Africa's groundwater is characterized by the trans-boundary nature of its aquifers. Out of the 40 most important aquifers identified in Africa, 10 are entirely located in West Africa and shared by two or more countries of the sub region. Amongst the 15 continental West African countries, 12 are directly connected to at least one cross border aquifer (GWP/WA 2011).
Two essential factors need to be taken into account in assessing and ameliorating the knowledge of groundwater resources in West Africa: the knowledge of aquifers in their hydrodynamic and geometrical dimensions on the one hand and the evolution of physicochemical parameters due to anthropogenic interaction on the other.

1. TYPOLOLOGY OF KNOWLEDGE

It is important to distinguish the knowledge of the resources related to the satisfaction of the water demands from the knowledge of the aquifers which include a set of parameters and the resource itself. Experience has taught one that in order to better know an aquifer; it must be regularly exploited and appreciated in all its dimensions (hydrodynamic, geometric physic-chemical characteristics including the inflow and outflow fluxes.)

A better knowledge on the groundwater resources may be premised on two essential aspects: the knowledge of the aquifers' geometric dimensions on one hand and of the monitoring of the evolution of the physic-chemical parameters on the other.
In order to achieve this goal an optimum national network allowing accurate evaluation of the groundwater resources must be defined for each hydrogeological unit as a function of the state of its knowledge, the hydrogeological complexity, the geological structure of the aquifer, its recharge mode and the state of exploitation, as well as the vulnerability parameters.

2. CASE STUDIES: SENEGAL AND MALI AND THE IULLEMEDEN AQUIFER SYSTEM

A look at the rapid assessment of the state of knowledge and management of groundwater in Mali, Niger and Senegal provide a helpful preliminary appreciation of the situation in the sub-region.

The aquifers in Senegal are located in the Senegalo-Mauritanian Aquifer System which occurs in Mauritania, Senegal, Bissau Guinea and Gambia in the form of a coastal plain covering an area of nearly 500 000 km2. They serve a population of more than 6 million inhabitants. The basin occurs in a semicircular form opened to the Atlantic Ocean over 1400 km. The Senegal aquifers form a coherent group of basins including many trans-border aquifers with the Senegalo-Mauritanian basin.

.

The several hydro geological studies of the last half century carried out several researchers have allowed identifying most of the Senegalese sedimentary basin aquifers. Nine hydro geological units grouped into four big aquifers systems corresponding to the main geological formations have been identified. The most important piezometric network of the Senegalo-Mauritanian basin is the one put in place by OMVS from 1985 to 1990. It had 1174 observations points of which 748 for groundwater boreholes (332 piezometers) and 416 for traditional wells. Out of this network, the aquifers intensively used or showing some risks of quality losses from diverse origins (such as pollution and salt water intrusion) are identified and more or less regularly monitored.

State of the data base management: Several data bases exist for the monitoring and management of groundwater resources in Senegal. The Directorate for water resources management and planning (DGPRE), which is responsible for this function, is equipped with several of powerful groundwater modelling softwares.
Groundwater quality: The principal physical and chemical characteristics of the aquifers have been established from a survey of available sources and literature.

In Mali, the aquiferous basin of Taoudeni is entirely located in the Saharan area and covers over 2 000 000 square kilometres and occurring in Mauritania, Mali and Algeria. Its extensions reach some parts of Niger, Senegal and Burkina Faso if one considers all its geological formations. The stratigraphical configuration of the basin consists of ancient and recent sedimentary with their aquifers linked to the following:

- The individualized Intercalary Continental (CI)
- The undifferentiated CI and Continental Terminal (CT),
- The higher Cretaceous and the lower Eocene,
- The CT and the Quaternary.

In Mali, the Taoudeni basin is relatively better known due to the execution of several drilling works in search for oil. According to evaluations by SSO, the Taoudenni aquiferous system covers a surface area of about 500 000 km2 with a water potential estimated at 2 000 billion cubic meters.

The Gondo plain is located in the South West of the Bandiagara cliffs and extends to Burkina as far as the confluence between the Sourou and Mouhoun rivers. The Malian portion of the Gondo plain covers about 26 000 km2. According to the Hydro-geological Summary of Mali, the Gondo plain is a formation of the Terminal Continental and the Quaternary without any generalized aquifers, but it contains water tables lying at different levels between the depth of 10m and 50m. However, according to the Report produced by the integrated hydro-geological prospecting Mission in the Gondo Plain (University of Neuchatel 1988), Gondo constitutes a system of two discontinuous stacked up water tables flowing temporally towards the Sourou River in the South due to the link that probably exists between the Gondo aquiferous system and the Sourou River.

The Iullemeden Aquifer System (sedimentary groundwater basin) covers an area of 525 000 km2 and is the best known among the basins in Sub-Sahara due to the scientific studies that OSS has conducted during the last fifteen years.

It occurs in Mali over an area of 31 000 km2; it spreads to Nigeria where it covers a 60 000-km2 area known as the Sokoto basin. Niger with a coverage of 434 000 km2 of Iullemeden hosts the bulk of the aquifer system. Its water potential is not yet sufficiently known, but is estimated at about 40 000 billion m3. Algeria also shares a portion of the basin.

Past and Current status of Monitoring and database creation in Iullemeden Aquifer and beyond

Aspects of Data	Mali	Niger	Nigeria
Databases established through policy and master plan studies in the 1990s & updates	Nationwide Hydro-geological Synthesis of Mali, including the establishment of the digitised GIS SIGMA data base completed in 1993 (by UNDP assistance) provided a comprehensive physical parameter, piezometric, hydrodynamics and hydrochemistry, water balance and utilization.	The new national water sector strategy (2001) based on The Comprehensive National Water Resources Master Plan established in 1993 with support from UNDP, recognizes and supports the need for planning and research.	National Borehole Program established under the National Water Resources Policy Study in 1993 yielded database for sourcing and updating water resources data nationwide; FAO-supported National Water Resources Master Plan in 1985 & JICA's of 1994-1995 were adopted in 1999.
GIS Database	The SIGMA data base is currently being updated.	The SIGNER GIS database established in the Ministry of Water Resources in the 1990s is currently being updated under project NER/99/001 "Water and Sustainable Development", supported by UNDP	3- year National Hydro-geological Map project to update and establish a GIS database.
Recharge studies using varied techniques- chemical and isotopes/tracer elements	In the Iullemeden basin, water resources development under a joint program with Algeria in support of nomadic populations for deep water drilling and data collection has recently been initiated in north-eastern Mali.	Recent and ongoing recharge studies, land use/degradation using remote sensing and ground surveys, and modeling studies of the Iullemeden in Niger (by ETH and others; with IRD-HSM support around Niamey).	Recent (2000) isotopic study of groundwater recharge in Iullemeden basin in Nigeria with IAEA support
Hydro-geological Studies of the 1970s and 1980s.	--------	--------	Hydro-geological studies of the Iullemeden aquifers in Nigeria in the 1970s and 80s by the Geological Survey of Nigeria and USAID provided important reference data from deep exploratory drilling.
Basin data and studies are available with national Universities active in groundwater research	ENI in Mali	Abdou Moumouni University in Niamey, Niger	University of Benin, Benin City, Nigeria, University of Maiduguri, Nigeria

While national monitoring, data collection and study networks established in the 1970s and 1980s have declined, the countries in the last few years have initiated programmes for data collection and assessment of the water and land resources, including the general modeling studies of the Iullemeden aquifer system. However data collection and modeling are constrained to country sections of the basin and data remain scattered and fragmented between the countries and in individual institutions.

A piezometric network of 230 sites covers the various aquifers in Mali.

Groundwater Quality: SIGMA 2 contains about 10 000 results of analyses results (dating from 1982 to 1991) on water quality, but only 2 822 have adequate information which may help to clearly identify water points. Information processing is often limited by certain technical hindrances, particularly because the current computer filing of laboratory analysis does not readily support data entry in SIGMA2.

State of the data base management: The only data storing and filing tool is the SIGMA data base. It helps to manage all data on water resources and catchment works. All the actors intervening in the hydraulic sector were required to transmit the information and data they will have collected during their tasks to the database. The regional directorates of hydraulics have been trained and have a copy of SIGMA2 to facilitate the transmission of relevant data to the central data base. According to the HydroCouncil-BREESS Group, out of the 15 930 boreholes recorded in SIGMA2:

- the static level is not reported in 4891 boreholes, i.e. 30.7% of the total;
- lithology is not reported in 14,3 % of the boreholes; and
- 30,6 % of the total number of boreholes are not geographically located.

3. STRATEGY (STEPS) FOR IMPROVING STATE OF KNOWLEDGE OF GROUNDWATER:

A national optimal piezometrical network that will permit an adequate evaluation of groundwater resources needs to be defined for each hydro-geological unit in accordance with the state of its knowledge, hydro-geological complexity, the aquifer geological structure, its supply method and the state of its exploitation.
Therefore the following recommendations should be taken into consideration:

- The different aquifers should be identified, demarcated and updated ;
- A unique codification system for water points and aquifers needs to be drawn up and applied;
- The existing piezometers need to be assessed, charted, probably reshaped and monitored on a regular and continuous basis;
- An adequate and sustainable financing mechanism for ground waters control should be established.

i. Making an inventory of the existing literature/data and metadata at each country's level

- identifying what exists and the weaknesses; Advertizing this literature/data and metadata.
- The identification and delimitation of the different aquifers be updated ;
- A unique codification system of the water points and the aquifers be drafted and implemented ;
- An inventory of the existing piezometers be made, that they be mapped, regularly and continuously monitored ;

ii. Improving the knowledge of aquifers (Geometry, hydrodynamic characteristics including recharge and discharge mechanisms, water levels and quality).

iii. Setting up a common/regional database for the countries in order to share data: heterogeneity and disparity of the data format and codifications amongst countries need to be eliminated. Process

- Digitizing the data, harmonizing them
- Creating central databases
- Establishing synergies with similar initiatives (e.g. WRCC/ECOWAS Observatory,

iv. Establishing adequate and permanent financing mechanism for groundwater monitoring activities and information system to be operational and sustained.

4. SUMMARY AND RECOMMENDATIONS

The adequate knowledge of groundwater resources remains a prerequisite to sustainable or integrated management. Information and communication of the scientific and technical knowledge on the groundwater status are extremely relevant for the management of the vital resources;

It is essential to promote and establish adequate sustainable soft and hard investments for the scientific and technical knowledge generation on the trans-boundary aquifer Concrete incentives for knowledge and information generation and dissemination and sharing at all levels should be provided. The Inventory of the "grey" literature, existing databases at the level of each country, recovery the existing data, and creation of a database network as well as upgrading of the existing piezometric network. Then, of course, digitalising and harmonizing the data in usable spatial and times series formats should be undertaken.

Priority should be given to no/low regret research work on aquifers and climate impact studies, the resource vulnerability,. Such systematic studies should be shed light on the impacts of climate variability and change on aquifers, and the adaptation and coping mechanisms or measures to be undertaken.

Efforts should be geared up for the improvement of the knowledge through monitoring and analysis of the aquifer systems, their geometry, hydro-geological complexity, capacity, instantaneous recharge, limits and discharge rates, depth from surface to water table, and water quality (pollution sources and industrial wastes) as well the hydro-dynamics of each aquifer system and its resources.

set up a common database for the countries in order to share data such as digitized data, then harmonize, create central databases,

Creation of common regional databases (at aquifer basin under an appropriate institution, or West Africa level) that facilitates normalizing, organizing and disseminating data on the climate, environment and water resources, based on data collected at the national and the aquifer/river basin levels. Regional monitoring network should be strengthened, synergies established with similar initiatives (e.g. CCRE/ECOWAS Observatory, G-WADI/UNESCO Project).

Time is now to improve scientific bases that promote effective tackling water resource problems in order to fill the gaps in the knowledge of the resource (quantitative and qualitative information pertinent to both surface and ground water) in order to provide proper orientation for better decision making.

5. REFERENCES

GEF. 2003 (April). *Managing Hydro-geological Risk in the Iullemeden Aquifer System, Project Brief, GEF Medium Size Project, Global Environmental Facility.*

GWP/WA 2011a. *Diagnosis Study report on the Dialog on concerted management of groundwater in West Africa, 53p.*
GWP/WA. 2011b. Dialog on concerted management of groundwater in West Africa: Climate change consequences on underground water in West Africa

UNECA/ACPC. 2011. *Management of Groundwater in Africa Including Trans-boundary Aquifers: Implications for Food Security, Livelihood and Climate Change Adaptation. Working paper. http://www.uneca.org/acpc/publications.*

University of Neuchatel. 1988. Report of the Integrated Hydrogeological Prospecting Mission in the Gondo Plain.

This document is an output from the regional study and workshop organized by GWP in West Africa. They were funded by the African Climate Policy Center (ACPC) at the UN Economic Commission for Africa, the Food and Agricultural Organisation (FAO) regional office, the West African Economic and Monetary Union (UEMOA). However, the views expressed and information contained in it are not necessarily those of or endorsed by those organisations, which can accept no responsibility or liability for such views, completeness or accuracy of the information or any reliance placed on them.

05 B.P. 6552 Ouagadougou 05 - Tel. : (+226) 50 48 31 93 / 50 36 18 28
E-mail: secretariat.gwpao@gwpao.org - Site Web: http://www.gwpao.org - Burkina Faso