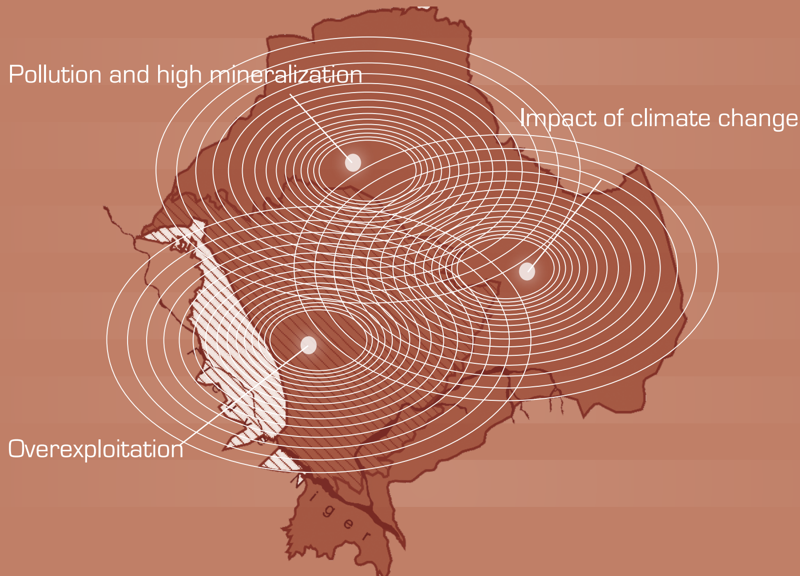
Iullemeden Aquifer System

The GEF TDA/SAP approach applied to the IAS



SAHARA AND SAHEL OBSERVATORY

Iullemeden Aquifer System

Mali - Niger - Nigeria

The GEF TDA/SAP approach applied to the IAS

Tunis, 2011

Edited in Tunis with the financial suppot of Unesco/IHP and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

ISBN : 978-9973-856-55-5

Acknowledgments

This document was reviewed and edited under the supervision of M. Chedli Fezzani, Executive Secretary of the Sahara and Sahel (OSS). It emanates from the work lead from January 2004 to June 2009, in partnership with Mali, Niger and Nigeria, under the scientific coordination of the technical project team "Iullemeden Aquifer System" based at OSS, compound: M. Abdel Kader Dodo Regional Project Coordinator, M. Mohamedou Ould Baba Sy, Expert in database, GIS and groundwater modelling, and scientific advisor Ahmed Mamou Wafa Jouini, Assistant to the Water Programme of the OSS.

We express our deep gratitude to the personalities who contributed in this work, especially:

MALI

- Mme Ly Fatoumata, Directrice nationale de l'hydraulique
- M. Malick Alhousseini, ex-directeur national de l'hydraulique, actuellement Conseiller du ministre des Transports
- M. Sidi Touré, Chef de division Inventaire des ressources hydrauliques à la DNH
- M. Séïdou Maïga IRH/DNH, Point focal national
- M. Alpha Oumar Kergna, IER/ECOFIL
- M. Amadou Maïga, ministère de l'Environnement et de l'Assainissement, STP/CIGQE
- Pr Amadou Zanga Traoré, Ecole nationale d'ingénieurs de Bamako

NIGER

- M. Radji Garba, Directeur national des ressources en eau, ministère de l'Hydraulique,
- Dr Abdou Guero, ex-directeur des ressources en eau, actuellement Directeur technique à l'Autorité du bassin du Niger,
- M. Abdou Moumouni Moussa, Hydrogéologue, ex-point focal national et chef de la Division hydrogéologie, actuellement en thèse de doctorat (Ph. D)
- M. Sanoussi Rabe, Hydrogéologue, chef de la Division hydrogéologie, Direction des ressources en eau
- M. Kaïgama Kiari Noudjia, Juriste, Directeur national de la législation, MH
- M. Rouscoua Boubacar, Socio-économiste, MH

NIGERIA

- Mrs Doris Isoken Enobakhare, Senior Advisor of the Permanent Secretary, Federal Ministry of Agriculture and Water Resources (FMWR), Abuja
- Mr. John Chabo, Executive Director of Nigeria Hydrological Services Agency (NHSA), FMWR, Abuja
- Mr. Patrick Oburo, Assistant Director, NHSA, FMWR, Abuja
- Mr. Stephan M. Jabo, ACHg., NHSA, FMWR, Abuja
- Prof. L.J. Goldface-Irokalibe, Lawyer, University of Zaria

We express our deep gratitude to our partners for their financial, scientific and technical support:

- Takehiro Nakamura, UNEP/GEF
- Alice Aureli, UNESCO/PHI

- Stephano Burchi, FAO

We also thank the UNESCO/IHP and GIZ for their financial support in publishing this document, as well as France, Switzerland, AWF/ADB and the NBA for their continued support to the Water Programme of OSS.

We are also indebted to Mrs Tharouet Elamri who undertook the design of the model and the finalization of this document not to mention the financial and administrative team who have spared no effort for the successful implementation of all activities of this project.

Water Programme coordinator

Abdelkader Dodo

Executive Secretary

Dr. Chedli Fezzani

Contents

List of acronyms

ADT	Analyse diagnostique transfrontalière
AUE	Association des usagers de l'eau
CCSEA	Comité de coordination du secteur eau et assainissement
CEDEAO	Communauté économique des États de l'Afrique de l'Ouest
CES/DRS	Conservation des eaux et des sols / Défense et restauration des sols
CH	Continental Hamadien
CI	Continental intercalaire
CNCS	Comités nationaux de coordination et de suivi des activités du projet
CT	Continental Terminal
FAO	Organisation des Nations unies pour l'agriculture et l'alimentation
FEM	Fonds pour l'environnement mondial
GIRE	Gestion intégrée des ressources en eau
GIS	Geographic Information System
OMS	Organisation mondiale de la santé
ONG	Organisation non gouvernementale
OSS	Observatoire du Sahara et du Sahel
PANA	Plans d'action nationaux d'adaptation aux changements climatiques

PAS	Programme d'action stratégique
PNUD	Programme des Nations unies pour le développement
SAI	Système aquifère d'Iullemeden
SAP	Système d'alerte précoce
SIG	Système d'information géographique

1. Introduction

The Iullemeden Aquifer System consists of a number of sedimentary deposits containing two large aquifers: the cretaceous Continental intercalaire (Ci) in the bottom, overcome by the tertiary Continental Terminal (CT). It is shared by Mali, Niger and Nigeria and covers a total area of approximately 500.000 km^2. It is crossed by part of the Niger River hydrographic network. The Iullemeden Aquifer System constitutes a strategic resource for the sustainable development of the concerned countries. However, it is:

- **exposed to a fragile and constraining environment:** 1) lower rainfall of about 20 to 30% since 1968; 2) reduction of the runoff of about 20 to 50% with sometimes severe low water levels moving to stop; 3) silting and establishment of sand dunes in the aquifer's areas recharge and in the Niger river hydrographic network;
- **facing several constraints in particular:** 1) difficulties of accessing groundwaters by places because of high depth (more than 600 meters); 2) degradation of water quality (pollution, withdrawing high mineralised deep waters); 3) shortcomings in shared groundwater management among riparian countries;
- **subjected to:** 1) increasing water demand linked to population growth (about 6 million inhabitants in 1970, 15 million in 2000 and a projected 30 million inhabitants in 2025);

2) an exponential rise in abstractions which went from 50 million m^3 in 1970 to 180 million m^3 in 2004.

To identify, analyze and assess risks which affect groundwater of the Iullemeden Aquifer System, the Transboundary Diagnostic Analysis/Strategic Action Program (TDA/SAP) GEF International Waters approach has been adapted and applied. It is important to remember that this is the first application of this approach on transboundary aquifers in Africa, and the second in the world after the Guarani Aquifer System in Latin America (shared by Argentina, Brazil, Paraguay and Uruguay).

II. International Waters

In order to distinguish between the GEF concept of « International Waters » and the legal definition of the United Nations law on the "Seas Convention"[1] the GEF operational strategy focuses on "Transboundary" water resources and emphasises the management of pollution and water resources based on a binational and multinational stakeholders' participatory process[2].

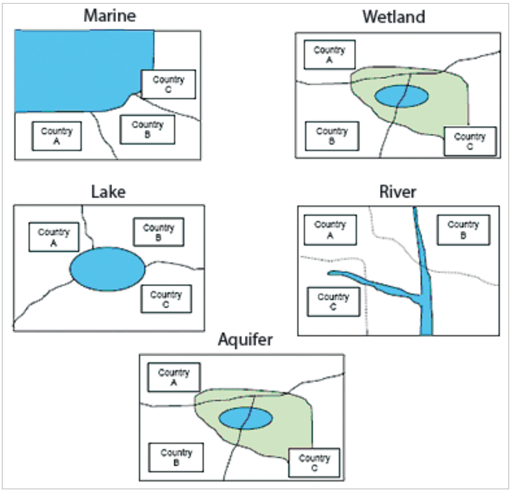


FIGURE 1 : Examples of Transboundary Waters

On the other hand, most of the international waters projects, financed by GEF, relate to environmental water problems which extend beyond any single country and, therefore, have a Transboundary character. The areas concerned are: marine waters, lakes, rivers, wetlands

---

[1] Under UNCLOS III, the high seas (or international waters) apply to all parts of the sea which are not included in the exclusive economic zone, of the territorial waters or inland waters of a State or of the archipelago waters of a archipelago State.

[2] The stakeholders are the parties involved or affected by an environmental problem or by its solution.

and aquifers (figure 1).

Each problem of management of international waters can justify the achievement of the desirable environmental objectives based on a International Waters project. One component of a International Waters project is the TDA/SAP process[3].

Three key principles are prevalent in the whole of the process:

- consultation[4] the persons affected by the problem (they are the stakeholders);
- adaptive management[5], follow-up, adjustment and revision as work progresses;
- gradual involvement of the waters responsible of the action.

---

[3] UNEP. The GEF IW TDA/SAP Process: Notes on a Proposed Best Practices Approach.

[4] By including a clear representation of the stakeholders at all stages, consensus building will be more likely and will increase the likelihood of ownership by the stakeholders of the result which will, therefore, have long-term viability.

[5] Adaptive management is a process by which the long term environmental goals are reached in a series of pragmatic action measures. Within each measure, agreed performance indicators are controlled and an exercise of joint planning is initiated to review progress and to adjust the approaches as required, as well as to plan the next stage.

III. Development of the Transboundary Diagnostic Analysis

The Transboundary Diagnostic Analysis is an objective evaluation, an analytical study of the scientific and technical facts, which serves to determine the relative importance of the sources, the causes and their impacts on Transboundary issues in matter of water. In other words, the Transboundary Diagnostic Analysis uses the best technical and scientific information, both **available and validated**, to examine the state of the environment and the underlying causes of its degradation. It must be an objective evaluation and not a negotiated document.

The analysis is conducted in a cross-sector way, while focusing on Transboundary issues, and without losing sight of national concerns and priorities. So that the analysis would be more effective and sustainable, it must include a detailed analysis of governance, which examines local, legislative and political environment.

The process of the Transboundary Diagnostic Analysis makes it possible to break down complex Transboundary situations into smaller components, which are more manageable within the framework of the actions to be conducted, such as degradation specific sub-zones or priority "hot spots".

The TDA is a scientific and technical process of study of the facts (or of diagnosis) of the state of, and threats to, international waters. Its objective is to:

- identify, quantify and prioritise the environmental problems of a Transboundary character;
- identify their immediate, major and underlying causes.

The identification of the causes comprises: the practices, sources, sites and sectors of human activity from which environmental degradation originates or represents a risk.

The stages involved in the TDA development process are (figure 2):

- Preparation of the TDA;
- Analysis of the impacts and consequences of each Transboundary problem;
- Final prioritisation of the Transboundary problems;
- Analysis of cause/effect chains and analysis of governance;
- Production and submission of the complete draft TDA;
- The TDA is adopted by the Steering Committee.

Throughout the world, Transboundary Diagnostic Analysis has very often been applied to the first four surface areas, i.e. rivers (basins), lakes, wetlands and marine water[1].

The first aquifer system that benefited from the GEF TDA/SAP approach of the Guarani Aquifer System (GAS) shared by Argentina, Brazil, Paraguay and Uruguay. However, the SAG is not yet known within its natural limits to better understand the dynamics of groundwater flows well as tools for managing the resource has been developed. Iullemeden Aquifer System

[1] http://www.iwlearn.net/ftp/iwps.pdf

represents the first case, at least on the African continent, where Transboundary Diagnostic Analysis is developed.

FIGURE 2 : Flow chart of the whole process. The main decision boxes are in pink colour

PROJECT DEVELOPMENT

- Preliminary project request
- Appointment of facilitator
- Identification of, and consultation with, stakeholder groups
- Identification of Technical Task Team (TTT)
- Preparation of a draft concept paper
- Project approved by GEF CEO

PLANNING OF TDA/SAP

- Appointment of Project Manager
- Form of Interministry Committees
- Form Steering Committees
- Set up of the TDA Technical Task Team
- Design work plan for the TDA/ SAP implementation phase, including budgets
- Detailed stakeholder analysis and draft public involvement plan
- Preparation of full Project brief

DEVELOPMENT OF TDA

- TDA Preparation
- Identification and initial prioritisation of the transboundary problems
- Analysis of the impacts/ consequences of the Transboundary problems
- Final prioritisation of the Transboundary problems
- Causal chains Analysis and governance analysis
- Production and submission of complete draft TDA
- TDA adopted by steering com

next page

Formulating the SAP

- Bridging the TDA and SAP, and developing long-term EcoQOs
- Planning the remaining steps of the SAP and appointing SAP and NAP formulating teams
- Brainstorming ways to attain the EcoQOs
- Examination of and political consultation on alternative options
- Development the targets and indicators
- Agreement on the institutional framework
- Drafting the NAP and the SAP

SAP Implemen-tation

- Adoption of SAP. Ministerial conference
- Conducting a donors' conference
- Development of the relevant interventions by GEF and/or other donors

III.1. Identification and "prioritisation" of transboundary issues

The National Committees carried out the Transboundary Diagnostic Analysis (TDA) for Coordination and Monitoring of Project Activities (CNCS), as well as by national consultations, based on the information and data existing and available. The CNCS, which is set up in each of the countries, is multidisciplinary; comprises both governmental institutions (Ministries of Water, the Environment, Agriculture, Stockbreeding, Foreign Affairs (with regard to Transboundary legal aspects), and Water Utilities), and non governmental organizations with an interest in Water issues.

The activities of the CNCS were carried out under the form of discussion sessions in their periodic meetings intended to identify the risks to the SAI water resources, as well as to examine the investigations carried out by the national consultants. Besides, national workshops dedicated to the

Transboundary Diagnostic Analysis (TDA) were organized to validate these Transboundary risks. Thus, **14 risks were identified in Mali, 08 in Niger and 24 in Nigeria**.

The reports on the proceedings of these meetings have highlighted the richness of the data available in the fields of surface water, groundwater, geology and climatology. These reports are also informative about the existence of a national database, studies and projects conducted, and aquifer models developed, which are likely to be of relevance to the SAI.

The Transboundary risks which represent a threat to water resources, as analysed by the CNCS and national consultant, and in view of the investigations conducted by the OSS team, are summarised hereunder.

III.1.1. Impact of Climate Variability and Change

It has been noted that, for the whole zone, there was a wet period extending from the beginning of the 20th century up to the year 1967 and that there has been a dry period running from 1968 to date. The rainfall deficit has translated into a decrease in rainfall by about 20% to 50%, inducing, on the one hand, a shift of the isohyets by about 200 km towards the south and, on the other hand, a decrease in the flows of Niger River ranging from 20% (Mali) to 36% (Niger), as well as a decrease in aquifer recharge by the hydrographic network and useful rain.

This shift has resulted in accelerated degradation of farmland, as well as the migration of the population to, and concentration in, the wetlands in the South, thus exacerbating the deforestation phenomenon.

III.1.2. Deforestation

Wood cutting for energy production is a job -and income-generating activity. It produces 270 879 steres (that is, 37 095 quintals of charcoal) in Mali, and 827 442 tons of wood in Niger. Estimates for Nigeria are not available. This wood and charcoal production induces, on annual average, a land loss of 100 000 ha in Mali, and of 338 180 ha in Niger.

Land loss exacerbates wind and water erosion which contributes in the sanding up of the water network (Niger River, ponds). Sanding up tends to reduce aquifer recharge by useful rain, as well as affects the recharge of the water network by blocking off the recharge areas. Moreover, silting of the riverbeds does induce, by occupying the place of flow water in the Niger riverbed, frequent floods for normal flows.

III.1.3. Exploitation of Water Resources

Table 1 presents the abstractions from water resources to meet water needs concerning all tapping structures.

In spite of the irrigable land potential (390 000 ha in Mali, 226 600 ha in Niger and 42 272 ha in Nigeria) and of the land irrigated (26 030 ha in Mali, 13 500 ha in Niger and 27 230 ha in Nigeria) by River water and/or drillings or wells, there are no estimates available on the abstracted volumes. Yet, this activity is one of the largest water-consuming activities.

III.1.4. Decline of Artesianism

This phenomenon has been reported on artesian drillings tapping the Continental intercalaire in Mali and Niger, and/or the Continental Terminal in Niger. These flowing drillings had re-

	Mali	Niger	Nigeria
Drinking water supply (million m^3/year)	1.3 (mainly River water)	117.6 (of which 14.3 River water for Niamey)	15.4 (1990) 32.3 (2020)
Stock-breeding (million m^3/ year)	84	119,77	271,36
Industries, Mines (million m^3/ year)	-	9,9	-

Table 1 : Water consumption as per socio-economic sector

mained open since their date of construction, thus sometimes creating ponds in their immediate vicinity. The flows have decreased since then, but they are not monitored to appreciate the decrease of artesianism and to seek to identify the causes (natural decrease or sign of overexploitation?).

III.1.5. Water Pollution

A significant part of the pollutants disposed of in the wild (agricultural waste) ends up in Niger River, either directly or by runoff. Irrigated crops are practised especially based on water from the Niger which feeds the aquifer in period of high waters. This income-generating activity uses chemical fertilisers and pesticides. These amount, on annual average (between 2000 and 2002), to 10 000 tons of fertilisers (Urea, NPK 15-15-15, Super triple, phosphates of Tahoua, DAP) in Niger.

In Mali, 200 tons of fertilisers, on average, end up every year in the Niger River or in the aquifers around Bamako. In 1994, some 5 939 tons of urea and 4 055 tons of ammonia phosphate were applied to the **47 000 ha** of irrigated land.

In Nigeria, over 15 million people and as many head of cattle live in the Sokoto basin based on exploiting the aquifers by traditional wells that are not provided with a protection zone. High nitrate contents, with respect to normal, are frequently recorded in these exploitation structures.

III.1.6. Soil Salinisation

Soil degradation, by salinisation and alkalisation in Mali, affects 7 to 15% of developed land which are in process of being abandoned. In Niger, the zones irrigated in the valleys along the River, in the Dallols and in the vicinity of ponds, are affected by salinisation due to improper drainage of wastewater, as well as by the phenomenon of evaporation.

III.1.7. Non Concerted Exploitation of Water Resources

In spite of the existing sub-regional structures, such as the NBA (Niger Basin Authority), ECOWAS (IWRM), CILSS (Permanent Inter-State Committee for Drought Control in the Sahel), the ALG (Liptako-Gourma Authority), there is no organization ensuring a monitoring of the exploitation of groundwater resources. Only NBA is provided with surface water monitoring network with has scientific tools to estimate in real time the flows of the River at a given station, but not the abstractions made from the River. On the other hand, aquifer monitoring networks remain each country's self-imposed duty. These networks are not adapted for aquifer monitoring and evaluation, but were intended from the start to meet the water demand of the population.

> In conclusion, Real risks are threatening, both in quality and in quantity, the groundwater (as well as the surface water) resources. However, these risks have been identified based on the database and the information derived from the documentation available. Their assessment

(Table 2) remains more of a qualitative nature, even though major studies have been conducted in the zone.

Type of risk	Mali	Niger	Nigeria	Mean value
Climate change: floods, droughts	H	H	H	H
Deforestation	H	H	H	H
Exploitation of water resources	L	L	L	L
Uncontrolled decline of artesianism	F	H	H	H
Water pollution	H	H	H	H
Soil salinisation	F	F	L	F
Inadequate aquifer monitoring network	H	F	H	H
Non concerted exploitation of water resources	H	H	H	H

Table 2 : Qualitative assessment of the risks to the SAI aquifers.

H = High F = Fair L = Low

III.2. Final detailed Prioritisation of Transboundary issues

An analysis of the list of the risks identified by the countries (14 risks identified in Mali, 8 in Niger and 24 in Nigeria) is necessary in order to ascertain the following aspects in particular:

- the Transboundary nature of the identified risk;
- the scope of the risk with respect to national priorities and regional and international conventions, as well as the various global initiatives;
- impacts of the risk on economy, the environment and human health;

- the benefits expected upon examination of the risk.

This analysis has thus revealed, among others, that certain risks are causes or consequences and/or impacts. Such is the case, for instance, of the decline of artesianism or the decrease in the piezometric level of the aquifers, both of which are consequences of the combined effects of water abstractions made and the impact of climate variability and change. The phenomenon of deforestation belongs in the causes of the climate change contributing in global warming. Aquifer pollution is a major risk. The exploitation of water resources is a cause of water reduction. The non-concerted exploitation of the common resource belongs in water governance, which is related to the legal and institutional systems of each country.

Other Transboundary risks related, above all, to the natural surface resources: loss of biological diversity. In the context of the study of groundwater resources, the loss of biological diversity may be considered as the consequence of several factors:

- degradation of the medium due to human activities (deforestation, for example),
- impact of climate change (recurring droughts),
- generalized decrease of the level of the aquifers, inducing an increase in the non saturated area, then the drying up of the areas of the plant roots, leading thus to aridity and then to desertification.

In view of this second analysis, the Transboundary risks which may be regarded as major concerns common to the three countries and for which the efforts of a single country could not possibly find a correcting and lasting solution, are of three types:

1. **reduction in the water resources:** This reduction may be due to the combined effects of gradual abstractions and of a reduction of the recharge of the aquifers because of climate change. This type of risk is characterized by the modification of the groundwater potential in terms of water reduction or water scarcity. This reduction can be due to the combined effects 1) from the progressive water abstraction, and 2) the reduction of the recharge of the aquifers because of the reduction in rainfall.

   The results of the mathematical modelling of the Iullemeden Aquifers System made it possible to quantify this risk: the overexploitation threshold was exceeded in 1995, the year from which abstraction (152 million m^3/year) exceeded recharge which is estimated at 150 million m^3/year in 1970 (red line on figure 3).

2. **the water quality degradation:** it was identified as the pollution of the groundwater (shallow aquifer mainly) because of (1) the infiltration of waste water with chemical concentration beyond the quality standards, and (2) the abstraction of (deep) groundwaters with high contamination (i.e. excess of fluoride) conducted by the geochemistry of the geological formation;

3. **(impacts of) the variability and of the climate changes:** Climate risk is characterised by the random nature due to the occurrence of climate extreme (droughts, floods) over the next years and decades. Global climate models are further developed for surface water (including rain) than groundwater.

   This kind of risk is characterized in particular by 1) the silting process in the hydrographic network of the Niger River which reduces the groundwater supply (exchanges

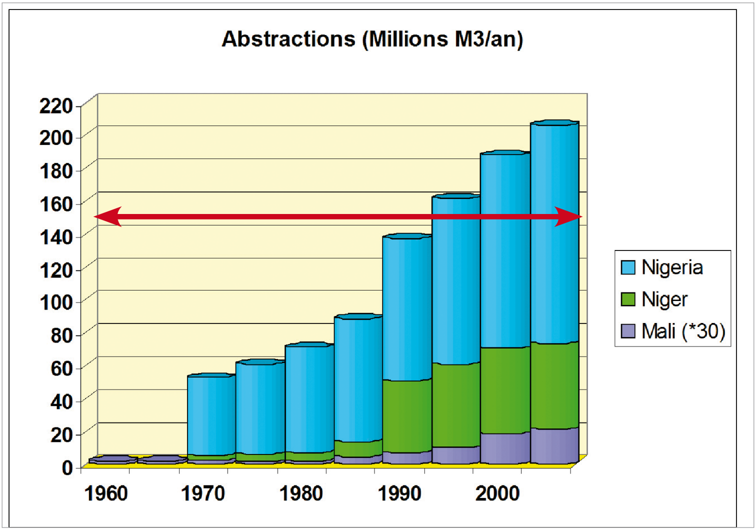


Figure 3 : The overexploitation limit was exceeded in 1995 according to the preliminary estimates. These are estimates based on the data provided by the countries. These data on abstractions are those resulting from the exploitation flows of the water point (drilling, well) at the date of its construction, and this, for four (4) hour duration of exploitation per day. These estimates remain to be corroborated by an exhaustive inventory of the real abstractions made from all the exploitation structures (water points).

between River and groundwater) resulting from the Continental intercalaire (Ci) and the Continental Terminal (CT), supporting therefore frequent floods, 2) the establishment of sand dunes in the recharge areas and on land cover reducing the infiltration of rainwater in particular, 3) the destruction of the areas of hydraulic exchanges due to the migration of the population from arid zones of the wetland areas.

These three major risks t were analysed by using the Causal chain Analysis through their immediate causes, fundamental causes and roots causes. The root cause also integrates the water governance.

IV. Causal chain Analysis

A causal chain is a series of statements that relate the causes of a given problem to its effects. The causal chain is composed of three types of causes:

- **immediate causes:** or primary causes, are often the problem's direct technical causes. They are, above all, tangible;
- **underlying causes:** they contribute in the immediate causes and include the uses and practices applied to the key resources, as well as the related social and economic causes;
- **root causes:** these are often related to the key aspects of macroeconomy, consumption patterns, environmental values, access to information, democratic processes, governance.

Accordingly, the three major Transboundary risks are examined based on these three types of causes (Table 3).

Table 3 : Causal chain analysis applied to the water resources of the Iullemeden Aquifer System (IAS)

Immediate causes	Major transboundary risks
• Reduction of the rainfall • Reduction of the runoffs in the Rivers • Reduction of recharge (filling of the recharge areas due to silting, etc.) • Reduction of the recharge (filling of the recharge areas due to silting, etc.) • Frequently droughts	Reduction of the water resource
• Natural degradation controlled by geology (mineral paragenesis: strong concentration fluorine-Apatite, nitrates, etc.)	water quality degradation
• Increasing of greenhouse gases in the Troposphere	Impacts of variability & climate changes on groundwater

Fundamental causes	Root causes
• Increase in water abstraction (increase in the water points) • Increasing water demand (growing population, activities in the social and economic sectors) • Reduction of the recharge because of silting in human activities the recharge areas – land use and land cover)	• Shortcomings in consultation among the riparian countries • Non-application of the laws and rules • Shortcomings in water governance and awareness • Decreasing livelihood
• Pollution from various origins (domestic, industrial, mining, livestock, all kinds of waste water) • Agricultural activities (manures, pesticides) • Discharge of pollutants in the rivers having hydraulic connection with the aquifers • Land uses and change in land use systems	• Non respect of the current laws (Water code) • Shortcomings and lack of monitoring and assessing water quality • Inadequate water governance • Decreasing livelihood
• Deforestation (production of firewood) • Clearing areas for agriculture and other land uses • Migration of the populations from arid zones to wetland areas • Land uses and change in land use systems	• Shortcomings in awareness at national and regional levels • Weakness or lack of commitment of the countries to their financial contribution in the research studies for sustainable solution • Shortcoming and lack of application of the results and outputs obtained from several studies on the climatic risks

V. Contribution of the TDA in the identification of hydrogeological risk

The Transboundary Diagnostic Analysis is based on technical and scientific information **available and verified**, to examine the state of the environment and causes its degradation by focusing on transboundary issues without ignoring national concerns and priorities.

In the area of transboundary groundwaters, the Transboundary Diagnostic Analysis allows to identify and assess the transboundary risks in qualitative point of view. In fact, in most cases, the aquifer system shared by the riparian countries has never been studied at the regional level in order **to understand first the groundwater flow patterns**.

While the Transboundary Diagnostic Analysis offers flexibility in its concept, it is very easy to recognize that it was designed, preferably to the surface water resources domains including: marine waters, streams water (rivers), lakes, and wetlands, even though wetlands may result in some aquifer outlets (low artesian, resurgence).

Surface water resources are subject to regular monitoring of their characteristics since several decades which is not the case for the aquifers. Indeed, the field work for monitoring the fluctuation of groundwater levels is made according to the current projects. Where available, these data allow to build the common management tools (Database, Geographic Information System, mathematical model) which enhance the appetence of a concerted management between the national teams and to determine the risks.

The Transboundary Diagnostic Analysis is certainly an effective method to identify major transboundary issues (Table 4). However, its application and adaptation to transboundary groundwater require a revision of the TDA/SAP approach by integrating data collection on filed ("Ground Truth") and the development of management tools such as the common database, the Geographical Information System and Mathematical Model. The North-Western Sahara Aquifer System (SASS) project is an excellent example ready to receive TDA/SAP approach.

Table 4 : SWOT Matrix of the TDA contribution.

<table>
<tr><th>STRENGTHS</th><th>WEAKNESSES</th></tr>
<tr><td>The Transboundary Diagnostic Analysis is flexible and offers a wide scope to accommodate it to the aquifers of the area.
The ADT is a participatory approach involving all stakeholders concerned by the problem. To this goal, it contributes to a climate of solidarity and confidence.
The implementation of the Transboundary Diagnostic Analysis encourages to build Database on aquifers, Geographic Information System and to develop a Mathematical Model.</td><td>The Transboundary Diagnostic Analysis is qualitative, it is based on existing data collected through inter-ministerial committees meetings and the consultants' works; it does not explore sufficiently the risk because of lack of actual field studies (collecting "Ground Truth").
The deadline on a predetermined framework reduces the opportunities given by the Transboundary Diagnostic Analysis to well apply it in the groundwater domain.</td></tr>
<tr><th>OPPORTUNITIES</th><th>TREATS</th></tr>
<tr><td>The process leading from the development of the Transboundary Diagnostic Analysis to the Strategic Action Programme is not well explicit for the aquifers domain; this lack precision of gives the opportunity to adapt the process to the transboundary aquifers issues ;
The development of the Transboundary Diagnostic Analysis to the IAS has encouraged cooperation with agencies (OMVS) and Authority (NBA) River basin which have already developed the TDA surface water.
The TDA / SAP approach for aquifers opens up perspectives for sustainable cooperation with organizations and institutions specialized in the study of aquifers such as the OSS.</td><td>The TDA may fail in case of refusal of one or several countries to provide data on groundwater.
Applying the TDA / SAP approach is very often an eligibility criterion for access to GEF funding.</td></tr>
</table>

General conclusion

The Transboundary Diagnostic Analysis (TDA) advocated by the Global Environment Facility (GEF) International Waters was applied to the Groundwater Aquifer System Iullemeden shared by Mali, Niger and Nigeria. Three major transboundary risks were identified: (1) the diminution of the water resource, (2) the degradation of water quality, and (3) the negative impacts of variability / climate change.

Given the “non visible” character of groundwater, monitoring their hydrodynamic characteristics for decades is irregular. This is not the case with four other GEF focal areas namely: (1) marine waters, (2) the rivers, (3) lakes, and (4) wetlands, even though wetlands may result in some outlets of aquifers (artesian low, resurgence).

This required the development of a database of more than 17,200 water points, a Geographic Information System and a Mathematical Model. This has among other things, highlighted the overexploitation since 1995 and the interconnection between the Niger River and groundwater.

The TDA approach is a participatory approach involving all stakeholders concerned by the problem. To this end, it contributes to a climate of solidarity and confidence. It strengthens the appetence for a concerted management between national teams..

Bibliography

UNDP/GEF/UNEP/UNIVERSITY PLYMOUTH. Training course on the TDA/SAP approach in the GEF International Waters Programme (Documents disponibles en français sauf le module 2) :

- Module 1 : overview of the TDA/SAP process
- Module 2 : the project development phase and planning the TDA/SAP
- Module 3 : joint fact-finding i - identification and prioritisation of problems and the analysis of impacts
- Module 4 : joint fact-finding 2 - causal chain analysis, governance analysis, integration and submission of the TDA
- Module 5 : formulating the SAP
- Module 6 : governance analysis & stakeholder involvement

UNDP. The GEF IW TDA/SAP Process: Notes on a proposed best practice approach.

http://www.iwlearn.net/ftp/iwps.pdf

UNDP/GEF, 2005. Brief introduction on the TDA/SAP processes and their requirements. Project entitled "reducing environmental stress in the yellow sea large marine ecosystem".

OSS, 2007. Transboundary Diagnostic Analysis of the Iullemeden Aquifer System. Tunis. Edited by OSS in 2011 (Volume I).

OSS, 2007. Common Database of the Iullemeden Aquifer System. Tunis. Edited by OSS in 2011 (Volume II).

OSS, 2007. Hydrogeological Model of the Iullemeden Aquifer System. Tunis. Edited by OSS in 2011 (Volume III).

OSS, 2008. Iullemeden Aquifer System: Participatory management of transboundary risks. Tunis. Edited by OSS in 2011 (Volume IV).

OSS, 2008. Iullemeden Aquifer System: Monitoring & Evaluation of transboundary aquifers. Tunis. Edited by OSS in 2011 (Volume V).

The GEF TDA/SAP approach applied to the IAS

The Transboundary Diagnostic Analysis recommended by the Global Environment Fund has been applied to the transboundary groundwater of the Iullemeden Aquifer System shared by Mali, Niger and Nigeria. The Transboundary Diagnostic Analysis is a scientific and technical fact-finding analysis based on technical and scientific information available and verified, to examine the state of the environment and the causes of its degradation, focusing on transboundary problems without ignoring national concerns and priorities.

Three major transboundary risks were identified: (1) reducing the availability of the water resource, (2) degradation of water quality, and (3) the impacts of climate variability/change. This required the development of a database with more than 17000 water points, a Geographic Information System and a mathematical model. This model has among other things, highlighted the overexploitation of the resource since 1995 and the interconnection between the Niger River and the aquifers. The immediate, root and underlying causes (including the governance of water) of these risks were analyzed.

The Transboundary Diagnostic Analysis is a participatory approach involving all stakeholders concerned with the issue. To this end, it contributes to strengthen solidarity and confidence between them.

Partners

Mali Niger Nigeria

IAEA ESA GEF

FAO UNEP UNESCO

Edited with the financial support of

United Nations Educational, Scientific and Cultural Organization · International Hydrological Programme

giz

Sahara and Sahel Observatory
Bd du Leader Y. Arafat, BP 31, 1080 Tunis Carthage, Tunisia
Tel. : (+216).71.206.633 - Fax : (+216).71.206.636
URL : www.oss-online.org - Email : boc@oss.org.tn