Arab Republic of Egypt

Libya

Republic of the Sudan

République du Tchad

REGIONAL STRATEGIC ACTION PROGRAMME

FOR THE

NUBIAN AQUIFER SYSTEM

IAEA Technical Cooperation Programme

UNDP GEF

Agreement

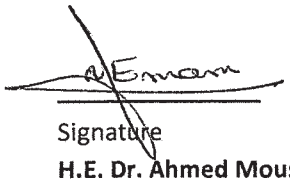
We, countries of Chad, Egypt, Libya, and Sudan, are committed to the cooperative management of our shared aquifer, the Nubian Sandstone Aquifer System. The effective management of our common water resource requires balancing the needs of human populations and fragile desert ecosystems with the potential for development that this vast but finite resource has to offer. Cooperative efforts formalized by the creation and ongoing activities of the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System, have been further strengthened through the development, in the frame of the IAEA/UNDP/GEF Nubian Sandstone Aquifer System Medium Size Project of the Shared Aquifer Diagnostic Analysis and the Strategic Action Programme.

We the undersigned agree that this Strategic Action Programme reflects the shared vision for the cooperative management of the Nubian Sandstone Aquifer System and describes strategies for realizing this vision, with the full involvement of the Joint Authority.

We hereby confirm our commitment to implement the actions to protect the shared resources and sustain the ecosystem and livelihoods of the peoples, under the auspices of the Joint Authority.

Signature Page

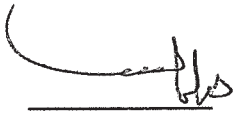
On behalf of the Government of
Arab Republic of Egypt



Signature
H.E. Dr. Ahmed Moustafa Emam Shaaban
Minister
Ministry of Electricity and Energy

18.09.2013 . Vienna
Date and Place

On behalf of the Government of
Libya



Signature
H.E. Eng. Al Hadi S. Henshir
Minister
Ministry of Water Resources

18.09.2013 Vienna
Date and Place

On behalf of the Government of
Republic of the Sudan

Tabita D. Teia Shokai

Signature
H.E. D.Tabita Potros Teia Shokai
State Minister
Ministry of Water Resources and Electricity

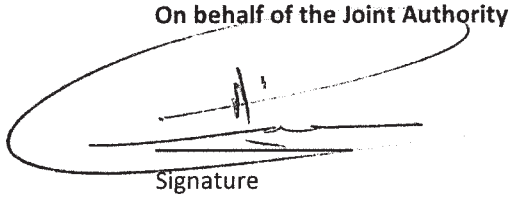
18.9.2013 Vienna
Date and Place

On behalf of the Government of
République du Tchad

Signature
H.E. Ali Mahamat Abdoulaye
Ministre
Ministère de l'hydraulique rurale et urbaine

18/09/2013
Date and Place

On behalf of the Joint Authority



Signature
Mr Seifeldin Hamad Abdalla
Chairperson
Present Representative

18th Sept. 2013, Vienna
Date and Place

Contents

Abbreviations

CCA	Causal chain analysis
CEDARE	Centre for Environment and Development for the Arab Region and Europe
Eco QO	Ecosystem Quality Objective
GEF	Global Environment Facility
GIS	Geographic Information System
GW	Groundwater
IAEA	International Atomic Energy Agency
IFAD	International Fund for Agricultural Development
IWRM	Integrated Water Resources Management
JA	Joint Authority (Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System
M&E	Monitoring and Evaluation
mcm/yr	Million cubic meters per year
MSP	Medium Sized Project
NARIS	NSAS Regional Information System
NGO	Non-governmental organization
NSAS	Nubian Sandstone Aquifer System
PSC	Project steering committee
SADA	Shared aquifer diagnostic analysis
SAP	Strategic Action Programme
TDA	Transboundary diagnostic analysis
TTT	Technical Task Team
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WR QO	Water Resources Quality Objective

Summary

This Strategic Action Programme (SAP) establishes a framework on agreed management actions to address the key transboundary concerns, and concerns that are shared between countries, impacting the unique and important Nubian aquifer shared by Chad, Egypt, Libya, and Sudan. The transboundary concerns were identified collectively by the four countries in the preparation of a Shared Aquifer Diagnostic Analysis (SADA).

The SAP and the SADA were prepared by a team of experts drawn from the four countries with financial support of the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the International Atomic Energy Agency (IAEA).

The Nubian Sand Stone Aquifer System (NSAS) occupies about two million square kilometres with an estimated volume of water of about 500,000 km^3 of which the recoverable resource is thought to be in the region of 15,000 km^3. The water resources over the last million years or so have been controlled by the glacial and interglacial periods: the glacial periods were pluvial and the interglacial, relatively arid. During the pluvial periods there were likely significant surface water bodies that provided recharge to the aquifer, however it is believed that during the arid periods (including the present time) there has been little or no recharge of the aquifer.

The importance of the aquifer to the people of the region cannot be overstated. In the desert regions distant from the Nile River, this is the only resource to provide water for irrigation, livestock, industry and of course as a drinking water source. Protecting the NSAS from over exploitation and pollution are imperative. In addition, the importance of assessing any transboundary impacts between countries from abstraction wells is a priority in maintaining good international relationships in the region.

An important advancement in the management of the NSAS was made with the establishment of the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System. The Joint Authority was established in 1989 between Egypt and Libya and launched in 1991. Sudan jointed in 1996 and Chad joined in 1999.

One challenge in developing an adequate management strategy is to gain sufficient knowledge about the aquifer. Accordingly, cooperation was activated from 1997-2002 through important initiatives and baseline activities supported by the International Fund for Agriculture Development

(IFAD) under the project management of the inter-regional organization, the Centre for Environment and Development for the Arab Region and Europe (CEDARE). This resulted in a joint survey of the socio-economic development policies and plans in the aquifer areas and the establishment of a NSAS Regional Information System (NARIS) database. NARIS was envisioned to facilitate data storage, processing, display and analysis and would provide input files for geographic information system (GIS) and mathematical models. The groundwater modelling efforts have been well documented (CEDARE 2001) and provide indications of the impacts on water levels and water quality over a period of 60 years of development and abstractions.

The Joint Authority and the CEDARE program made important advances in regional cooperation that resulted in an improved understanding of the aquifer system and established mechanisms for data sharing and groundwater monitoring and modelling. These advances laid the groundwork for a partnership of the GEF, UNDP, and the IAEA to work with member countries to strengthen regional cooperation, address data gaps, improve the technical understanding of the NSAS, and develop policy strategies for managing the aquifer system. This partnership led to the funding of this project in 2006 by GEF, UNDP, UNESCO, and IAEA as a Medium Sized Project (MSP) titled, *The Regional Formulation of an Action Programme for the Integrated Management of the Shared Nubian Aquifer*. The overall objective of the project was to develop the framework for the sustainable management and use of the Nubian Aquifer System in the four Nubian countries: Chad, Egypt, Libya, and Sudan. The project expands and consolidates the technical and scientific knowledge base regarding the aquifer System.

The purpose of the SADA was to provide clear scientific evidence for transboundary concerns impacting the NSAS that could support the development of the SAP through clear management actions and targets. An essential component of the analysis undertaken has been achieved through the development of a new collaboratively developed hydrological model to assess the impacts on the available water resources from abstraction and natural processes.

The SADA identified the following key transboundary concerns (or issues shared by the countries):

1. Declining water levels related to abstractions.
2. Damage or loss of the ecosystem and biodiversity that are linked to the aquifer at oasis
3. Water quality deterioration from pollution (industry, agriculture and urban)

Changes in groundwater regime were also initially considered as important but this was later considered to be a local problem following the modelling work conducted by the GEF Project. In

addition, the potential impacts of climate change and the need for adaptation in this arid region are considered by the SAP that impacts all transboundary concerns.

The SADA identified that the root causes of these transboundary concerns are:

- Population growth
- Regional and national governance structures
- Poverty

Key findings of NSAS modelling

Modelling to support the SADA revealed that direct transboundary threats are low, even those due to pumping centers located near national borders, such as Jaghboub in Libya and Siwa and East Owienat in Egypt. Localized drawdown in pumping locations, however, is predicted to be high. The highest capacity pumping centers in Sarir and Kufra in Libya and Dakhla in Egypt will produce significant drawdown, but the lateral extent of drawdown toward national borders will be insignificant for the foreseeable future. From a management standpoint, the modelling results indicate that member countries can develop their water resources without significant concern either that they will affect neighbouring countries or that neighbouring countries will affect their water resources.

It is still early enough in the development of the NSAS that priority threats have not yet, according to national reports, resulted in ecosystem impairment, providing the Nubian countries the unique opportunity to *prevent* rather than *mitigate* resource impairment. This window of opportunity is likely to close soon though. Modelling predictions indicate that localized drawdown in pumping centers located in or near oases can have a severe impact on water levels in oases. While these localized impacts are not *direct* transboundary problems, they are certainly problems *shared* by all Nubian countries.

The need for further co-operation

The NSAS model is in a complete, but early form. Limited data exist on which to calibrate the model. Rigorous testing of the model indicated that it is accurate, but that uncertainty bands are wide. The prediction of low direct transboundary impacts is valid, but continued monitoring is necessary, both to provide additional data to improve modelling efforts and to provide direct evidence that transboundary drawdown does not occur.

Continued cooperation among the NSAS countries to improve the model and collect additional monitoring data serve at least two important purposes: to confirm that direct transboundary drawdown does not occur and to develop collectively water resource management strategies to prevent adverse impacts of localized drawdown. These purposes address but the *direct* and the *shared* threats to the NSAS.

This SAP supports these purposes by supporting the regional and national management of the NSAS. This requires both changes to policy and the implementation of monitoring to support the conclusions of the model.

Benefits from the development of the SADA/SAP to regional co-operation have already been realised:

- *Improved data sharing*
- *A shared regional groundwater model*
- *Improved understanding of transboundary threats*

The objectives of the SAP are to provide a regional vision for the NSAS and propose means to achieve this goal through objectives, management actions and targets. Toward this end the NSAS has already established the Joint Authority to co-ordinate the activities of the countries. This SAP fully supports the role of the Joint Authority. This SAP has been developed through teams in all countries preparing National Reports and identifying priority national actions that were consolidated into this regional SAP.

The **vision** for the NSAS adopted by the countries is:

To assure rational and equitable management of the NSAS for sustainable socio-economic development and the protection of biodiversity and land resources whilst ensuring no detrimental effects on the shared aquifer countries.

To assist in reaching the vision for the NSAS three overarching water resources and ecosystem quality objectives were agreed.

Water Resource / Ecosystem Objective 1: To manage the shared aquifer in a sustainable and equitable way for the benefit of the NSAS countries on the basis of joint regional planning in order to minimise negative effects within and between countries, anticipating the challenges including increasing population, needs of agricultural expansion, and climate change.

a. To strengthen the role and capacity of the Joint Authority to effectively manage the shared aquifer.
b. To achieve water-efficient use priorities and activities and to reduce the negative impacts of anthropogenic activities on groundwater regime, levels, and quality.
c. To enhance the NSAS resilience to adapt to climate change impacts.

Water Resource / Ecosystem Objective 2: To mainstream environmental aspects in the integrated management of the NSAS to conserve the dependent ecosystems and reduce the risk of loss/damage to biodiversity.

Water Resource / Ecosystem Objective 3: To utilize the Nubian aquifer resources on sustainable socio-economic development basis

a. To enable integrated transboundary and national socio-economic development activities in the NSAS region, such as implementing appropriate agricultural, industrial and municipal practices to protect the water resources and allow growth.
b. To manage the aquifer and its ecosystems in such a way as to reduce threat from human migrations and associated detrimental effects.

Over one hundred management activities, actions and targets were defined to strengthen the regional and national capacity to achieve the objectives and the vision for the NSAS. The majority of the management actions are under the co-ordination of the Joint Authority with expected fully co-operation between national institutes and administrations and the Joint Authority.

The process of continuous stakeholder engagement that the four countries have adopted in the development of the SADA and the SAP should be further encouraged for the future SAP Implementation.

With the agreement of the four countries on this SAP there is the requirement to further develop a more detailed understanding of the costs and benefits of the management actions outlined in this document and to identify and secure funding. In addition it will be necessary for the four countries to develop corresponding National Action Plans that reflect the regional goals and objectives. This should be done under the close supervision and co-ordination of the Joint Authority.

Introduction

Background to the Strategic Action Programme

The Nubian Sandstone Aquifer System (Figure 1) occupies a region rich in natural and cultural history. Geologic events and climatic patterns created a constantly changing environment in the region which provides, over geologic time, cycles of rainfall and aridity. These cycles, in turn have supported temperate ecosystems filled with lush vegetation, which have yielded to encroaching deserts. In present day, the region is at the point in the climatic cycle of advanced desertification. The enormous resources of the Nubian aquifer offer the potential to hold or reverse the climatic trend in desertification.

The significant water resources of the Nubian Sandstone Aquifer System (NSAS) are considered to be 'non-renewable' and the countries sharing the aquifer (Chad, Egypt, Libya and Sudan) have been co-operating over the past four decades to develop the NSAS. The countries have expressed their interest in regional co-operation to share their experiences.

The countries agreed to form a Joint Authority to study and develop the NSAS and to seek international assistance to establish a regional strategy for the utilisation of the NSAS water resources. Egypt and Libya initiated the process in the early 1970s and formalized the Joint Authority for the Management of the NSAS in 1992 (Joint Authority). Sudan joined the Joint Authority in 1996 and Chad followed in 1999.

One challenge in developing an adequate management strategy is to gain sufficient knowledge about the aquifer. Accordingly, cooperation was activated from 1997-2002 through important initiatives supported by the International Fund for Agriculture Development (IFAD) under the project management of the inter-regional organization, the Centre for Environment and Development for the Arab Region and Europe (CEDARE). This resulted in a joint survey of the socio-economic development policies and plans in the aquifer areas and the establishment of a Nubian Aquifer Regional Information System (NARIS) database. NARIS was envisioned to facilitate data storage, processing, display and analysis and would provide input files for geographic information systems (GIS) and mathematical models. The groundwater modelling efforts have been well documented (CEDARE 2001) and provide indications of the impacts on water levels and water quality over a period of 60 years of development and abstractions.

The Joint Authority and the CEDARE program made important advances in regional cooperation that resulted in an improved understanding of the aquifer system and established mechanisms for data sharing and groundwater monitoring and modelling. These advances laid the groundwork for a partnership of the Global Environment Facility (GEF), United Nations Development Program (UNDP), the United Nations Educational, Cultural and Scientific Organization (UNESCO), and the IAEA to work with member countries to strengthen regional cooperation, address data gaps, improve the technical understanding of the NSAS, and develop policy strategies for managing the aquifer system.

This partnership led to the funding of this project in 2006 by GEF, UNDP, and IAEA as a Medium Sized Project (MSP) titled, The Regional Formulation of an Action Programme for the Integrated Management of the Shared Nubian Aquifer. The overall objective of the project was to develop the

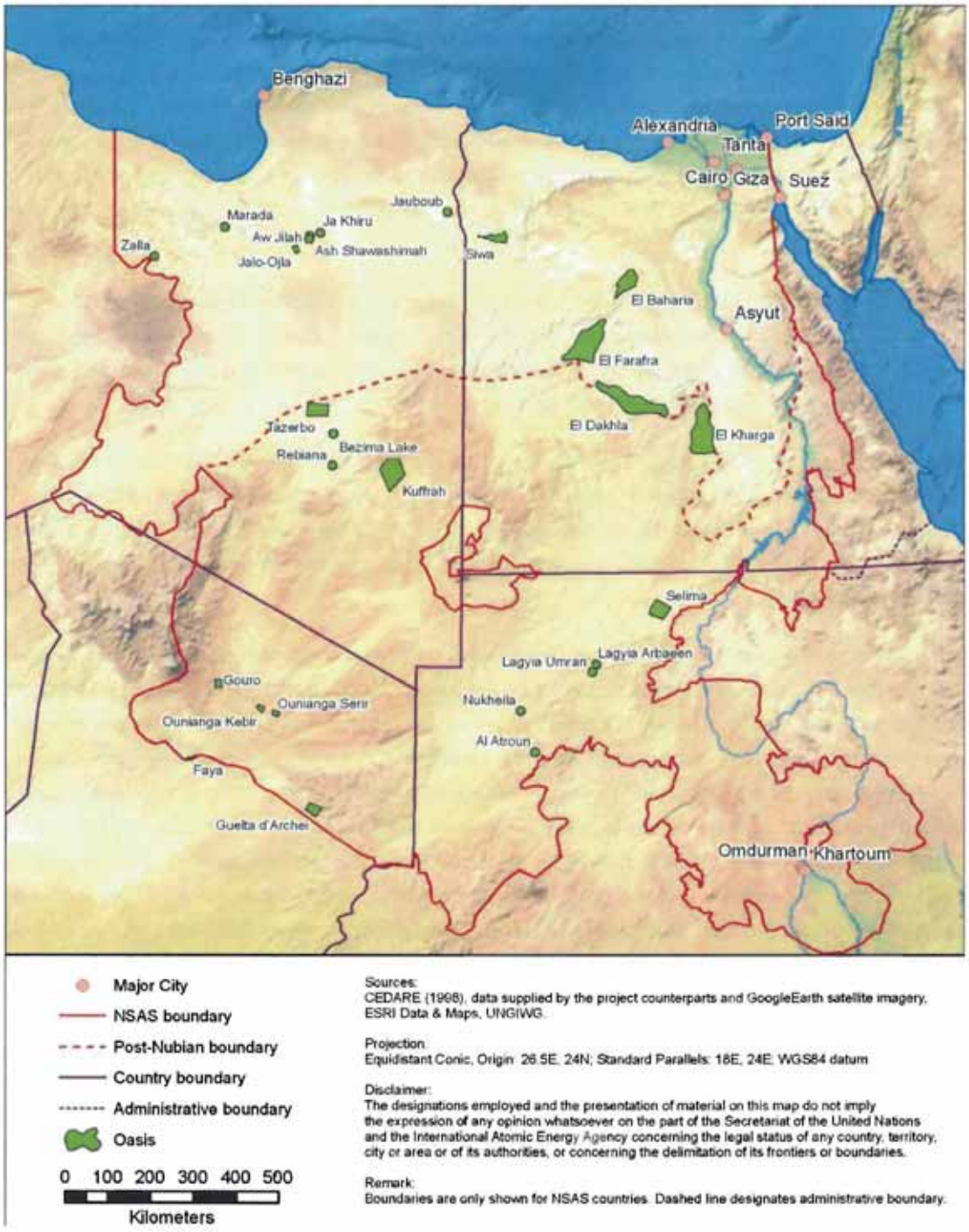


Figure 1. The Nubian Sandstone Aquifer System, including locations of known oases and the boundary of the Post Nubian Aquifer. (Source: 09–a Oases.png)

framework for the sustainable management and use of the Nubian Aquifer System in the four Nubian countries: Chad, Egypt, Libya, and Sudan.

This Strategic Action Programme (SAP) establishes a framework on agreed management actions to be implemented that address key transboundary concerns (or concerns that are shared between the countries) to conserve the valuable and unique resources of the Nubian Shared Aquifer System. The concerns impacting the NSAS and associated ecosystem have been identified through a joint process of data collection and analysis within the region (the Shared Aquifer Diagnostic Analysis – SADA).

This SAP is designed to support the role of the Joint Authority through the provision of priority actions to strengthen the JA resulting in improved overall management of the NSAS and protection of the water resources and associated ecosystems.

Contents of this Strategic Action Programme

This document provides an overview of the values, pressures, impacts and management actions that have been identified by the SAP formulation team, drawn from the four countries sharing the NSAS and the IAEA, based on the initial analysis undertaken by a Technical Task Team that developed the agreed SADA. Over 100 actions of relevance to the region are identified and a preliminary budget estimation is made (Annex 1) targeted at strengthening the management role and capacity of both the regional Joint Authority and National institutes.

The following summarises the key sections of this SAP:

- **Section 2:** Description and importance of the NSAS – presents a brief summary of the natural and human resources of the region and summarises the socio-economic pressures on the NSAS.
- **Section 3:** Approach adopted to SADA/SAP preparation – the preparation of the SADA and SAP has followed the GEF best practices in identifying and prioritising the key transboundary issues and their causes, leading to a common vision for the future use and protection of the NSAS.
- **Section 4:** Strategy for protecting the water resources and ecosystem of the NSAS – presents the agreed management principles for managing the shared aquifer and defines water resources and ecosystem objectives that though the defined management actions will ensure that the Joint Authority and national institutions are better resourced (human capacity and facilities) to address the transboundary issues.
- **Section 5:** Legal and institutional framework for SAP implementation – provides an analysis on the Joint Authority's agreements and assesses the compatibility of these to implement the SAP
- **Section 6:** Monitoring and evaluation of SAP implementation – following best practices identified in GEF projects, process, stress reduction and ecosystem/socio-economic indicators are identified that could be utilised by the Joint Authority (and National agencies) to monitor the progress of SAP implementation.
- **Section 7:** Next steps – this SAP provides an overview of actions that are needed at the regional level or are shared by the NSAS countries. However there is a future need to develop detailed National Action Plans to implement national actions. In addition more

details and full cost-benefit assessments are required on the Management Actions (Annex 1) to assess the efficacy of the various options and to identify sources and level of finances required.

- **Annexes:** The annexes consist of the Management Action Tables (Annex 1) which address the key transboundary problems following the agreed quality objectives for the NSAS, more detailed pilot project descriptions based on the MATs (Annex 2), the National SAP Reports developed by the SAP formulation team for each of the NSAS countries (Annexes 3 through 6), and the Regional SADA report.

Description and importance of the NSAS

This section presents a brief summary of the natural and human resources of the region. It draws on a variety of technical resources which present in greater technical detail information on these topics. A more complete analysis of the natural and human resource context of the aquifer can be found in the baseline report for each Nubian country prepared in the SADA and SAP developments.

Historical Summary and Perspective

The NSAS occupies about two million square kilometres in the North African countries of Libya, Egypt, Sudan, and Chad. The NSAS is bounded roughly in the east by impervious basement formations of the mountain ranges of the Red Sea. The southern extent is defined in southern Sudan by outcrops of the Kordofan and Darfur blocks of basement rocks. The southern boundary in Chad is a depression defined roughly by the Faya and Archei oases. The western boundary is a groundwater divide extending from the Tibesti mountains in the south and northward along the 19th meridian. The northern boundary corresponds to the Mediterranean coast. The aquifer is contained in a sedimentary basin overlying impermeable Precamrian formations. A complex series of geologic events filled and reshaped the basin over geologic time. Volume II of the CEDARE report (2001) provides a detailed description of the geologic and hydrogeologic history of the aquifer.

The region has a long and interesting history, but the most recent million or so years is of greatest relevance to this project. This was a time of glacial and interglacial periods. In the NSAS region, glacial periods were pluvial periods and interglacial periods were relatively arid. An example chronology based on ice-core atmospheric carbon dioxide is shown below for the past 650ka. There is a periodicity of roughly 100 thousand years for repeated periods, each containing a glacial and an interglacial phase. During pluvial periods, there were likely significant surface water bodies (lakes and rivers) and a shallow groundwater table in NSAS that received recharge from both rain and from surface waters. During arid periods, there was likely little or no groundwater recharge, once the surface waters dissipated. The NSAS has been in an arid-zone state for the past approximately five to ten thousand years, which is the natural situation during Holocene interglacial periods such as the present.

It is this most recent transition from pluvial to arid which is of greatest interest to archaeologists, ecologists, and water engineers. While the cycles of aridity and humidity have marched, it was during the most recent humid period that the current ecosystems, or their direct descendents, were established and became a dwelling place for humans.

The human and environmental ecosystems of the NSAS have endured an ongoing transition from humid to arid conditions for thousands of years. Archaeological and paleo-environmental records of the region document the transition of decaying richness in both ecological diversity and human populations during the current arid period. Humans have coped with changes in aridity either by adapting or migrating. Present day conditions are no exception. Progressive desertification has the effect of changing pastures and oases and upsetting the fragile boundaries established in the ranges staked out by competing tribal groups, with resulting conflict.

Water Resources

The water resources of the aquifer vary significantly across the four Nubian countries. The aquifer is most massive in Libya and parts of Egypt, where it can be up to 5,000 meters thick. In Chad and Sudan the aquifer can be as thin 100 meters or less. The total amount of water stored in the aquifer has been estimated to be about a half million cubic kilometers. However, only a relatively small amount of this can be recovered for environmental, cultural, technical, and economic reasons. One estimate places the recoverable resource at about 15 thousand cubic kilometers.

The present climatic conditions in the region can be characterized as arid or hyper-arid. While the sparse rainfall in the coastal and southern areas is insufficient for any meaningful recharge to the aquifer, it does manage to support some grasslands toward the south of the region.

Groundwater Development

The earliest uses of the aquifer to support human needs were direct extraction from oases and springs, and through the use of hand-dug boreholes. Both of these methods continue to the present and support the range of local water needs: potable use, agricultural irrigation, and for livestock. The next level of intensification in use was the introduction of relatively shallow driven wells which serve the same local needs. These methods are similar in that they create a fairly low-intensity, geographically distributed demand on the aquifer. Because they draw water from only the top meters of the aquifer, these methods are also the most vulnerable to declines in the water table and to water quality impairments.

The pattern of groundwater development in the Khartoum-Omdurman urban area for the most part, consists of similarly distributed and low-yield wells. However the density of these wells is much higher than any other place in the region. Additionally, the NSAS is thinner in this area and includes mudstone semi-confining or confining units. As a result this area is particularly vulnerable to drawdown and to contamination from contaminated recharge water.

Starting in the early 1960s, deeper wells were drilled and equipped with high-capacity pumps to support larger scale irrigation projects in Egypt and Libya, as well as for some mining, water supply, and petroleum-related needs. The earliest major development programs were in the Dakhla and Kharga oases in Egypt in 1960. The combined extraction at these two sites from springs, shallow wells, and deep wells was just over 100 million cubic meters per year (mcm/yr). By 1998 nearly two dozen well fields had been developed, mainly in Egypt and Libya, but also in Sudan. The total estimated extraction that year was about 1,300 mcm/yr from the Nubian aquifer and about 900 mcm/yr from the Post Nubian aquifer (CEDARE 2001). Future abstraction from the NSAS depends on factors such as policy decisions regarding national food security, investments in infrastructure,

changes in the balance of national water sources, and changes in populations. All of the Nubian countries have national development plans in place.

Social and Economic Aspects

The demographics of the region reflect the natural resources available. In all Nubian countries oasis areas traditionally have supported a combination of settled agriculturalists and nomadic herders and traders. Toward the south in Chad and Sudan, where conditions are less arid livestock herders have taken advantage of the sparse grasslands.

In Sudan, the trade in livestock consisting of sheep and camels takes place year around. The market destination for sheep is Omdurman, for both domestic use and export to Libya. Camels are herded from Dongola to Egypt or through a western route to Libya. In both cases, livestock are herded on journeys of up to 40 days both to Omdurman and Egypt via Wadi el Melik, Ed Debba, and Dongola.

In the Nubian countries outside of the Nile corridor agriculture is limited to oasis areas and varies in extent proportional to the degree of groundwater abstraction dedicated to local irrigation. In Egypt, the Western Desert within the NSAS is characterized by scattered oases and depressions with traditional Bedouin populations that depend exclusively on groundwater. In Chad, agriculture consists of some date palm production, but is limited due to absence of abstraction from drilled wells. In Sudan, agriculture is currently limited to subsistence production of the staple crops of vegetables, melons, cucumber, and citrus. As with Chad there is currently limited use of drilled wells outside of the Nile riparian corridor. Within the Nile corridor several development projects in Sudan and Egypt are being planned.

Libya and Egypt have invested in much more development of oases for local agriculture. Additionally Libya has several oasis well fields dedicated to water transport to coastal areas, where water is used for both irrigation and domestic purposes. Both countries have seen success in developing an oasis tourist industry in the oasis areas.

The linkage between the NSAS and the national economies of Nubian countries varies. In Libya, petroleum development is a driving force in the economy and has provided the economic resources for the country to develop agricultural industries both in oasis and coastal areas. Petroleum extraction occurs in the NSAS region, though, and the NSAS is both used for petroleum recovery and is vulnerable to contamination from brine wastes associated with petroleum recovery.

In Egypt, the economic importance of the NSAS is secondary to the Nile River. The vast majority of agricultural development occurs in the Nile delta. However with growing water demands associated with population increases and an expanding economy, the NSAS is recognized as an alternative of growing importance in agricultural development. An important challenge will be to avoid adverse impacts of water level decline and water quality impairment with increased agricultural development. Western Desert oases already support most of the tourism development in the NSAS and serve as a model for other countries.

As with Egypt, Sudan has Nile River resources available for economic development. The NSAS however remains the key resource for indigenous populations in the western and northern states. These communities in Sudan, and their neighbours in Chad, rely on agricultural and livestock

products which are both rain-fed and supported by the NSAS through oases and borehole wells. As a result, these communities are highly vulnerable to drought. Periods of low rainfall result in both increased demand on the aquifer where it is accessible and on human migrations where it is not. This region has the additional burden of political instability and resulting cross-border migrations.

As with Sudan, Chad has the promise of petroleum development to build the economy. To date, petroleum recovery has failed to meet expectations and the country relies on agriculture and livestock to drive the economy. The NSAS region of Chad has several oasis regions which support some date palm agriculture and have the potential for tourism development. These however are threatened to varying degrees by encroaching dune migration.

Approach adopted to SADA/SAP preparation

The Shared Aquifer Diagnostic Analysis (SADA) is based on GEF Transboundary Diagnostic Analysis (TDA) methodology. A TDA is an objective, non-negotiated assessment using best available verified scientific information to examine the state of the environment and the root causes for its degradation. The analysis is carried out in a cross-sectoral manner, focusing on transboundary issues without ignoring national concerns and priorities. It provides the factual basis for the formulation of a Strategic Action Programme (SAP). A SAP is negotiated policy document which should establish clear priorities for action to resolve the priority transboundary problems which were identified in the SADA.

SADA Development

This project followed well-defined procedures established by GEF for conducting transboundary diagnostic analyses. The basic elements were training for national counterparts in GEF methods and establishing planning documents for key components of the SADA report (causal chain, governance, and stakeholder analyses). Unique to this project was the collaborative development of a regional groundwater model to provide a technical basis for evaluating transboundary risks. And finally, national SADA meetings were held to discuss issues of national concern in a stakeholder forum. Another aspect of this project has been to collect additional data

Training

Several training workshops were conducted during the SADA phase of the project, using the GEF IW:LEARN TDA/SAP training materials. The initial training workshop was conducted in March 2007 in Khartoum and was attended by representatives of all four Nubian countries. A TDA/SAP refresher training was conducted in October 2008 in Cairo and December 2008 in Tripoli. Training workshops were attended by key national staff and were conducted by an international expert on TDA/SAP procedures.

The three main component documents for the SADA were the causal chain analysis, the stakeholder analysis, and the governance analysis. Causal chain analysis provides a systematic approach to recognize and prioritize existing and potential problems. This analysis also enables mapping of the threats in terms of their underlying and root causes. The stakeholder analysis was conducted to determine the groups and individuals who have an interest in and are affected by the project. The

project undertook the analysis and identification of key stakeholders and their possible contribution/impact. A series of workshops was conducted for each country for open consultation and participation. A Technical Task Team was also formed for the purpose. Further, consultations with some prominent opinion leaders and experts on the water resources and related issues were undertaken. Governance analysis provided an understanding of the political and institutional structures affecting the project.

Modelling

Although it has wide-ranging policy and water management implications, the issue of transboundary impacts of water extraction from aquifers is essentially technical. The causes and effects that define groundwater movement are too complex to be evaluated intuitively and even the location of groundwater in an aquifer is usually invisible and difficult to determine, even under the best circumstances. Policy decisions cannot be made on *a priori* assumptions that transboundary effects either do or do not occur in particular locations. The development of rational water policy and management strategies requires that the response in an aquifer to changes in water management practices can be anticipated. The magnitude or even existence of transboundary effects can only be evaluated using a set of analytical tools agreed upon by member countries and subject to open and transparent analysis.

Regional modelling of the NSAS was conducted to provide an objective, technical basis on which to evaluate the priority threats determined through causal chain analysis. The model was developed by an international expert through a series of regional workshops held in Vienna. National program coordinators and national technical experts participated in these workshops and to participate actively in the development of the model.

The model created a platform agreed upon by all countries through which data can be shared and interpreted in an open, transparent manner. This constitutes a logical extension and strengthening of the successes of the Joint Authority in shaping cooperative agreements for data sharing and formation of a shared aquifer database.

The model in its current state has been calibrated to the best knowledge available in the region and is the final work product of the collaborative modelling effort. As such, the Nubian countries have accepted the model as a joint planning tool and have adopted the model for future activities related to the SAP phase of the project.

Nubian Groundwater Models

Numerical models to understand the behaviour of the NSAS have been produced since the 1970s and fall into the general categories of local models to predict the effects of pumping wells and regional models to characterize the larger scale behaviour of the aquifer. Researchers at Technical University of Berlin have been working on regional models for the NSAS since the 1980s. Their efforts have confirmed that it is necessary to take into account the gradual draining of the aquifer through the natural discharges of springs, oases, and sabkhas. Another regional groundwater model was developed by CEDARE in 2001. An important contribution of this effort was to describe and

organize all of the existing data into geographic information system (GIS) database, thereby providing ready access to spatially referenced data.

The model developed for this project builds on these earlier models with several innovations. The previous models considered the aquifer in two-dimensions, with the assumption that water flows horizontally. The current model is three dimensional and permits the consideration of vertical flow. This adds some complexity, but has several advantages, one of which is the capability for *particle tracking*, or tracing the movement of water masses over time. In this way the age of a particular water mass can be estimated.

Particle tracking enabled the model to be validated through krypton-81 analysis, an advanced isotopic technique for dating very old waters. The model predicted that deep waters extracted from wells in certain parts of the Nubian aquifer in Egypt should range from several hundred thousand to more than a million years old, depending on the location. Krypton-81 analysis confirmed these date ranges and provided insights regarding the patterns of water movement in the aquifer.

National SADA Reports

National SADA reports were prepared to present baseline data on each country and present their national perspectives on priority transboundary issues. The results of the national reports provided the basis for developing regional perspectives presented in the Regional SADA report. The National SADA reports are annexes to the Regional SADA

SAP development

To prepare this summary SAP a team of experts, drawn from the four countries sharing the NSAS met with the IAEA in June 2010 to review the scope and expectations for the SAP. The meeting participants agreed on the key aspects of the SAP and formed the basis for the preparation of National reports. These agreements included:

- The importance of strengthening the role and capacity of the existing Joint Authority
- The Vision for the NSAS
- The key Water Resource Objectives and Ecosystem Objectives for the NSAS
- Information needs to enable national management actions to be identified that would meet the Objectives and lead to the Vision.

A final meeting was held by the SAP formulation team in October 2011 to review and agree the wording of the Vision and Objectives, and to begin the process of preparing a common set of management actions addressing the key transboundary (and shared) concerns of the NSAS.

These discussions and agreements led to the management targets and actions presented in this SAP. (Section 4.3 and Annex 1)

Summary of SADA

Understanding priority threats and their root causes is the initial step in defining both the technical challenges in managing the NSAS as well as identifying the policy and institutional reforms necessary to manage the resource in the most rational and effective way possible.

The process of identifying priority transboundary concerns was initiated with diagnostic analysis training (Khartoum, March 2007) and evolved through national workshops in the late-summer and autumn of 2007. In these workshops priority problems and their root causes were assessed through the formal process of causal chain analysis. The analysis itself was conducted by each country separately through national workshops. The results were presented in a summary document in late 2008 and approved by the Project Steering Committee at their January 2009 meeting.

Modelling Results

The modelling approach was to calibrate the model to accurately represent the gradual natural draining of the aquifer since the last Ice Age. The calibrated model was then used to run a set of predictions for the response of the aquifer to scenarios of future water extraction based on historical, current, and anticipated demands. It is important to recognize that the model solution is not unique. The prediction of how the aquifer responds to water withdrawal has to be represented as a range of likely values rather than a single map showing meters of drawdown, due to uncertainties in the parameters that govern the model. These uncertainties are caused by the relative lack of detailed knowledge of the structure of the aquifer and the hydrogeologic characteristics that control water movement through the aquifer. As more data are collected and incorporated into the model, the degree of certainty in model predictions will increase.

Having made these qualifications, the modelling results indicated that the likelihood for direct transboundary drawdown is low. Even pumping centers located near national borders, such as Jaghboub in Libya and Siwa and East Owienat in Egypt, are not predicted to cause significant drawdown across national borders. Localized drawdown in pumping locations, however, is predicted to be high. The highest capacity pumping centers of Sarir and Kufra in Libya and Dakhla in Egypt produce significant drawdown, but the lateral extent of drawdown toward national borders is insignificant. Impacts of pumping will be most significant where the aquifer is thinnest, which is in the southeastern lobe of the aquifer in Sudan. There, widespread drawdown is predicted and the threat of depletion exists.

The NSAS model can be considered to be in a complete, but early form. The conclusions drawn from the predictive modelling runs are accurate, but have relatively wide error ranges. As a result, it is a valid conclusion that direct transboundary drawdowns are expected to be low, but it is essential to continue monitoring water levels and collecting data on the hydrogeology of the system to improve the predictions. This is particularly critical in Sudan, where the threat of resource depletion is the most immediate.

Direct Versus Shared Transboundary Risks

The risks described in this section have the potential for transboundary effects, however at present and under forecast conditions, risks of *direct* transboundary impacts for all areas of concern are low. Take for example abstraction in the East Oweinat production area in Egypt and its potential effects on Sudan. The risk of water level decline is low or non-existent, depending on the accuracy of recent

modelling. There is no transboundary risk of water quality deterioration on the Sudan side of the border near East Oweinat, because of the low mobility of contaminants that could enter the aquifer at the Oweinat agricultural areas. The risk of change in groundwater regime is lower than the risk of water decline, which itself is at or near zero. The risk of loss of ecosystems or biological diversity is linked to changes in water level decline, but there would have to be an oasis ecosystem present in Sudan near enough to the East Oweinat production area to be affected.

The example of East Oweinat can be repeated for the other two existing production areas near borders, Siwa in Egypt and Kufra and Tazerbo in Libya. The current modelling results indicate that there is little risk of cross-border effects. This example can be extended to unforeseen near-border developments as well, for example along the camel route between Sudan and Egypt to the east of the East Oweinat production area. These are areas worthy of more focused attention in the region for direct transboundary impacts. The current modelling effort and all previous modelling studies agree that there is no risk of direct transboundary effects due to production areas distant from borders. Even abstraction projects as large as the Great Manmade River result, by all accounts, in only localized direct transboundary effects.

At a regional level, the existing and prospective near-border development projects constitute the only direct transboundary risk and these risks are low. Of far greater importance are the *shared* transboundary risks. These are the adverse impacts of water extraction that have only national effects, but are common to the region.

Management of the Aquifer for Prevention of Impairments

One aspect of risks due to abstraction in the region, whether they are considered direct or shared, is that no significant adverse effects have yet been observed. This presents a unique opportunity to create shared management strategies oriented around prevention. The risk of direct transboundary effects is low, but sufficiently large to merit vigilance in monitoring. This risk is also low enough that each country can exercise their sovereign right to use their resources as they see appropriate. The region is also in a position to take advantage of the existing framework of the Joint Authority to cooperate in shared management of the aquifer to minimize the risk of adverse impacts of national origin.

Gaps

Although the Nubian countries have made great advances in understanding the condition of the aquifer and the linkages between potential changes in the aquifer and responses of environmental and human systems, much work remains.

- ***Geology and Water Levels:*** The single greatest limitation in analyzing data for this project was the uncertainty introduced by the lack of geologic and hydrologic data. Vast expanses of the aquifer are essentially unknown. Modelling activities described in Section 4 were able to provide forecasts of future effects of abstraction, however, improved knowledge is necessary to confirm these findings and improve statistical confidence in the predictions.

- ***Isotopic Age Dating:*** A promising technique employed in this project has been the analysis of groundwater in Egypt for krypton-81 isotope ratios (^{81}Kr). These data revealed ages of groundwater on the order of hundreds of thousands of years and were important in confirming theories regarding water movement in the aquifer. These theories supported statistical confidence in the current modelling efforts. Existing wells in Libya and Egypt can be sampled for this analysis and as a result important information can be provided at a relatively low cost.

- ***Ecosystem Vulnerability:*** The calibrated regional groundwater model has not yet been applied extensively. An important early application of the model is to refine the grid in the region of pumping and oasis areas and determine the vulnerability or oasis ecosystems to abstraction.

- ***Ecosystem Assessment:*** Only limited data appear to be available on the condition of terrestrial and oasis ecosystems. As indicated in Sudan's Baseline Report, additional monitoring is necessary to understand the current extent and conditions of ecosystems.

- ***Climate Change Threat:*** Adverse environmental change can occur in both terrestrial grassland, as well as aquatic oasis ecosystems, in response to some combination of abstraction, climate change, and even a continuation of the current climatic conditions. A better understanding of the impacts of climate change is necessary in order to separate the effects of the natural trajectory of the desert ecosystems from the human-related impacts.

- ***Capacity Equalization:*** The Nubian countries vary considerably in their capacities for field, laboratory monitoring, and groundwater modelling activities. The cooperative mechanisms developed through the Joint Authority need to be exploited to equalize capacity among the countries.

Benefits

Benefits related to the work in preparing the SAP have already been realised for the countries of the NSAS and the Joint Authority.

- ***Improved Data Sharing:*** For reasons related primarily to limitations in capacity, the NARIS database has not been updated since 1998. This project has resulted in data sharing that enabled updating of hydrogeologic databases for modelling purposes.

- ***A Shared Regional Groundwater Model:*** As a result of SADA activities, the member countries now have a common basis for sharing and interpreting hydrogeologic data. This model has already produced results that have reshaped how member countries view their national and transboundary aquifer resources.

- ***Improved Understanding of Transboundary Threats:*** Perhaps the single greatest benefit realized by the project so far has been the recognition that the immediate, direct transboundary threat of water-level declines due to cross-border abstraction are far lower than originally thought. This awareness does not relieve the member countries from maintaining and enhancing their shared monitoring programs, but does inspire a variety of

related benefits, including the recognition that water management strategies can be directed toward *preventing* rather than *mitigating* both transboundary and national and water management problems.

Stakeholder Analysis

A detailed stakeholder analysis, the interests of the stakeholders and the relative power or importance of the stakeholders was undertaken and reported in 2008. This work was undertaken by a working group that defined a list of stakeholders and interests and reviewed both the primary stakeholders (those who are ultimately impacted by the activities of the project, e.g. farmers, local tribes, etc.) and secondary stakeholders (e.g. government departments, NGOs, private sector organisations).

In addition to the national stakeholders, international and regional stakeholders (e.g. international organisations, the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer Waters, etc.) are described. The detailed stakeholder report also provided a breakdown of the involvement of different stakeholder groups at the varying stages of the plan development and implementation.

This analysis will provide an important basis for the future implementation of the SAP and provide a means for the assessment of the success of the outcomes relating to the SAP.

Governance Analysis

A Governance Analysis was conducted by the SADA technical task team and completed in June 2008. This document provides national summaries of the water resources situation, socioeconomic situation, and governance information for the four countries. The latter provides an overview of the national ministries involved in the assessment and management of water and a summary of legal issues related to water. National legal and institutional reports have been prepared separately by legal experts as part of the Legal and Institutional component of this project. It is anticipated that these will be compiled and a transboundary legal component will be added as the culmination of that component.

SADA Findings

The SADA process revealed two critically important aspects relevant to the management of the Nubian aquifer: (1) it is still early enough in the development of the NSAS that priority threats have not yet, according to national reports, resulted in ecosystem impairment; and (2) the risk of transboundary causes for these threats is low. These findings provide the Nubian countries the unique opportunity to *prevent* rather than *mitigate* resource impairment.

From a management standpoint, the modelling results indicate that member countries can develop their water resources without significant concern either that they will affect neighbouring countries or that neighbouring countries will affect their water resources. Modelling was based on limited data and these data limitations resulted in sufficient uncertainty in drawdown predictions that continued monitoring is necessary, both to provide additional data to improve modelling efforts and to provide direct evidence that transboundary drawdown does not occur. From the standpoint of governance, the Joint Authority provides a first basis for the regional legal and institutional mechanisms necessary to formalize future plans for regional cooperation.

The five transboundary problems prioritised by the SADA Technical Task Team are presented in Table 1.

Table 1 Summary of Priority Transboundary Problems.

Transboundary Problems	Rank	Comment
Declining Water Levels	1	The aquifer is highly vulnerable to localized drawdown. There is little indication that the lateral extent of drawdown can extend far enough to cause transboundary effects.
Damage or Loss of Ecosystem and Biodiversity	2	Closely linked with Declining Water Levels. Oases are highly vulnerable to water level declines and practically all well fields are located in or near oases.
Water Quality Deterioration	3	As more water is abstracted from the aquifer, the potential increases for recharged wastewater to cause water quality problems.
Climate Change	4	Depends on timing and magnitude of climate change. Can affect changes in water use patterns. In southern part of region, can affect grasslands.
Changes in Groundwater Regime	5	Modelling indicates that changes in groundwater flow patterns will not occur outside of the very immediate area of well fields.

Immediate, underlying and root causes of Transboundary problems

During the SADA preparation a detailed causal chain analysis (CCA) was undertaken to review the sources of the perceived problems identified for the NSAS.

Table 2 Summary of the Causal Chain Analysis.

Transboundary Problems	Immediate, underlying and root causes
Declining Water Levels	Accelerated water level decline is directly related to abstraction, so the immediate cause of any associated problems would be excessive abstraction from the aquifer. Since the primary use for abstracted water is agricultural irrigation, the underlying causes would be related to demands related to the expansion of agriculture, and intensified by issues of efficiency and conservation. Examples of inefficiency are technical and managerial shortcomings and pumping water in excess of demand for various reasons. The root cause is population growth, which implies increasing water demand for all purposes, and may affect institutional decisions regarding food security, and consequently agricultural water demand.
Damage or Loss of Ecosystem and Biodiversity	The immediate causes of impairment to ecosystem health and losses in biodiversity are different for aquatic and terrestrial ecosystems. For the oasis ecosystems, the immediate causes are water level decline and water quality deterioration, which can occur either separately or in concert. The

Transboundary Problems	Immediate, underlying and root causes
	underlying causes are similar to previously described impairments: over-abstraction resulting in declining water levels and inadequate pollution prevention practices resulting in water quality deterioration. The root causes are expansion in agricultural and industrial sectors due to population growth and related to decisions on food security. For terrestrial ecosystems, the immediate cause is decline in rainfall, and the root cause is climate change.
Water Quality Deterioration	The immediate causes of water quality deterioration are pollution, salinization, and disturbed water balance. These causes are of a technical nature. The underlying causes are agricultural and industrial growth and improper waste disposal leading to aquifer contamination. The root causes of water quality deterioration are the increase in agricultural and industrial development, related to the combination of increased population and national decisions related to food security priorities.
Climate Change	Global and not reviewed for the SADA or SAP
Changes in Groundwater Regime	The immediate cause of change in groundwater regime is a drop in water levels. The underlying cause is over-abstraction which is aggravated by unmanaged water use and exploitation. The root causes are again the growth in agricultural and industrial sectors due to population growth and related to decisions on food security.

Impact of SADA Process

The NSAS SADA team followed the principles of TDA development established by GEF/IW Learn to devise the regional SADA as an objective, non-negotiated technical document. As summarized above, the SADA process enabled the NSAS countries to rank the threats to the aquifer system resulting from continued development of the aquifer. Technical evaluation of these threats was possible through sharing of aquifer data and a collaborative modelling effort. These mechanisms of data sharing and collaborative modelling build on an administrative structure already in place through the Joint Authority (described below) and set the stage for future activities proposed by the SAP.

The technical approach taken in the SADA process marks an important milestone in regional cooperation. All four countries participated in every stage of the modelling process and agreed that the model and data developed through the SADA process will form the basis for future enhancement of the model. Additionally the model will be used both for evaluating monitoring data collected through ongoing efforts as well as to assist in determining locations of new monitoring sites.

The SADA process was effective in building on existing institutional structures to achieve regional agreement on the status of and threats to Nubian water resources. The tools developed as part of this process provide a common basis for the four countries to share and evaluate data and to design

and implement future strategies for the management of the water, environmental, and ecological resources of the region.

Regional co-operation

An overview of the history of the Joint Authority.

A Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System was established between Egypt and Libya in 1989 and was formally launched in 1991[1]. The agreement providing "Constitution of the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer Waters" seem to have been adopted in 1992.

Sudan jointed the Joint Authority in 1996[2]. Its accession to the Joint Authority was formerly approved by the Council of Minister resolution No. /81/at 1997[3].

Chad was invited to attend as an observer a meeting of the Joint Authority in 1998, and was then officially invited to be an active member of the Joint Authority[4]. The participation of Chad to the Joint Authority was formally acknowledged by a letter of the Ministry of Foreign Affairs (Chad) in August 1998 addressed to the Regional Coordinator of the Technical Committee in Tripoli (Libya)[5]. In March 1999, Chad officially joined the Joint Authority[6].

During the first project on the Nubian aquifer, the "Regional Strategy for the Utilization of the Nubian Sandstone Aquifer System" executed by CEDARE (1998-2002), the Joint Authority held yearly meetings as it acted as the Project Steering Committee. The project seems to have allowed a revitalization of the Joint Authority, as it had a defined role to play.

A summary of the constitution and subsequent agreements on monitoring and data sharing

The agreement on the Joint Authority

The agreement on the "Constitution of the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer Waters" is as its name indicates an agreement creating the Joint Authority, and providing the basic rules for its functioning. The Constitution is divided in four chapters namely:

- Chapter 1 Establishment, headquarters, purpose and membership
- Chapter 2 Authority Management

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[1] Salem O., Tripoli III Conference
The National Legal Report of Lybia mentions « Minutes of July 1991creating the Joint Authority between both countries. The National Legal Report from Egypt mentions the minutes of the first session of the Egypt-Libyan Joint High Committee (6-8 July 1991) regarding the establishment of the JA.
[2] Khater A., oral presentation, The 5th Biennial GEF International Waters Conference

[3] National Legal Report of Sudan
[4] Regional Strategy for the Utilisation of the Nubian Sandstone Aquifer System, vol IV Administration.
[5] National Legal Report Chad.
[6] Regional Strategy.

- Chapter 3 Budget, Accounts and Financial Resources
- Chapter 4 General Provisions

Chapter 1 is composed of four articles. The two first ones are very short. Article 1 provide for the establishment of the "Joint Authority for the Study and Development of the Nubian Sandstone Aquifer Waters" , while in article 2 its headquarters are fixed in Tripoli (Libya) with the possibility for the board of directors to open branches in other member countries. Article 4 opens the membership to the other countries sharing the Nubian Aquifer. This article does not have any meaning now that the four countries are member of the Joint Authority. Article 3 is the most important one as it defines the responsibilities of the Joint Authority, which are quite important and wide. The responsibilities assigned to the Joint Authority can be divided into three categories:

- **Scientific**
  - Collection of all information, data and results of studies
  - Prepare and execute studies
  - Study of environmental aspects of Aquifer development, desertification control and renewable energy use
- **Management, policy**
  - Develop programs, plans for the utilisation of water, propose a common policy for the development and utilisation of water resources, nationally and regionally, execution of the common policy
  - Adopt scientific basis for the water management of the Aquifer
  - Undertake to ration the consumption of Nubian Sandstone Aquifer waters in member countries
- **Training, dissemination**
  - Establish cooperation in the field of training
  - Organise symposiums and disseminate information, consolidate relationship with relevant regional and international organizations

Chapter 2 provides the rules for the management of the Authority (articles 5 to 15). The Joint Authority is managed by a board of directors composed of three members from each country. The chair of the board of directors is appointed on a rotation basis, for one year. The chair represents the Authority in its relations with others, and acts on behalf of the Authority. A quorum of two thirds of the members needs to be reached for the validity of a board meeting. If such a quorum is not reached, after the second call the meeting is considered valid if attended by any number of members. The board of directors is in charge of managing the affairs of the Authority, in particular (article 10):

- Payment of initial expenses for establishment and registering the authority making all the necessary procedures and the determination of general administration expenses or the establishment period.
- Audit and approve the authority's annual draft budget.

- Draw an annual report on the authority's activities at the end of each financial year, and submit it to the governments of member countries to be sent by certified mail to the concerned authorities.
- Establish branches and offices for the Authority inside or outside member countries.
- Appoint a general Director for the Authority and define his duties.
- Directors for branches and offices to be opened in accordance to this constitution.
- Draw plans and polices aimed to the achievement of the purposes of the Authority.
- Issue By-laws and instructions for the management of administrative and financial affairs.
- Approve the organizational structure and personnel cadre of the authority, to be proposed by the Executive General Director.

The resolutions of the board of directors are adopted at the majority, except on the following issues, where a majority of two-thirds is requested:

- Budget consideration and approval.
- Proposals for establishing relationships with regional and international organisations and institutions and donor countries.
- Opening of branches or offices in founder countries or new members countries.

The board of directors nominates an executive general director for a period of three renewable years with the following responsibilities (article 13):

- Execution of the recommendations and resolutions of the Board of Directors.
- Follow-up technical studies related to the activities of the Authority.
- Record meeting minutes and decisions of the Board of Directors.
- Direct supervision of the technical, administrative and financial departments of the Authority.
- Execute memos and letters related to the Authority operations and activities.
- Any other works assigned by the Board of Directors of the Authority.

And finally the last article of chapter 2 provides for an administrative body for the Joint Authority in charge to execute the recommendations and resolutions of the board of directors.

Chapter 3 deals with the budget and the financial issues. The principle is that each government contributes to the budget of the Authority on equal share (article 16). In addition to the Member States' contributions, the financial resources of the Authority can be constituted of donations from national and international institutions and organizations and donor countries (article 21). The Executive General Director the final accounts of the annual budget for approval by the board of Directors.

Chapter 4 provides for the autonomy of the internal regulations and by-laws of the Joint Authority vis-à-vis the regulations in Member States. According to article 25, the financial and administrative regulations adopted by Arab States League and its organizations shall apply until detailed financial and administrative regulations for the Authority shall be made.

The agreements on monitoring and data exchange

In the frame of the first project on the Nubian aquifer, executed by CEDARE, two agreements were prepared and approved the Directors in charge in the four countries.

The first agreement is related to the "Terms of reference for the monitoring and exchange of groundwater information of the Nubian Sandstone Aquifer System". In this agreement, the four countries, Chad, Egypt, Libya and Sudan agree to exchange the data consolidated through the project, and included in the information system NARIS, which had been achieved, as well as information related to socio-economic aspects, meteorology, drilling experiences, and data agreed upon in the second agreement.

The second agreement is related to the monitoring and data sharing. In this agreement, the four countries decide to monitor and exchange the following information:"

- Yearly extraction in every extraction site, specifying geographical location, and number of producing wells and springs in each site
- Representative Electrical Conductivity once a year
- Water level measurements, twice a year"

An annex is attached to this agreement with a proposed regional monitoring network including a map and a list of wells.

Vision for the NSAS

The technical task team (TTT)/SAP formulation team met in June and October 2010 to agree a Vision for the NSAS. The discussions considered the importance of a wide range of issues, including:

- The importance of socio-economic development of the region to assure the livelihoods of the NSAS population;
- The value of the NSAS resource to the region for irrigation, industry, human health and ecosystem maintenance;
- The benefits of sharing knowledge and information on the status and use of the aquifer;
- The importance of minimising pollution of the aquifer;
- The value and vulnerability of the ecosystems dependent on the aquifer;
- The need to reduce demand for human migration;
- Further developing the model for the NSAS and strengthening the capacity in the use of isotope methods to further understand the functioning of the NSAS;
- The importance of enhance the role and capability of the Joint Authority building on the existing international agreements;
- Recognising the potential impacts of climate change and implementing measures to adapt to these changes.

The Vision for the NSAS

To assure rational and equitable management of the NSAS for sustainable socio-economic development and the protection of biodiversity and land resources whilst ensuring no detrimental effects on the shared aquifer countries.

To achieve this Vision a series of Water Resource Objectives and Ecosystem Objectives that will be reached through a programme of management actions laid out below were agreed.

Strategy for Protecting the Water Resources and Ecosystem of the NSAS

The strategy for achieving the Vision for the NSAS is set-out below and is based on some over-arching principles on water resource and environmental management, and the definition of agreed management objectives. These objectives are then translated into agreed transboundary management actions and targets. Whilst these are defined at the 'transboundary' level it is recognised that the implementation of many of these will be the responsibility of the individual states of the NSAS and it is therefore expected that the transboundary actions will need to be transposed into corresponding National Management Actions.

Key Management Principles

The SAP will adhere to two key environmental management principles. These are:

- The Ecosystem Based Management Approach[7]; and
- Integrated Water Resources Management[8]

The Dublin Principles:

The 1992 Dublin Conference established four guiding principles for managing freshwater resources:

1) Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
2) Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels.
3) Women play a central part in the provision, management and safeguarding of water.
4) Water has an economic value in all its competing uses and should be recognized as an economic good.

These four Dublin Principles are at the heart of the IWRM concept

7 Ecosystem-based management: An ecosystem-based approach, which maintains key characteristics of ecosystems in a way that sustains species and ecological processes but also supports some human intervention for economic or social purposes. (http://www.biodiversitybc.org/EN/main/where/131.html)

8 IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

The NSAS states share a common desire for the sustainable management of the natural resources and biodiversity of the NSAS, and recognize their role and responsibility in conserving the global value of these resources. The states have considered and taken into account, where appropriate, the following principles and values when further developing and implementing the SAP recognising that that these principles may be already adopted in some states and should be further promoted.

- The principle of **sustainable development** shall be applied such that there is a prudent and rational utilization of living resources and the preservation of the rights of future generations to a viable environment.
- The **precautionary principle** shall be applied, such that measures shall be taken when there are reasonable grounds for concern that any activity may increase the potential hazards to human health, harm living resources or ecosystems, damage amenities, or interfere with other legitimate uses of the NSAS, even when there is no conclusive evidence of a causal relationship between the activity and the effects; and by virtue of which, greater caution is required when information, including scientific information, is uncertain, unreliable or inadequate.
- The **polluter pays principle** shall be applied, such that the cost of preventing and eliminating pollution, including clean-up costs, shall be paid by the polluter.
- The principle of **anticipatory action** shall be applied, such that contingency planning, environmental impact assessment and strategic impact assessment (involving the assessment of the environmental and social consequences of governmental policies, programmes and plans) shall be undertaken in the future development in the region.
- The principle of **preventative action** shall be applied, such that timely action shall be taken to alert the responsible and relevant authorities of likely impacts and to address the actual or potential causes of adverse impacts on the environment, before they occur.
- **Environmental and health considerations** shall be included into all relevant policies and sectoral plans and programmes, including, *inter alia*, urban planning, industrial development, agriculture, tourism, etc.
- Use of **clean technology** shall be promoted when replacing or phasing-out high waste and waste-generating technologies, including the use of Best Available Technique/Technology (BAT).
- Use of **Sustainable Agriculture** shall be promoted in order to replace or phase-out unsustainable agricultural practices, including the use of Good Agricultural Practices (GAP).
- Development planning and environmental planning processes should be integrated to the maximum extent. The use of **economic instruments** that foster sustainable development shall be promoted through, *inter alia*, the implementation of economic incentives for introducing environmentally friendly technologies, activities and practices; the phasing-out of subsidies which encourage the continuation of non-environmentally friendly technologies, activities and practices; and the introduction of user fees.
- The principle of **accessibility of information** shall be applied, such that information on the pollution of the environment of the NSAS
- The principles of **public participation and transparency** shall be applied, such that all stakeholders, including communities, individuals and concerned organizations shall be given the opportunity to participate, at the appropriate level, in decision-making and management processes that affect the NSAS. This includes providing access to information concerning the environment that is held by public authorities, together with effective access to judicial and administrative proceedings to enable all stakeholders to exercise their rights effectively. Public authorities shall widely disseminate information on the work proposed and undertaken to monitor, protect and improve the state of NSAS.

Long-Term Water Resources and Ecosystem Quality Objectives

To achieve the vision for the NSAS, three Water Resources (WR QOs) / Environmental Quality Objectives (Eco QOs) have been designed that will address the shared concerns identified in the SADA.

WR/Eco QO 1: To manage the shared aquifer in a sustainable and equitable way for the benefit of the NSAS countries on the basis of joint regional planning in order to minimise negative effects within and between countries, anticipating the challenges including increasing population, needs of agricultural expansion, and climate change.

a. To strengthen the role and capacity of the Joint Authority to effectively manage the shared aquifer.
b. To achieve water-efficient use priorities and activities and to reduce the negative impacts of anthropogenic activities on groundwater regime, levels, and quality.
c. To enhance the NSAS resilience to adapt to climate change impacts.

WR/Eco QO 2: To mainstream environmental aspects in the integrated management of the NSAS to conserve the dependent ecosystems and reduce the risk of loss/damage to biodiversity.

WR/Eco QO 3: To utilize the Nubian aquifer resources on sustainable socio-economic development basis

a. To enable integrated transboundary and national socio-economic development activities in the NSAS region, such as implementing appropriate agricultural, industrial and municipal practices to protect the water resources and allow growth.
b. To manage the aquifer and its ecosystems in such a way as to reduce threat from human migrations and associated detrimental effects.

Management actions and targets to meet the WRQOs/EcoQOs

This SAP addresses concerns of a transboundary nature or concerns that are shared between the four NSAS countries. The SAP provides a framework for action at the transboundary level, under the co-ordination of the Joint Authority. However as emphasised throughout this SAP it is anticipated that most actions will be implemented at the national level and therefore this SAP has to be complimented through corresponding National Action Plans. The SAP formulation team has only identified actions that were considered to be of the highest importance that will lead to improved overall management of the NSAS and these are presented below and in Annex 1. At the Regional SAP Meeting held in Vienna, July 2011, the Nubian countries present (Chad, Egypt, and Sudan) selected a sub-set of the management actions for early implementation in a follow-on SAP project. These are presented in Annex 2 as pilot projects proposed by each country, but which may be replicable in the region.

Regional management actions and targets to reach the expected Water Resources and Ecosystem Quality Objectives are centred on four classes of actions to provide structure to the future implementation:

- Policy, legislative and institutional actions;
- Monitoring and data management actions;
- Research training and awareness-raising actions, and;
- Investment actions.

NB: There is a certain degree of overlap between the targets, activities/actions under these classes. For example, investment actions will be needed to 'assist' actions under the other three classes. The recommendation is that these actions will be consolidated in the development of National Action Plans under the co-ordination of the Joint Authority.

Management actions and budget estimations

The National SAP reports prepared by all the countries to guide the SAP identified actions, from a national perspective, of relevance to both regional management and national management. Cost estimates for these actions are provided in the national reports. In compiling the regional SAP, the SAP formulation team discussed (October 2010) a common set of 'regional management actions' which are presented in Section 4.4 and in Annex 1. A budget estimate for these regional actions (corresponding to actions that are required at a regional level and/or are shared between countries) was compiled based on national reports, specific input from countries and expert judgement. However a more detailed cost-benefit assessment of options is required prior to SAP implementation, but these preliminary budget estimations provide an overall guide to the comparative costs of the agreed actions.

WR/Eco QOs 1: Shared Aquifer Management

Objective: To manage the shared aquifer in a sustainable and equitable way for the benefit of the NSAS countries on the basis of joint regional planning in order to minimise negative effects within and between countries; anticipating the challenges of increasing population, expansion of development, and climate change.

WR/Eco QOs 1a: To strengthen the role and capacity of the NSAS Joint Authority (JA) to effectively manage the shared aquifer

Expected Outcomes: Empowered regional and national management capacity of the Joint Authority to enable providing development assistance and advice to all countries with a web-based information system available to stakeholders.

Policy, Legislative and Institutional Actions:

Target 1a.1: Establish enhanced transnational mechanisms to strengthen the existing cooperation through the JA and explore new areas of cooperation

- Action 1a.1.i: Pursue capacity building and training possibilities in the NSAS countries for monitoring and modelling.

- Action 1a.1.ii: Develop regional policy recommendations to include the ecosystem monitoring and management within the responsibilities of the JA.
- Action 1a.1.iii: Enhance the institutional structure of the JA to cover regional policy, legal and institutional aspects of the NSAS.
- Action 1a.1.iv: Grant the JA the privileges and immunities necessary for carrying out its responsibilities.
- Action 1a.1.v: Provide financial means to the JA including country contributions.

Target 1a.2: Establish a cooperation framework on data exchange.

- Action 1a.2.i: Revive and update previously signed agreements on groundwater monitoring and exchange.
- Action 1a.2.ii: Develop a management framework.

Target 1a.3: Ensure the effective establishment and performance of national offices of the JA

- Action 1a.3.i: Ensure that national offices are well established and well equipped with qualified and motivated staff.
- Action 1a.3.ii: Supply the JA with monitoring data and information according to the provisions of the agreements.

Target 1a.4: Improve the effectiveness of JA in managing NSAS

- Action 1a.4.i: Implement exchange of staff and sharing of experiences with other water commissions

Monitoring and Data Management Actions:

Target 1a.5: Implement, maintain and utilise a transboundary monitoring network and information database providing comparable information to assess the status of water and biological resources of the NSAS.

- Action 1a.5.i: Design and implement harmonised routine regional monitoring network covering water level, abstraction, and quality.
- Action 1a.5.ii: Review and update existing monitoring methods ensuring compatibility of data including for biological parameters.
- Action 1a.5.iii: Develop and implement appropriate programme for establishing and monitoring the biological status of oases.
- Action 1a.5.iv: Implement transboundary quality assurance and quality control procedures.
- Action 1a.5.v: Update, operate and maintain on-line regional database management system.
- Action 1a.5.vi: Design, agree, and implement routine reporting of water and biological resources to regional stakeholders based on agreed monitoring programme.

Research, Training and Awareness-raising Actions:

Target 1a.6: Implement a regional network of research and training centres addressing the needs to the NSAS.

- Action 1a.6.i: Prepare detailed training needs assessment for enhanced water resource management within the NSAS. This training to address the needs of monitoring, modelling, isotope hydrology, GIS & databases, data management & interpretation, management and awareness-raising for stakeholders.
- Action 1a.6.ii: Prepare detailed training requirements for establishing a ecosystem monitoring and assessment for the NSAS.
- Action 1a.6.iii: Develop and deliver capacity building programmes within the regional network of centres leading to the creation of a permanent capacity building capability across the NSAS.

Target 1a.7: Update, maintain, and utilise a NSAS-agreed modelling capability providing water resource and use assessments to the JA and Governments of the NSAS region.

- Action 1a.7.i: Develop NSAS-specific modelling capacity within the JA and Government Institutes of the NSAS through the regional network of research and training centres.
- Action 1a.7.ii: Develop and agree protocols for sharing the results of localised improvements to the model for consistent recalibration.
- Action 1a.7.iii: Use the agreed model to develop regional responses to different modelled scenarios on water resources based on demand and potential climate change.

Investment Actions:

Target 1a.8: Ensure the prompt and adequate provision of funding for the JA through a programme of national and international investments.

- Action 1a.8.i: Provide the JA with sufficient operating resources to fund needed equipment (office facilities, including computers and software) at both the JA central office and in national offices.
- Action 1a.8.ii: Develop within the JA an agreed work programme identifying all investments required at the transboundary level and works with all countries in the NSAS to ensure compatibility with national requirements.
- Action 1a.8.iii: Maintain within the JA (in close collaboration with NSAS countries) an updated list of all future investment needs and develop a strategy to work with national governments and international donors to ensure that the on-going needs of the region are documented and brought to the attention of finance ministries and donors.

WR/Eco QOs 1b: To achieve water-efficient use priorities and activities and to reduce the negative impacts of anthropogenic activities on groundwater regime, levels, and quality.

Expected Outcomes: Improved regional and national management of the aquifer system and groundwater development and utilization activities, leading to control and stabilization of the NSAS declining groundwater levels, limiting pollution from inefficient water use practices, reducing

impacts of over-use/ over-application and maintaining relatively transboundary effects-free development.

Policy, Legislative and Institutional Actions:

Target 1b.1: Enhance legal and institutional mechanisms to exercise regional protection and control on water use activities and priorities.

- Action 1b.1.i: Identify the legal and institutional requirements to enforce regional protection and control on the development of the NSAS.
- Action 1b.1.ii: Develop regional policy and guidelines for water allocation, water use activities and priorities.

Target 1b.2: Establish control on waste disposal practices.

- Action 1b.2.i: Develop waste disposal quality standards and guidelines.

Monitoring and Data Management Actions:

Target 1b.3: Achieve regional control on water resources based on objective-directed monitoring and information management.

- Action 1b.3.i: Develop database for water use and consumption across the NSAS.
- Action 1b.3.ii: Develop and implement regional monitoring across NSAS on water consumption.
- Action 1b.3.iii: Evaluate water loss from different users of NSAS resources.
- Action 1b.3.iv: Develop an inventory of sites, uses etc. with the potential to negatively impact the quality of the NSAS (potential pollution hotspots).

Research, Training and Awareness-raising Actions:

Target 1b.4: Strengthen regional research and cooperation on reducing excess water use.

- Action 1b.4.i: Assess water use efficiency across the NSAS and identify means to reduce demand.
- Action 1b.4.ii: Establish expertise (through the network of research and training centres) on advising users on water conservation techniques.
- Action 1b.4.iii: Develop agreed R&D programmes (linked to network of research and training centres and pilot demonstration projects) on water conservation, salt-tolerant and drought-resistant crops, etc.
- Action 1b.4.iv: Develop targeted awareness campaigns aimed at different users to reduce or conserve water resources and to minimise any pollution or environmental impacts.

Investment Actions:

Target 1b.5: Ensure the prompt and adequate provision of funds for transboundary priority programmes to achieve protective controls on NSAS water resources and to minimise anthropogenic impacts on the ecosystem.

- Action 1b.5.i: Develop a database of investment needs for control of water demand across the NSAS linked to potential donors.
- Action 1b.5.ii: Provide appropriate regional equipment to be used by the JA to assist with monitoring.

Target 1b.6: Gain regional experience on water conservation techniques and minimise impacts from overuse of water and pollution on the ecosystem

- Action 1b.6.i: Implement pilot demonstration projects addressing water conservation in different sectors.
- Action 1b.6.ii: Develop replication/sustainability strategy to enable pilot projects to be applied across the NSAS.

WR/Eco QOs 1c: To enhance the NSAS resilience to adapt to climate change impacts.

Expected Outcomes: Improved regional and national understanding of the conceivable impacts of climate change on the NSAS. Development of regional and national policies for monitoring and assessment of climate change impacts. Identification of approaches and actions proposed to facilitate adaptation to climate change and to introduce climate-proof adaptive management of the aquifer system.

Policy, Legislative and Institutional Actions:

Target 1c.1: Establish legal and institutional mechanisms to enable adaptation to climate change.

- Action 1c.1.i: Develop regional policy for climate change adaptation in the NSAS countries.
- Action 1c.1.ii: Develop regional policy, and legal and institutional mechanisms for monitoring climate change and its impacts.

Target 1c.2: Cooperate on collecting data related to climate change.

- Action 1c.2.i: Develop a cooperation framework for climate change monitoring and exchange of data.
- Action 1c.2.ii: Establish a unified methodology for climate-risk screening for proposed projects and activities.

Monitoring and Data Management Actions:

Target 1c.3: Develop and implement regional programme for monitoring and analysis of climate change and impacts.

- Action 1c.3.i: Identify potential direct and indirect transboundary impacts of climate change on the NSAS and its ecosystem.

- Action 1c.3.ii: Agree on parameters for monitoring the direct and indirect impacts of climate change on the NSAS and its ecosystem.
- Action 1c.3iii: Select key monitoring locations for assessing transboundary impacts of climate change.
- Action 1c.3.iv: Include transboundary data in the JA's database for the NSAS.

Research, Training and Awareness-raising Actions:

Target 1c.4: Explore joint research to enhance the NSAS resilience to adapt to climate change impacts at the transboundary level.

- Action 1c.4.i: Assess the risks from climate change on the aquifer and potential future groundwater developments in the Nubian countries including related ecosystems.
- Action 1c.4.ii: Establish regional expertise on joint research linking climate change and groundwater models.

Target 1c.5: Increase awareness among stakeholders of the impacts of climate change on the NSAS.

- Action 1c.5.i: Develop targeted training on climate adaptation for local communities and other stakeholders.
- Action 1c.5.ii: Develop a consultative process for engaging a wide range of stakeholders and providing appropriate awareness raising and capacity building material.

Investment Actions:

Target 1c.6: Ensure the prompt and adequate provision of funding for transboundary actions enabling climate change adaptation in the NSAS.

- Action 1c.6.i: Assess investment needs to address and resolve likely transboundary impacts of climate change.
- Action 1c.6.ii: Identify regional actions and funding sources.

Target 1c.7: Gain experiences through targeted pilot demonstration projects to illustrate potential adaptation approaches within the NSAS

- Action 1c.7.i: Implement pilot demonstration project addressing responses to climate change (e.g. alternative crops, irrigation methods and other water conservation approaches).
- Action 1c.7.ii: Develop replication/sustainability strategy to enable pilot projects to be applied across the NSAS

WR/Eco QOs 2: Mainstreaming environmental issues within the NSAS

Objectives: To mainstream environmental aspects in the integrated management of the NSAS to conserve the dependent ecosystems and reduce the risk of loss/damage to biodiversity.

Expected Outcomes: identification of the NSAS-dependent ecosystems and threats to biodiversity in order to suggest conservation measures related to groundwater development in the system.

Policy, Legislative and Institutional Actions:

Target 2a.1: Establish a regional legal and institutional mechanism to protect the NSAS dependant ecosystems and biodiversity, and extend the competence of the JA in this field.

- Action 2a.1.i: Develop regional policy to establish cooperation on ecosystem conservation, and include conservation of dependent biodiversity and ecological functions in the integrated management of the NSAS
- Action 2a.1.ii: Identify legal and institutional mechanisms to monitor and conserve the NSAS dependent biodiversity and ecological functions.

Target 2a.2: Establish and maintain a regional database for ecosystem and biodiversity, in view of proper management and conservation.

- Action 2a.2.i: Formulate agreements on monitoring and exchange and management of data related to the ecosystems and to the biodiversity.

Monitoring and Data Management Actions:

Target 2a.3: Implement routine monitoring of the NSAS ecosystem enabling the JA and the NSAS Countries to develop appropriate practices and procedures to protect the natural resources.

- Action 2a.3.i: Develop protocols for monitoring and data management which are consistent among NSAS countries.
- Action 2a.3.ii: Catalogue NSAS dependent ecology and assess ecological functions and threats to the ecosystem.
- Action 2a.3.iii: Design an agreed transboundary monitoring system addressing the NSAS dependent ecosystem.
- Action 2a.3.iv: Publish regular (yearly) summaries by the JA of the NSAS biological status.
- Action 2a.3.v: Identify species under threat from anthropogenic activities in the NSAS.
- Action 2a.3.vi: Analyse the ecosystem in relation to abstractions, water quality and climate change.

Research, Training and Awareness-raising Actions:

Target 2a.4: Strive to better understand value and protect the NSAS ecosystem through joint research on transboundary environmental management.

- Action 2a.4.i: Establish a network of expertise in each country on environmental assessments of the NSAS.
- Action 2a.4.ii: Develop a joint catalogue of the potential environmental problems within the NSAS and their transboundary impacts for subsequent investment actions.

- Action 2a.4.iii: Assess the relative importance of the different impacts on the biodiversity and ecological functions within the NSAS.
- Action 2a.4.iv: Implement research on desertification and sand encroachment into habitats.

Target 2a.5: Share experiences and provide training through a range of NSAS joint capacity building workshops on ecosystem management and provide awareness material for stakeholders.

- Action 2a.5.i: Develop NSAS relevant training courses for use in all countries.
- Action 2a.5.ii: Develop a series of NSAS publications to raise awareness of the importance and benefits of the important habitats to a wide range of stakeholders.

Investment Actions:

Target 2a.6: Ensure the prompt and adequate provision of funding for transboundary actions to enable conservation of the NSAS dependent ecosystems.

- Action 2a.6.i: Assess investments needed to address research on the identification of transboundary impacts on the ecosystem within the NSAS region.
- Action 2a.6.ii: Identify priorities, financing arrangements, and possible sources for funding including donors and non-governmental organisations.
- Action 2a.6.iii: Identify and procure necessary equipment for field and laboratory assessments of the NSAS ecosystem and ensure that national experts are given appropriate training to ensure comparable data.

Target 2a.7: Gain experience on ecological protection through the identification and implementation of specific pilot demonstration projects that illustrate the methods and the benefits of conservation in the NSAS dependent ecosystem.

- Action 2a.7.i: Implement 'green oasis' pilot project to conserve ecosystem of region.
- Action 2a.7.ii: Implement pilot project to establish cross-border protected area between Chad and Sudan.
- Action 2a.7.iii: Develop replication/sustainability strategy to enable pilots to be applied across NSAS.
- Action 2a.7.iv: Conduct preservation studies on ecological status of rare and/or endangered species of flora and studies addressing the social and cultural integrity of indigenous people as well as integrity of ecosystems and their components.

WR/Eco QOs 3: Socio-Economic Development

Objective: To utilize the Nubian aquifer resources on sustainable socio-economic development basis.

WR/Eco QOs 3a: To enable integrated transboundary and national socio-economic development activities in the NSAS region, such as implementing appropriate agricultural, industrial and municipal practices to protect the water resources and allow growth.

Expected Outcomes: Identification of the most effective national and mutual investment opportunities for socio-economic development and poverty alleviation, based on efficient and equitable utilization of the shared aquifer resources.

Policy, Legislative and Institutional Actions:

Target 3a.1: Develop legal and institutional procedures to develop transboundary cooperation and integration of the NSAS dependent socio-economic activities and schemes of land use; considering efficient utilization of the waters.

- Action 3a.1.i: Identify regional legal and institutional requirements to integrate soocio-economic activities.
- Action 3a.1.ii: Develop a policy on the integration of socio-economic development aspects in the management of the NSAS.
- Action 3a.1.iii: Enhance legal and institutional structure of the JA to enable formulation of regional policies for NSAS socio-economic activities.
- Action 3a.1.iv: Formulate joint irrigation and animal production projects where the financial, land, and human resources are integrated for the benefit of all.
- Action 3a.1.v: Construct service centres along (animal) transboundary trade routes with fodder, water veterinary services, etc.

Target 3a.2: Preserve and protect the water resources of the NSAS from agriculture.

- Action 3a.2.i: Develop regulations on specific standards for use of chemicals in agriculture, and for industrial and municipal waste disposal.

Monitoring and Data Management Actions:

Target 3a.3: Develop and implement protocols for monitoring socio-economic development consistent across NSAS region.

- Action 3a.3.i: Design and utilise a GIS and database for NSAS development activities and corresponding driving forces within the region (covering water use, water disposal practices, agriculture demands, industrial – especially oil related – use, etc.).
- Action 3a.3.ii: Implement routine water monitoring programmes (quantity and quality) in all NSAS countries.
- Action 3a.3.iii: Populate the database with all countries providing data. Implement data sharing to demonstrate that no country gives or receive any water resources across borders as a result of human activities.
- Action 3a.3.iv: Develop agreed set of water-related socio-economic indicators for the NSAS region and prepare a status assessment.

Target 3a.4: Increase knowledge on sites and activities likely to act as pollution hot-spot or be a potential burden on the NSAS resources.

- Action 3a.4.i: Identify pollution sources (municipal, agricultural, industrial, waste deposits, mines, etc.) in the NSAS and document activities / potential pollutants. Incorporate in NSAS database.
- Action 3a.4.ii: Identify all water abstraction in the NSAS and quantities used. Incorporate in NSAS database.

Research, Training and Awareness-raising Actions:

Target 3a.5: Initiate transboundary research on mainstreaming socio-economic aspects in the integrated management of the NSAS.

- Action 3a.5.i: Establish expertise in each country on assessment of the current status and future requirements of socio-economic development in the NSAS.
- Action 3a.5.ii: Assess the NSAS development requirements to minimise risks of high socio-economic costs and loss of resources and benefits.
- Action 3a.5.iii: Identify the most effective investment opportunities for shared transboundary socio-economic development in the NSAS region.

Target 3a.6: Improve awareness of collective land and water development in the NSAS region.

- Action 3a.6.i: Develop a series of workshops and awareness raising campaigns aimed at a range of stakeholders on the importance of protecting the NSAS and its ecosystem whilst ensuring sustainable economic development in the region.

Target 3a.7: Increase capability to determine water quantity and quality impacts from developments.

- Action 3a.7.i: Refine the NSAS model at a more local scale.
- Action 3a.7.ii: Conduct water quality modelling in local aquifer systems.

Target 3a.8: Initiate research on water quality protection (linked to pilot demonstration projects)

- Action 3a.8.i: Conduct programme on effective use to minimise loss of agro-chemicals.
- Action 3.8.ii: Implement programmes on alternative means for disposal of industrial and municipal waste.

Investment Actions:

Target 3a.9: Ensure the prompt and adequate provision of funding for transboundary actions to enable integration of socio-economic development activities.

- Action 3a.9.i: Assess investments needed to address research on integration of transboundary socio-economic activities within the NSAS region.
- Action 3a.9.ii: Prioritize relevant transboundary actions and identify financing arrangements and possible sources for funding including donors and non-government organizations.
- Action 3a.9.iii: Provide field and laboratory equipment to monitor and assess agricultural and industrial impacts.

Target 3a.10: Gain regional experience on implementing environmentally friendly and water conserving actions having regional application.

- Action 3a.10.i: Implement a range of pilot demonstration projects addressing industrial, municipal and agriculture sectors that will enhance socio-economic development whilst minimising impacts on the water resource and ecosystem. Potential pilots to include:
    - Reducing / controlling agricultural use of pesticides and fertilisers through good agricultural practices (GAP)
    - Demonstrating the benefits of small – medium sized wastewater treatment including low energy demand solutions
    - Addressing problems of oil polluted water from extraction wells through appropriate wastewater treatment
    - Demonstrate the benefits of integrated land and water use and management
    - Demonstration of environmentally sustainable solid waste disposal (municipal or industrial)
- Action 3a.10.ii: Develop replication/sustainability strategy to enable pilot projects to be applied across the NSAS

WR/Eco QOs 3b: To manage the aquifer and its ecosystems in such a way as to reduce threat from human migrations and associated detrimental effects.

Expected Outcomes: Identify and assess transboundary and national potentials and opportunities for human migrations in the NSAS region; in terms of indicators, driving forces, most vulnerable areas, socio-economic development context, detrimental effects, prevention, control and enhancement of transboundary and national management capacities.

Policy, Legislative and Institutional Actions:

Target 3b.1: Develop strategies to establish cooperation on prevention, control and management of human migrations in the Nubian region.

- Action 3b.1.i: Explore the role of pastoral water needs in human migrations.
- Action 3b.1.ii: Advise governments and international organisations in terms of human migrations related to water needs and develop scientific expertise in these terms.
- Action 3b.1.iii: Identify regional legal and institutional requirements to enable control and management of likely human migrations and associated consequences.
- Action 3b.1.iv: Develop policy to reduce demand for movement along transboundary trekking routes connecting the different NSAS countries.
- Action 3b.1.v: Establish national incentives that reduce transboundary migration.

Monitoring and Data Management Actions:

Target 3b.2: Develop protocols and identify regional arrangements for monitoring and data management to control and manage likely human migrations and associated consequences in the NSAS.

- Action 3b.2.i: Construct geographic information and data management systems for the NSAS-dependent population, development activities and likely migration driving forces in the NSAS.
- Action 3b.2.ii: Assess migration potential according to indicators related to socio-economic/ecosystem status, to be developed and agreed on by the NSAS countries.

Research, Training and Awareness-raising Actions:

Target 3b.3: Undertake research on assessment of likely human migrations and associated consequences in the NSAS.

- Action 3b.3.i: Establish expertise on identification and assessment of driving forces for migration of the NSAS-dependent population in the NSAS.
- Action 3b.3.ii: Assess the likely impacts of transboundary migrations of the NSAS-dependent population on the aquifer resources and associated risks of transboundary conflicts and high socio-economic costs.

Region Target 3b.4: Achieve higher effectiveness in the placement of water access points.

- Action 3b.4.i: Apply NSAS aquifer model and other scientific resources to assist international aid organization to determine the locations and depths of future water points.

Investment Actions:

Target 3b.5: Ensure the prompt and adequate provision of funding for actions to enable identification and assessment of potentials and opportunities for transboundary human migrations in the NSAS region.

- Action 3b.5.i: Assess investments needed to address research on the potential and impacts of likely human migrations within the NSAS region.
- Action 3b.5.ii: Prioritize actions and identify financing arrangements and possible sources for funding including donors and non government organizations.
- Action 3b.5.iii: Procure necessary equipment and facilities to undertake assessment on migration and associated pressures on the NSAS and its related ecosystem.

Target 3b.6: Gain regional experience on reducing water dependent migration through targeted pilot demonstration projects

- Action 3b.6.i: Identify and implement pilot projects that will mitigate the pressure for population migration or to alleviate the pressures caused by migration on water resources
- Action 3b.6.ii: Develop replication/sustainability strategy to enable pilot projects to be applied across NSAS

Stakeholder engagement

Stakeholder engagement is an essential aspect for successful SAP implementation and an expectation under the principles of Integrated Water Resources Management. The development of the SADA and the SAP has held to these principles. Under the SADA a detailed analysis of stakeholders with an interest in the NSAS was undertaken and this led to a recommended plan for further information collection and review in both the SADA and the SAP.

The approach adopted in the SADA and SAP preparation has worked and this should be continued under the co-ordination of the Joint Authority and national administrations for the future SAP implementation.

Financing and sustaining the SAP implementation

An intrinsic aspect of the SAP is the importance of long-term sustainability with national / regional resources. However it is evident that the initial requirements of implementing the SAP will include significant external funds from international donors and/or programmes for the NSAS to supplement the national commitments that are required with SAP endorsement.

The SAP provides a regional framework for co-operation and makes recommendations on actions to improve co-ordination, sharing data and experiences through targeted pilot demonstration projects. It is imperative that the SAP framework is complemented through National Action Plans that will deliver national activities that will assist the regional SAP achieve the expected objectives and vision for the NSAS.

The development of the detailed National Action Plans, providing cost-benefit assessments and validating the approach of the regional SAP, and identifying the required external donors or programmes for full SAP implementation is an important next step.

Legal and Institutional Framework for SAP Implementation

An analysis of how the Joint Authority's agreement establishes a basis for regional cooperation.

The agreements summarized above (Section 3.4) offer a good basis for regional cooperation among the four countries on the Nubian Sandstone Aquifer System.

The first agreement establishes the Joint Authority which is intended to serve as a joint institution/commission for the management of the shared aquifer. In this sense the responsibilities devoted to the Joint Authority are quite wide and large. As mentioned above, the Joint Authority can, conduct studies on the Nubian aquifer. It is entitled to develop programs and plans for the utilization of water. It can also propose a common policy for the development and utilization of the water resources of the aquifer, and execute this common policy. The Joint Authority can even ration the consumption of water from the Nubian Sandstone Aquifer in the member countries. Therefore the Joint Authority holds real management responsibilities.

As described above, the other provisions of the agreement are rather administrative organizational rules of the Joint Authority. In this sense, the agreement appears rather as an institutional agreement or an executive regulation for the Joint Authority. The only provision related to water management is the one concerning the responsibilities of the Joint Authority. The agreement does not include any provision related to any policy regarding the management of the Nubian Aquifer, as it does not include any water management principle.

The agreement lacks other provisions such as defining the objective for establishing the Joint Authority. It can be argued that this objective is implicit in the agreement as the responsibilities of the Authority are defined, however it is better if an objective is clearly mentioned. The agreement does not mention anything about the legal personality of the Joint Authority, even if it can be deduced from provisions on the possibility of holding a bank account etc, that the Joint Authority does have the legal personality.

It can be said that the agreement represents a good basis for regional cooperation. However in view of developing the cooperation among the four countries, it is advisable that the agreement, as an administrative regulation, be completed with other requirements needed for the functioning of the institution. Another agreement related to water management, or simply establishing a policy for the four countries on the waters of the Nubian Sandstone Aquifer system is highly recommended in view of developing the principles for the cooperation.

Regarding the two other agreements related to data sharing and monitoring, they represent the agreement and the acceptance by the four countries to exchange data related to the Nubian aquifer and to a regional monitoring network. Both agreements establish precisely the data to be exchanged and the information to be monitored. In this sense, these two agreements would certainly need an update now for their proper implementation. The countries would need to decide and agree again on the data to be exchanged, on the monitoring network, as on the requested information.

An assessment of the degree to which these agreements provide a foundation for the targets and actions

To some extent the existing agreements on the Nubian Aquifer can be considered as providing the first foundation for the targets and actions described in section 2. However they are not sufficient.

As mentioned above, the agreement on the Joint Authority is an institutional agreement or an executive regulation for the Authority, and it does not contain any principle for the management of the aquifer. The targets and actions rely on key principles. Some specific targets such as the targets related to climate change or to ecosystems and biodiversity require specific actions which are the adoption of a regional policy on the topic. The powers and responsibilities of the Joint Authority provided in the 1992 agreement are wide. However in view of developing the targets and action sunder the SAP, the countries of the Nubian aquifer would need to adopt regional policy documents covering these issues.

The existing agreements on data exchange and monitoring provide are limited to the list of data and information they provide. The targets and actions related to the exchange of data and monitoring identified under the present SAP are wider and go beyond. They concern mainly climate change and ecosystems and biodiversity. As expressed in the SAP, the agreements on data exchange and monitoring could be amended to cover thee evolution resulting in the current process.

Key targets on legal and institutional aspects related to the implementation of the SAP include:

- **Target 1a.1:** Establish enhanced transnational mechanisms to strengthen the existing cooperation through the Joint Authority and explore new areas of cooperation.

  The strengthening of the Joint Authority appears as the main focus and target of the SAP, in view of enhancing and developing cooperation.

  While the action related to capacity building is not a legal or institutional action per se, it is however linked with the concern of strengthening the capacities of the institutions, and to allow them to accomplish their role and responsibilities. Therefore pursuing capacity building in these fields is a coherent action within the frame-target of strengthening the Joint Authority, and enhancing cooperation. Such actions can also be linked to policy objectives.

  Consideration of the ecosystem is a relative new issue raised in the region of the NSAS. A regional policy document at the level of the NSAS for adoption by the Joint Authority is essential for defining common understandings and objectives for the ecosystem approach, as well as related actions such as the monitoring. The considerations in a regional policy document need also to be translated at the country level for ensuring the proper implementation of the regional objectives.

- **Target 1a.2**: Establish a cooperation framework on data exchange

  The first level of cooperation on a shared water body is the regular exchange of data. This is recognized in international law and acknowledged in Resolution 63/124 on the law of transboundary aquifers.

  The development of a management framework can be seen as a next step after the proper functioning of the sharing of data and information within the Joint Authority among the NSAS countries. It can be adopted in the form of a policy document, including a strategy and management principles for the NSAS, approved by the Joint Authority and proposed to the countries The Joint Authority would play a central role in promoting and implementing the strategy and management principles, and this would represent an enhancement in its role of coordination and cooperation over the NSAS.

- **Target 1a.3**: Ensure the effective establishment and performance of National Offices of the Joint Authority

  National offices of the Joint Authority were established in the member countries, as per its 1992 Constitution. Such offices can play an important role in performing and liaising between the member States and the Joint Authority. For example, data collected at the national level for the Nubian aquifer can be transmitted to the Joint Authority through the national office. In case of agreements on the sharing of data and information, the national offices would play a central role. Therefore the effectiveness of such offices is directly linked with the target of enhancing the Joint Authority and its cooperative task.

- **Target 1b.1:** Enhance legal and institutional mechanisms to exercise regional protection and control on water use activities and priorities

Control on water use activities means indirectly control on water abstraction. This is an essential element in the proper management of groundwater. The water in the NSAS is non-renewable, every drop abstracted and used is not replaced. Therefore control over water use means more than in the case of renewable groundwater. Establishing priorities among the water use activities gives an indication for allocation of the abstracted water. Protection is another important aspect of water management. Same as for the control protection in the case of non-renewable water is a crucial issue.

- **Target 1c.1:** Establish legal and institutional mechanisms to enable adaptation to climate change

  Within the global target of enhancing cooperation among the NSAS countries, this target defines cooperation under a specific topic: climate change. The identified actions, mentioned below, identify the development of a policy document, and the mechanisms for the regional monitoring of the climate change and its impacts.

- **Target 2a.1:** Establish a regional legal and institutional mechanism to protect the NSAS dependant ecosystems and biodiversity, and extend the competence of the Joint Authority in this field

  This target is about cooperation through the Joint Authority in a specific field: the protection of ecosystems and biodiversity within the NSAS, in the same way target 1c.1 was about cooperation in the field of climate change. The actions identified are related to developing a regional policy related to ecosystem conservation and to identify the legal and institutional mechanisms for their monitoring. These actions were formulated as follows:

- **Target 3a.1:** Establish legal and institutional procedures to develop transboundary cooperation and integration of the NSAS dependent socio-economic activities and schemes of land use; considering efficient utilization of the waters

  Some socio-economic activities, such as agriculture rely heavily on the waters of the NSAS. Agriculture is a main economic activity in the countries of the NSAS, with high social implications, but there might be other economic activities relying on water, such as tourism. Therefore including cooperation on dependent socio-economic activities as one of the targets in the SAP is important in view of the sound management and use of the waters of the NSAS, given in particular its non-renewable nature. The efficient utilization of the waters is a crucial issue, mainly for non-renewable waters.

- **Target 3b.1**: Develop a strategy to establish cooperation on prevention, control and management of human migrations in the Nubian region

  Human pressure is a cause of increase in water consumption. The changes in population schemes and the developments of human settlements in the area of the NSAS is a cause of growing demand of water. In the case of a non-renewable resource, it appears as more important to control such population movements.

The targets and actions are summarized in the table below.

General target	Related actions
Strengthen existing cooperation (Joint Authority)	• Capacity building for monitoring and modeling • Cover regional policy, legal & institutional aspects • Privileges and immunities • Financial means including country contributions
Cooperation framework on data exchange	• Update previously signed agreements on GW monitoring and exchange • Develop a management framework
Effective establishment and performance of National Offices of the Joint Authority Effective establishment and performance of National Offices of the Joint Authority	• National offices well established, well equipped, staff qualified • Supply Joint Authority with monitoring data and information
Regional protection on water use activities and priorities	• Legal and institutional requirements to enforce regional protection and control on the development of the NSAS • Regional policy and guidelines for water allocation, water use activities and priorities
Control on waste disposal practices	• Waste disposal quality standards and guidelines
Climate change	
➢ Legal and institutional mechanisms to enable adaptation to climate change	• Regional policy for climate change adaptation in the NSAS countries • Regional policy, and legal and institutional mechanisms for monitoring climate change and its impacts
➢ Cooperation on collecting data related to climate change	• Cooperation framework for climate change monitoring and exchange of data • Unified methodology for climate risk screening for proposed projects and activities
Ecosystems and biodiversity	
➢ Regional and legal institutional mechanism to protect the NSAS dependant ecosystems and biodiversity, and extend the competence of the Joint	• Regional policy to establish cooperation and to include ecosystem and biodiversity conservation in the integrated management of the NSAS

General target	Related actions
Authority in this field ➢ Establish and maintain a regional database for ecosystem and biodiversity in view of proper management and conservation	• Identify legal and institutional mechanisms to monitor and conserve the NSAS dependent biodiversity and ecological functions • Agreements on monitoring and exchange and management of data related to the ecosystems and to the biodiversity
Establish legal and institutional procedures to develop transboundary cooperation and integration of the NSAS dependent socio-economic activities and schemes of land use, considering efficient utilization of the waters	• Regional legal and institutional requirements to integrate socio-economic activities • Policy on the integration of socio-economic development aspects in the management of the NSAS • Enhance legal and institutional structure of the Joint Authority to enable formulation of regional policies for NSAS socio-economic activities • Joint irrigation and animal production projects where the financial, land, and human resources are integrated for the benefit of all • Construct service centers along (animal) transboundary trade routes with fodder, water veterinary services, etc.
Preserve and protect the water resources of the NSAS from agriculture	• Regulations on specific standards for use of chemicals in agriculture, and for industrial and municipal waste disposal

Monitoring and Evaluation of SAP Implementation

Monitoring the implementation of the SAP will be under the co-ordination of the Joint Authority. The Joint Authority will collect data to assist with establishing progress. Information on progress will be reported in the Joint Authority minutes and presented, for wider stakeholder assessment, on the Joint Authority website.

Monitoring and Evaluation (M&E) indicators are tools to assess and verify progress towards the goals of this SAP. GEF has established three types of indicators to monitor the successful outcomes of the EcoQOs. Preliminary indicators, for Process, Stress Reduction and Environmental / Socio-Economic Status are presented in are given below.

- **Process Indicators** focus on the process or outputs that are likely to lead towards a desirable outcome. They demonstrate actual on-the-ground, political, legislative and

regulatory process in resolving transboundary problems in the NSAS. They should assist in tracking the institutional, policy etc. reforms necessary to bring about changes on the ecosystem.

- **Stress Reduction Indicators** relate to project objectives or outcomes. In particular they focus on concrete actions that reduce environmental stress. Stress reduction indicators show the rate of success of specific on-the-ground actions being implemented by the collaborating NSAS countries.
- **Environmental Status (and Socio-economic Status) Indicators** are goal oriented and focus on the actual improvements of ecosystem quality (or socio-economic improvements). They are the measures of the actual success in restoring or protecting the targeted ecosystem element. There may be a significant time-lag between stress reduction interventions and the response from the environment.

To adequately measure the environmental status indicators the NSAS countries will have to fully harmonise their sampling, analysis and assessment methods to ensure comparable data is being recorded which is recognised in the management actions of this SAP and is an on-going activity of the Joint Authority

A key first step to further developing an appropriate M&E approach will be the establishment of baseline values for each indicator and ensuring that the indicators selected are as quantifiable as possible. This will be undertaken during the initial stages of SAP implementation.

The Management Actions proposed by this SAP (Annex 1) will provide mainly 'Process Indicators'. Whilst these are essential actions to initiate change that will lead to improved environmental conditions (and provide a detailed means to assess the implementation of the SAP)or provide the basis for subsequent monitoring programmes, they do not in themselves reduce the pressure on the environment or provide an immediate impact on the environment. The SAP also proposes a number of targeted pilot demonstration projects (for example, new irrigation methods, water conservation techniques, reducing pollution from wastewater, best agricultural practices) that will reduce stress on the environment at the pilot sites (and more widely when replicated) and pilots that will have a direct impact on the environmental status (e.g. 'green oasis' pilots, cross border protected areas).

Annex 2 lists 117 Management Actions, 101 are 'Process' focused actions, the remaining actions delivering Stress Reduction and establishing the Environmental Status or Socio-Economic Status.

To assist the Joint Authority in reporting progress of the SAP implementation, a ***preliminary*** set of indicators (aimed at the Transboundary level) to measure the progress of the overall Strategic Action Programme implementation is proposed below. (Target dates are indicated in parenthesis.) These preliminary indicators need further definition and specifications of relevant metrics.

Process Indicators

General Process Indicators

1. Approval / adoption of this SAP by all countries (2011)
2. Corresponding National Action Plans developed by all countries (2012)
3. Agreed list of SAP indicators endorsed by the Joint Authority (2012)
4. Agreed baseline established for assessing the indicators in SAP implementation (2012)

Specific Process Indicators

Over 100 specific process management actions are identified in Annex 1. Key specific indicators relating to these management targets include:

Target 1a.1:	Joint Authority has established and confirmed financial resources for rolling 5 year programme. (2016)
Target 1a.2:	Groundwater data provided on routine basis by all countries. (2014)
Target 1a.3:	National offices of Joint Authority functional as demonstrated by provision of national data to the central office of the Joint Authority (2014)
Target 1a.4:	Joint Authority visits and exchange staff with 2 other international water commissions (2015)
Target 1a.5:	Document procedures for monitoring (water quantity, water quality and biological status, etc.), analysis, quality control procedures and data management procedures endorsed by all Joint Authority countries. (2014)
Target 1a.6:	Training programme developed by Joint Authority to monitor and assess the aquifer implemented across NSAS countries. (2015)
Target 1a.7:	Joint Authority agrees protocol and procedures for use and updating of the aquifer model (2014)
Target 1b.1:	Countries agree Joint Authority's recommendations on institutional requirements for NSAS development and protection of the resource. (2013)
Target 1b.2:	Countries agree Joint Authorities guidelines for waste disposal (2015)
Target 1b.3:	Databases of water consumption and pollution hotspots developed by the Joint Authority (2014)
Target 1b.4:	Agreed R&D workplan on reducing water use prepared by the Joint Authority (2014)
Target 1b.5:	Database on investment needs for transboundary activities developed by the Joint Authority (2013)
Target 1c.1:	Joint Authority publishes approach for monitoring the potential impacts of climate change (2016)
Target 1c.2:	Joint Authority develops protocol and methodology for collecting climate change data. (2013)
Target 1c.3:	Potential impacts and parameters to be monitored published by Joint Authority. (2015)
Target 1c.4	Completion of workshops to define and agree approach to assessing the risks of climate change on the NSAS. (2013)
Target 2a.1:	An agreed policy on regional co-operation on ecosystem conservation published by the Joint Authority (2014)

Targets 2a.2/3: Agreement and implementation on ecosystem monitoring programme with the Joint Authority publishing yearly status reports on ecosystem status and 'at risk' species. (2016)

Target 2a.4/5: Complete workshops and stakeholder awareness raising on the value of the NSAS dependent ecosystem (2014).

Target 3a.1/2/5: Joint Authority publishes proposal to integrate socio-economic policies into the overall management plan for the NSAS (2013)

Stress Reduction Indicators

Target 1b.6: Completed demonstration projects on water conservation with clear plan for replication and targets for further water savings– (2015)

Target 1c.7: Completed demonstration projects testing means to adapt to climate change (2015)

Target 3a.1: Construction of service centres along transboundary trade routes (2016)

Target 3a.8: Completing of programmes on minimising agro-chemicals following the principles of good Agricultural Practices and targets for further source reduction across NSAS (2015)

Target 3a.8i: Implemented pilot programmes on alternative waste disposal (2015)

Target 3a.10: Completion of pilot projects with beneficial impacts on the environment (reducing wastewater, agricultural waste, oil pollution water, etc.) (2018)

Environmental Status / Socio-Economic Status Indicator

Target 2a.7: Completed 'green oasis' pilot demonstrating the importance and benefit of ecosystem conservation. (2018)

Target 2a.7: Established protected area between Chad and Sudan (2018)

Target 3b.6: Completion of pilot projects that reduce migration pressure through improved socio-economic conditions (2018)

Next Steps

This SAP represents the first agreed outline plan for overall management of the water resources and associated ecosystem of the NSAS that reflects the importance of the socio-economic development of the region. The SAP provides an overview of the priority management actions that will address the key transboundary issues that were agreed in the SADA and will achieve the required water resources and ecosystem quality objectives leading to the common vision for the NSAS.

More work is required prior to SAP implementation and this section sets out a summary of the remaining tasks.

1. The Joint Authority will take 'ownership' of the SAP and its future implementation and incorporate the actions within its work plan.
2. The management actions for regional (and shared) activities require further assessment to establish more precise budget estimates and to evaluate the effectiveness of each action. This evaluation should also consider an assessment of the alternatives to each proposed

management action. This will lead to an updated (and more detailed) catalogue of management actions.

3. Funding arrangements for the implementation of the SAP should be discussed and agreed between the four countries, the Joint Authority and international donors.
4. Further prioritisation of activities and actions are needed to achieve the objectives.

In conclusion, this SAP document represents the culmination of the cooperative development of a diagnostic analysis and action programme planning effort conducted by the four Nubian countries. Its success is built upon the cooperative mechanisms established by the Joint Authority and future implementation of the SAP relies on the continued effectiveness of the Joint Authority. The steps enumerated above, along with the management actions previously described and presented in Annexes 1 and 2, provide the basis for implementation of the Nubian Aquifer Strategic Action Programme.

Annex 1 Water Resources / Ecosystem Quality Objectives – Management Action Tables

The following tables provide outline information on the required actions and targets to achieve the Water Resources and Ecosystem Quality Objectives. The table also provides estimates of the budget needed to implement the actions *at the regional level.* This regional budget is based on national estimates from the National SAP reports and expert judgement, but this requires considerable additional analysis in the next steps. As a guide to the relative estimates of budgets the indicative figures for each action are: '$' < 50,000 USD; '$$' 50,000 – 250,000 USD; '$$$' > 250,000 USD

WR/ Eco QO 1: To manage the shared aquifer in a sustainable and equitable way for the benefit of the NSAS countries on the basis of joint regional planning in order to minimise negative effects within and between countries; anticipating the challenges of increasing population, expansion of development, and climate change.

WR/ Eco QO 1a: To strengthen the role and capacity of the NSAS Joint Authority (JA) to effectively manage the shared aquifer

	Management Target / action	Planned outputs	Time frame	Estimated budget	Reforms required / responsibilities	Indicators / source of verification	Links
1a.1	**Establish enhanced transnational mechanisms to strengthen the existing cooperation through the JA and explore new areas of cooperation.**						
1a.1.i	Pursue capacity building and training possibilities in the NSAS countries for monitoring and modelling	Trained staff at JA Trained staff in NSAS	2- 5 years	$$	JA role endorsed Linkages between JA and National Institutes	Number of trained staff	1a.6.iii
1a.1.ii	Develop regional policy recommendations to include the ecosystem monitoring and management within the responsibilities of the JA	Agreed regional policy endorsed by 4 countries on role of JA	2 – 5 years	$	JA role endorsed Linkages between JA and National Institutes	Signed document	
1a.1.iii	Enhance the institutional structure of the JA to cover regional policy, legal and institutional aspects of the NSAS.	Enhanced role of JA agreed	5- 8 years	$$	JA role endorsed Linkages between JA and National Institutes	Signed document JA develops new regional policy	
1a.1iv	Grant the JA the privileges and immunities necessary for carrying out its	International agreement on JA	3- 8 years	$$	JA legal status confirmed by countries	JA granted agreed status	

	Management Target / action	Planned outputs	Time frame	Estimated budget	Reforms required / responsibilities	Indicators / source of verification	Links
	responsibilities						
1a.1.v	Provide financial means to the JA including country contributions	JA has agreed budget for a rolling 5 year programme	5 years & on-going	$$$	JA role endorsed Linkages between JA and National Institutes Financial contributions from countries	JA budget approved	1a.3.i 1a.3.ii
1a.2	**Establish a cooperation framework on data exchange**						
1a.2.i	Revive and update previously signed agreements on groundwater monitoring and exchange	Implementation of agreement	2 – 5 years	$	Governments implement existing agreements	Data on groundwater monitoring provided by all countries	
1a.2.ii	Develop a management framework	Data management and exchange protocol	2 – 5 years	$	Governments implement existing agreements	Data on groundwater monitoring provided by all countries on a routine basis	
1a.3	**Ensure the effective establishment and performance of national offices of the JA.**						
1a.3.i	Ensure that national offices are well established and well equipped with qualified and motivated staff	Functional JA and national offices	3 years & on-going	$$$	JA and national institutes implement training programmes. Governments endorse role of JA	JA and national offices functional through preparation of NSAS reports and strategies	1a.1.v
1a.3.ii	Supply the JA with monitoring data and information according to the provisions of the agreements	JA prepare status reports on annual basis on NSAS	2 years & on-going	$	Governments implement existing agreements	Annual reports	1a.1.v
1a.4	**Improve the effectiveness of JA in managing NSAS**						
1a.4.i	Implement exchange of staff and sharing of experiences with other water commissions	Programme of exchange implemented	2 years and on-going	$	JA identifies programme for exchange of staff	Exchange reports	
1a.5	**Implement, maintain and utilise a transboundary monitoring network and information database providing comparable information to assess the status of water and biological resources of the NSAS.**						

	Management Target / action	Planned outputs	Time frame	Estimated budget	Reforms required / responsibilities	Indicators / source of verification	Links
1a.5.i	Design and implement harmonised routine regional monitoring network covering water level, abstraction, and quality.	Documented harmonised monitoring programme endorsed by all countries	3 years and on-going	$$$	Governments implement existing agreements JA implements programme in co-operation with national institutes	Annual report of JA	1a.5.v
1a.5.ii	Review and update existing monitoring methods ensuring compatibility of data including for biological parameters.	Agreed harmonised protocols for monitoring	2 – 5 years	$	JA and national institutions agree protocols	Protocol approved by JA / countries	
1a.5.iii	Develop and implement appropriate programme for establishing and monitoring the biological status of oases.	Agreed harmonised protocols for monitoring	3years and on-going	$$	JA and national institutes	Protocol approved by JA / countries	1a.5.i
1a.5.iv	Implement transboundary quality assurance and quality control procedures.	Agreed procedures for QA/QC	3 years and on-going	$	JA and national institutes	Documented procedures. Annual reports of JA	1a5.ii
1a.5.v	Update, operate and maintain on-line regional database management system (NARIS).	NARIS up-to-date	2 years and on-going	$	JA and national institutes	Annual reports of the JA	
1a.5.vi	Design, agree, and implement routine reporting of water and biological resources to regional stakeholders based on agreed monitoring programme.	Reports to regional stakeholders	3 years and on-going	$	JA, national institutes and feedback from stakeholders	Published reports on status	
1a.6	**Implement a regional network of research and training centres addressing the needs to the NSAS.**						
1a.6.i	Prepare detailed training needs assessment for enhanced water resource management within the NSAS. This	Agreed regional training needs identified	2 – 5 years	$	JA and national institutes	Training needs assessment and programme published	1a.6.ii

	Management Target / action	Planned outputs	Time frame	Estimated budget	Reforms required / responsibilities	Indicators / source of verification	Links
	training to address the needs of monitoring, modelling, isotope hydrology, GIS & databases, data management & interpretation, management and awareness-raising for stakeholders.						
1a.6.ii	Prepare detailed training requirements for establishing a ecosystem monitoring and assessment for the NSAS.	Agreed regional training needs identified	2 – 5 years	$	JA and national institutes	Training needs assessment and programme published	1a.6.i
1a.6.iii	Develop and deliver capacity building programmes within the regional network of centres leading to the creation of a permanent capacity building capability across the NSAS.	Routine training programme in place	3 years and on-going	$$$	JA and national institutes	Routine training programmes implemented across NSAS. Number of students trained	1a.1.i
1a.7	**Update, maintain, and utilise a NSAS-agreed modelling capability providing water resource and use assessments to the JA and Governments of the NSAS region.**						
1a.7.i	Develop NSAS-specific modelling capacity within the JA and Government Institutes of the NSAS through the regional network of research and training centres.	Established and harmonised approach to modelling	2 years and on-going	$$	JA and national institutes	Model in routine use by NSAS countries and JA	1a.7.ii
1a.7.ii	Develop and agree protocols for sharing the results of localised improvements to the model for consistent recalibration.	Agreed protocol on model calibration	2 years and on-going	$	JA and national institutes	Published protocol JA annual report	1a.7.i
1a.7.iii	Use the agreed model to develop regional responses to different modelled scenarios on water resources based on	Regional and national reports based on model outputs	2 years and on-going	$	JA and national institutes, national ministries on water resources, agriculture, finance etc.	National regional reports/ publications JA annual reports	

	Management Target / action	Planned outputs	Time frame	Estimated budget	Reforms required / responsibilities	Indicators / source of verification	Links
	demand and potential climate change.						
1a.8	**Ensure the prompt and adequate provision of funding for the JA through a programme of national and international investments.**						
1a.8.i	Provide the JA with sufficient operating resources to fund needed equipment (office facilities, including computers and software) at both the JA central office and in national offices.	JA has sufficient funds to implement work programme	3 years and on-going	$$	JA and national ministries	JA annual reports	
1a.8.ii	Develop within the JA an agreed work programme identifying all investments required at the transboundary level and works with all countries in the NSAS to ensure compatibility with national requirements.	JA maintains a database of all investments required	3 years and on-going	$	JA	JA annual reports and databases	
1a.8.iii	Maintain within the JA (in close collaboration with NSAS countries) an updated list of all future investment needs and develop a strategy to work with national governments and international donors to ensure that the on-going needs of the region are documented and brought to the attention of finance ministries and donors.	JA maintains a database of all investments required	3 years and on-going	$	JA	JA annual reports and databases	

WR/ Eco QO 1: To manage the shared aquifer in a sustainable and equitable way for the benefit of the NSAS countries on the basis of joint regional planning in order to minimise negative effects within and between countries; anticipating the challenges of increasing population, expansion of development, and climate change.

WR/ Eco QO 1b: To achieve water-efficient use priorities and activities and to reduce the negative impacts of anthropogenic activities on groundwater regime, levels, and quality

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	
1b.1	**Enhance legal and institutional mechanisms to exercise regional protection and control on water use activities and priorities.**						
1b.1.i	Identify the legal and institutional requirements to enforce regional protection and control on the development of the NSAS.	Report & recommendations	2 – 3 years	$	JA and Governments of NSAS	Published reports JA annual report accepting recommendations	
1b.1.ii	Develop regional policy and guidelines for water allocation, water use activities and priorities.	Agreed guidelines	2 – 5 years	$	JA and national institutes/ ministries	Published reports JA annual report	1b.2.i 1c.1.i 1c.1.ii
1b.2	**Establish control on waste disposal practices.**						
1b.2.i	Develop waste disposal quality standards and guidelines	Agreed guidelines	2 – 5 years	$	JA and national institutes/ ministries	Published reports JA annual report	1b.1.ii
1b.3	**Achieve regional control on water resources based on objective-directed monitoring and information management.**						
1b.3.i	Develop database for water use and consumption across the NSAS.	Functional web-based database for NSAS	2 years	$	JA	Functional database on JA website	1b.3.ii
1b.3.ii	Develop and implement regional monitoring across NSAS on water consumption.	Summaries of water consumption	2 years and on-going	$$$	JA and national institutions	National and JA reports on consumption published	1b.3.i 1b.3.iii 1b.3.iv 1b.4.i

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	
						annually	
1b.3.iii	Evaluate water loss from different users of NSAS resources.	Report & recommendations	3 years and on-going	$	JA and national institutions	JA reports	1b.3.ii
1b.3.iv	Develop an inventory of sites, uses etc. with the potential to negatively impact the quality of the NSAS (potential pollution hotspots).	Pollution hot-spot inventory	3 years and on-going	$$	JA and national institutions	JA website and annual report	1b.3.ii
1b.4	**Strengthen regional research and cooperation on reducing excess water use.**						
1b.4.i	Assess water use efficiency across the NSAS and identify means to reduce demand.	Report & recommendations on water use	3 years	$$	JA and national institutions	JA reports	1b.3.ii
1b.4.ii	Establish expertise (through the network of research and training centres) on advising users on water conservation techniques.	Additional skilled technical experts available	3 – 5 years and on-going	$$	JA and national institutions	Increased number of skilled experts on conservation	
1b.4.iii	Develop agreed R&D programmes (linked to network of research and training centres and pilot demonstration projects) on water conservation, salt-tolerant and drought-resistant crops, etc.	Regional and national harmonised R&D plans	3 years and on-going	$$$	JA and national institutions	Published R&D programmes	
1b.4.iv	Develop targeted awareness campaigns aimed at different users to reduce or conserve water resources and to minimise any pollution or environmental impacts.	Information for stakeholders on reducing water use	2 years and on-going	$	JA and national institutions	Publicity material Reduction in water waste	

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	
1b.5	**Ensure the prompt and adequate provision of funds for transboundary priority programmes to achieve protective controls on NSAS water resources and to minimise anthropogenic impacts on the ecosystem.**						
1b.5.i	Develop a database of investment needs for control of water demand across the NSAS linked to potential donors.	Database	2 – 5 years (and on-going)	$	JA with support of national institutions	Availability of database	
1b.5.ii	Provide appropriate regional equipment to be used by the JA to assist with monitoring.	JA has equipment	3 years	$$	JA with support of national institutions	Availability of equipment	I3a.9.ii
1b.6	**Gain regional experience through targeted pilot demonstration projects on water conservation techniques and minimise impacts from overuse of water and pollution on the ecosystem.**						
1b.6.i	Implement pilot demonstration projects addressing water conservation in different sectors.	Lessons learnt incorporated in to national practices	3 – 8 years	$$$	JA and national institutions International donors	Reports from demonstration projects JA annual report	1b.6.ii
1b.6.ii	Develop replication/sustainability strategy to enable pilot projects to be applied across NSAS.	Additional water conservation projects initiated	5 years and on-going	$	JA and national institutions	Reports from demonstration projects JA annual report National reports on water conservation	1b.6.i

WR/ Eco QO 1: To manage the shared aquifer in a sustainable and equitable way for the benefit of the NSAS countries on the basis of joint regional planning in order to minimise negative effects within and between countries; anticipating the challenges of increasing population, expansion of development, and climate change.

WR/ Eco QO 1c: To enhance the NSAS resilience to adapt to climate change impacts

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
1c.1	**Establish legal and institutional mechanisms to enable adaptation to climate change.**						
1c.1.i	Develop regional policy for climate change adaptation in the NSAS countries.	Agreed policy	3 – 8 years	$	JA and governments of NSAS	JA annual reports	1b.1.ii
1c.1.ii	Develop regional policy, and legal and institutional mechanisms for monitoring climate change and its impacts.	Agreed policy Implemented mechanisms for monitoring CC	3 – 8 years	$	JA and governments of NSAS	JA annual reports	1b.1.ii
1c.2	**Cooperate on collecting data related to climate change**						
1c.2.i	Develop a cooperation framework for climate change monitoring and exchange of data.	Agreed protocol	2 – 5 years	$	JA and governments of NSAS	JA annual reports	1c.2.ii
1c.2.ii	Establish a unified methodology for climate-risk screening for proposed projects and activities.	Agreed methodology	2– 5 years	$	JA and governments/ institutes of NSAS	JA annual reports	1c.2.i
1c.3	**Develop and implement regional programme for monitoring and analysis of climate change and impacts.**						
1c.3.i	Identify potential direct and indirect transboundary impacts of climate change on the NSAS and its ecosystem.	Report & workshops	3 years	$$	JA and national institutes	JA annual reports Workshop report	1c.3.ii 1c.7.i
1c.3.ii	Agree on parameters for monitoring the direct and indirect impacts of climate	Reports & workshops	2 years	$$	JA and national institutes	JA annual reports Workshop report	1c.3.i

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
	change on the NSAS and its ecosystem.						
1c.3.iii	Select key monitoring locations for assessing transboundary impacts of climate change.	Reports & workshops	2 years	$$	JA and national institutes	JA annual reports Workshop report	
1c.3.iv	Include transboundary data in the JA's database for the NSAS.	Reports	3 years	$	JA and national institutes	JA annual reports	
1c.4	**Explore joint research to enhance the NSAS resilience to adapt to climate change impacts at the transboundary level.**						
1c.4.i	Assess the risks from climate change on the aquifer and potential future groundwater developments in the NSAS countries including related ecosystems.	Reports & workshops	2 – 5 years	$$	JA and national institutes	JA annual reports Workshop report	
1c.4.ii	Establish regional expertise on joint research linking climate change and groundwater models.	Reports & workshops	3 years and on-going	$$	JA and national institutes	JA annual reports Workshop report	
1c.5	**Increase awareness among stakeholders of the impacts of climate change on the NSAS.**						
1c.5.i	Develop targeted training on climate adaptation for local communities and other stakeholders.	Reports & workshops Stakeholders informed by targeted material	2 years	$$	National Ministries, Institutes and JA	Reports Feedback from stakeholders	
1c.5.ii	Develop a consultative process for engaging a wide range of stakeholders and providing appropriate awareness raising and capacity building material.	Reports & workshops Stakeholders informed by targeted material	2 years	$	National Ministries, Institutes and JA	Reports Feedback from stakeholders	
1c.6	**Ensure the prompt and adequate provision of funding for transboundary actions enabling climate change adaptation in the NSAS.**						
1c.6.i	Assess investment needs to address and resolve likely transboundary impacts of	Report	3 years	$	JA supported by national institutes	JA annual reports	

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
	climate change.						
1c.6.ii	Identify regional actions and funding sources.	Report & workshops for donors	3 years	$	JA, national ministries and international donors	JA annual reports and donor responses	
1c.7	**Gain experiences through targeted pilot demonstration to illustrate potential adaptation approaches within the NSAS.**						
1c.7.1	Implement pilot demonstration project addressing responses to climate change (e.g. alternative crops, irrigation methods and other water conservation approaches)	Lessons learnt incorporated in to national practices	3 – 8 years	$$$	JA, national ministries and international donors	JA annual report Reports from pilot projects	1c.3.i
1c.7.ii	Develop replication/sustainability strategy to enable pilot projects to be applied across the NSAS	Agreed approach on additional water climate adaptation projects initiated	5 years and on-going	$	JA, national ministries and international donors	Number of new projects initiated reported to JA	1c.7.i

WR/ Eco QO 2a: To mainstream environmental aspects in the integrated management of the NSAS to conserve the dependent ecosystems and reduce the risk of loss/damage to biodiversity.

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
2a.1	**Establish a regional legal and institutional mechanism to protect the NSAS dependant ecosystems and biodiversity, and extend the competence of the JA in this field.**						
2a.1.i	Develop regional policy to establish cooperation on ecosystem conservation, and include conservation of dependent biodiversity and ecological functions in the integrated management of the NSAS	Agreed policy	2 – 5 years	$	JA and national ministries responsible for ecology	JA annual reports	
2a.1.ii	Identify legal and institutional mechanisms to monitor and conserve the NSAS dependent biodiversity and ecological functions.	Adopted legal/institutional arrangements	2 – 5 years	$	JA and governments of NSAS	JA annual reports	
2a.2	**Establish and maintain a regional database for ecosystem and biodiversity, in view of proper management and conservation.**						
2a.2.i	Formulate agreements on monitoring and exchange and management of data related to the ecosystems and to the biodiversity	Agreement on monitoring	2 – 5 years	$	JA and national institutes	JA annual reports	
2a.3	**Implement routine monitoring of the NSAS ecosystem enabling the JA and the NSAS Countries to develop appropriate practices and procedures to protect the natural resources.**						
2a.3.i	Develop protocols for monitoring and data management which are consistent among NSAS countries.	Adopted common protocol	2 – 5 years	$	JA and national institutes	JA annual reports	2a.3.ii 2a.3.iii
2a.3.ii	Catalogue NSAS dependent ecology and assess ecological functions and threats to the ecosystem.	Database	3 years	$$	JA and national institutes	JA annual reports	2a.3.i 2a.3.iii
2a.3.iii	Design an agreed transboundary	Agreed monitoring	2 – 5 years	$$	JA and national	JA annual reports	2a.3.i

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
	monitoring system addressing the NSAS dependent ecosystem.	programme			institutes		2a.3.ii
2a.3.iv	Publish regular (yearly) summaries by the JA of the NSAS biological status.	Reports and website	3 years & on-going	$	JA	JA annual reports	
2a.3.v	Identify species under threat from anthropogenic activities in the NSAS.	Reports & workshops	3- 5 years	$	JA and national institutes	JA annual reports Workshop reports	2a.3.vi
2a.3.vi	Analyse the ecosystem in relation to abstractions, water quality and climate change.	Reports & workshops	3 – 5 years	$$	JA and national institutes	JA annual reports Workshop reports NSAS model outputs	2a.3.v
2a.4	**Strive to better understand, value and protect the NSAS ecosystem through joint research on transboundary environmental management.**						
2a.4.i	Establish a network of expertise in each country on environmental assessments of the NSAS.	Increase in number / level of expertise	3 years & on-going	$$	JA, national institutes, universities	JA annual reports Number of qualified experts	2a.4.ii
2a.4.ii	Develop a joint catalogue of the potential environmental problems within the NSAS and their transboundary impacts for subsequent investment actions.	Database of problems	3 years & on-going	$	JA and national institutes International donors	JA annual reports	2a.4.i
2a.4.iii	Assess the relative importance of the different impacts on the biodiversity and ecological functions within the NSAS.	Reports & workshops	3 – 5 years	$$	JA, national institutes, universities	JA annual reports National assessment reports	
2a.4.iv	Implement research on desertification and sand encroachment into habitats.	Reports & workshops	3 – 5 years	$$$	JA, national institutes, universities	JA annual reports Published papers	
2a.5	**Share experiences and provide training through a range of NSAS joint capacity building workshops on ecosystem management and provide awareness material for stakeholders.**						

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
2a.5.i	Develop NSAS relevant training courses for use in all countries.	Harmonised training courses	3 years	$$	JA, national institutes, universities	JA annual report, Universities' reports Increase in expert numbers	
2a.5.ii	Develop a series of NSAS publications to raise awareness of the importance and benefits of the important habitats to a wide range of stakeholders.	Publications targeted at stakeholders	2 years	$	JA, national institutes, universities, communications experts	JA annual report Stakeholder awareness surveys	
2a.6	**Ensure the prompt and adequate provision of funding for transboundary actions to enable conservation of the NSAS dependent ecosystems.**						
2a.6.i	Assess investments needed to address research on the identification of transboundary impacts on the ecosystem within the NSAS region.	Reports & database	2 years	$	JA and national institutes	JA annual reports	
2a.6.ii	Identify priorities, financing arrangements, and possible sources for funding including donors and non-governmental organisations.	Reports, workshops & database	2 years	$	JA, governments of NSAS, NGOs, international donors	JA annual reports Donor participation at workshops	
2a.6.iii	Identify and procure necessary equipment for field and laboratory assessments of the NSAS ecosystem and ensure that national experts are given appropriate training to ensure comparable data.	Equipment available for JA and institutes	2 – 5 years	$$$	JA, national institutes, donors	JA annual reports Donor support fro NSAS programme	
2a.7	**Gain experience on ecological protection through the identification and implementation of specific pilot demonstration projects that illustrate the methods and the benefits of conservation in the NSAS dependent ecosystem.**						
2a.7.i	Implement 'green oasis' pilot project to	Report, workshops & experience	3 – 8 years	$$$	JA, national institutes, international donors	JA annual reports Project reports	2a.7.iii

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
	conserve ecosystem of region.						
2a.7.ii	Implement pilot project to establish cross-border protected area between Chad and Sudan.	Report, workshops & experience	3 – 8 years	$$$	JA, national institutes, international donors	JA annual reports Project reports	2a.7.iii
2a.7.iii	Develop replication/sustainability strategy to enable pilots to be applied across NSAS.	Agreed strategy	3 years	$	JA, national institutes, international donors	JA annual reports Project reports	2a.7.i
2a.7.iv	Conduct preservation studies on ecological status of rare and/or endangered species of flora and studies addressing the social and cultural integrity of indigenous people as well as integrity of ecosystems and their components	Reports & workshops	3 – 5 years	$$$	JA, national institutes, universities	JA annual reports Published papers	2a.7.iii

WR/ Eco QO 3: To utilize the Nubian aquifer resources on sustainable socio-economic development basis.

WR/ Eco QO 3a: To enable integrated transboundary and national socio-economic development activities in the NSAS region, such as implementing appropriate agricultural, industrial and municipal practices to protect the water resources and allow growth

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
3a.1	**Develop legal and institutional procedures to develop transboundary cooperation and integration of the NSAS dependent socio-economic activities and schemes of land use; considering efficient utilization of the waters.**						
3a.1.i	Identify regional legal and institutional requirements to integrate socio-economic activities.	Reports & recommendations	3 years	$	JA and NSAS governments	JA annual reports	
3a.1.ii	Develop a policy on the integration of socio-economic development aspects in the management of the NSAS.	Agreed policy	3 – 5 years	$	JA and NSAS governments	JA annual reports	
3a.1.iii	Enhance legal and institutional structure of the JA to enable formulation of regional policies for NSAS socio-economic activities.	Strengthened JA organisation	3 – 5 years	$$	JA and NSAS governments	JA annual reports	
3a.1.iv	Formulate joint irrigation and animal production projects where the financial, land, and human resources are integrated for the benefit of all.	Agreed project database	3 years	$$	JA and national institutes	JA annual reports	
3a.1.v	Construct service centres along (animal) transboundary trade routes with fodder, water veterinary services, etc.	Implemented service centres	3 – 5 years	$$$	JA, NSAS governments and international donors	JA annual reports	
3a.2	**Preserve and protect the water resources of the NSAS from agriculture and other activities.**						
3a.2.i	Develop regulations on specific standards for use of chemicals in agriculture, and	Agreed standards	3 – 5 years	$	JA and national institutes	JA annual reports National reports	

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
	for industrial and municipal waste disposal						
3a.3	**Develop and implement protocols for monitoring socio-economic development consistent across NSAS region.**						
3a.3.i	Design and utilise a GIS and database for NSAS development activities and corresponding driving forces within the region (covering water use, water disposal practices, agriculture demands, industrial – especially oil related – use, etc.).	Agreed database and data collection	3 years	$$	JA and national institutes	JA annual reports	
3a.3.ii	Implement routine water monitoring programmes (quantity and quality) in all NSAS countries.	Annual reports on water	3 years & on-going	$$$	JA and national institutes	JA annual reports	1a.5.i
3a.3.iii	Populate the database with human activities from all countries	Annual reports on water	3 years & on-going	$	JA and national institutes	JA annual reports	
3a.3.iiv	Develop agreed set of water-related socio-economic indicators for the NSAS region and prepare a status assessment	Status assessment prepared	3 years & on-going	$$	JA and national institutes	JA annual reports	
3a.4	**Increase knowledge on sites and activities likely to act as pollution hot-spot or be a potential burden on the NSAS resources.**						
3a.4.i	Identify pollution sources (municipal, agricultural, industrial, waste deposits, mines, etc.) in the NSAS and document activities / potential pollutants. Incorporate in NSAS database.	Database	3 years & on-going	$$$	JA and national institutes	JA annual reports	
3a.4.ii	Identify all water abstraction in the NSAS and quantities used. Incorporate in NSAS database.	Database	3 years & on-going	$$$	JA and national institutes	JA annual reports	

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
3a.5	**Initiate transboundary research on mainstreaming socio-economic aspects in the integrated management of the NSAS.**						
3a.5.i	Establish expertise in each country on assessment of the current status and future requirements of socio-economic development in the NSAS.	Increased expertise on socio-economic assessment	3 years & on-going	$$	JA and national institutes	JA annual reports	
3a.5.ii	Assess the NSAS development requirements to minimise risks of high socio-economic costs and loss of resources and benefits.	Report & workshop	3 years	$	JA and national institutes Wider stakeholders as needed	JA annual reports Workshop reports	
3a.5.iii	Identify the most effective investment opportunities for shared transboundary socio-economic development in the NSAS region.	Reports, workshop and database	3 – 5 years	$	JA and national institutes Wider stakeholders as needed	JA annual reports Workshop reports	
3a.6	**Improve awareness of collective land and water development in the NSAS region.**						
3a.6.i	Develop a series of workshops and awareness raising campaigns aimed at a range of stakeholders on the importance of protecting the NSAS and its ecosystem whilst ensuring sustainable economic development in the region	Information for stakeholders	2 years	$	JA and national institutes Wider stakeholders as needed	JA annual reports Stakeholder surveys	
3a.7	**Increase capability to determine water quantity and quality impacts from developments.**						
3a.7.i	Refine the NSAS model at a more local scale.	Enhance model	3 years	$$	JA and national institutes	JA annual reports	
3a.7.ii	Conduct water quality modelling in local aquifer systems.	Reports & workshops	3 – 5 years	$$	JA and national institutes	JA annual reports Workshop reports Published model outputs	

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
3a.8	**Initiate research on water quality protection (linked to pilot demonstration projects).**						
3a.8.1	Conduct programme on effective use to minimise loss of agro-chemicals.	Report & workshops providing lessons learned	2- 5 years	$$	JA and national institutes	JA annual reports Workshop reports Lessons learned published	3a.10.i
3a.8.ii	Implement programmes on alternative means for disposal of industrial and municipal waste.	Report & workshops providing lessons learned	2 – 5 years	$$	JA and national institutes	JA annual reports Workshop reports Lessons learned published	3a.10.1
3a.9	**Ensure the prompt and adequate provision of funding for transboundary actions to enable integration of socio-economic development activities.**						
3a.9.i	Assess investments needed to address research on integration of transboundary socio-economic activities within the NSAS region.	Database of investments & research	2 years	$	JA and national institutes	JA annual reports	
3a.9.ii	Prioritize relevant transboundary actions and identify financing arrangements and possible sources for funding including donors and non-government organizations.	Funding needs database	2 years	$	JA, national institutions, international donors	JA annual reports Donors' responses	
3a.9.iii	Provide necessary field and laboratory equipment to monitor and assess agricultural and industrial impacts	Equipment available	3 years	$$$	JA, national institutions, international donors	JA annual reports Donors' responses	1b.5.ii
3a.10	**Gain regional experience on implementing environmentally friendly and water conserving actions having regional application.**						
3a.10.i	Implement a range of pilot demonstration projects addressing industrial, municipal and agriculture sectors that will enhance socio-economic development whilst minimising impacts	Reports, workshops, experience, etc.	3 – 5 years	$$$	JA, national institutions, international donors Wider stakeholder as required	JA annual reports Workshop reports Published lessons learned Donors'	3a.8.i 3a.8.ii

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
	on the water resource and ecosystem. Potential pilots to include: - Reducing / controlling agricultural use of pesticides and fertilisers through good agricultural practices (GAP) - Demonstrating the benefits of small – medium sized wastewater treatment including low energy demand solutions - Addressing problems of oil polluted water from extraction wells through appropriate wastewater treatment - Demonstrating the benefits of integrated land and water use and management - Demonstrating environmentally sustainable solid waste disposal (municipal or industrial)					responses	
3a.10.ii	Develop replication / sustainability strategy to enable pilot projects to be applied across the NSAS	Experiences lead to new projects	> 5 years	$	JA, NSAS governments, donors, etc.	JA annual reports	3a.10.i

WR/ Eco QO 3: To utilize the Nubian aquifer resources on sustainable socio-economic development basis

WR/ Eco QO 3b: To manage the aquifer and its ecosystems in such a way as to reduce threat from human migrations and associated detrimental effects

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
3b.1	**Develop strategies to establish cooperation on prevention, control and management of human migrations in the Nubian region.**						
3b.1.i	Explore the role of pastoral water needs in human migrations.	Reports & workshops	2 years	$$	JA, NSAS governments and international organisations	JA annual reports Workshop reports International organisation reports	
3b.1.ii	Advise governments and international organisations in terms of human migrations related to water needs and develop scientific expertise in these terms.	Reports, workshops, government & international organisation briefings	3 years	$$	JA, NSAS governments and international organisations	JA annual reports Workshop reports International organisation reports	
3b.1.iii	Identify regional legal and institutional requirements to enable control and management of likely human migrations and associated consequences.	Reports & recommendations	3 years	$$	JA, NSAS governments and international organisations	JA annual reports Workshop reports International organisation reports	
3b.1.iv	Develop policy to reduce demand for movement along transboundary trekking routes connecting the different NSAS countries.	Control of migration	3 years and on-going	$$$	JA, NSAS governments and international organisations	JA annual reports Workshop reports International organisation reports	
3b.1.v	Establish national incentives that reduce transboundary migration.	Control of migration	5 years and on-going	$$$	JA, NSAS governments and international organisations	JA annual reports Workshop reports International organisation reports	

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
3b.2	**Develop protocols and identify regional arrangements for monitoring and data management to control and manage likely human migrations and associated consequences in the NSAS.**						
3b.2.i	Construct geographic information and data management systems for the NSAS-dependent population, development activities and likely migration driving forces in the NSAS.	Database	2 years & on-going	$$	JA and national institutes	JA annual reports International organisation reports	
3b.2.ii	Assess migration potential according to indicators related to socio-economic/ecosystem status, to be developed and agreed on by the NSAS countries.	Reports and workshops	3 – 5 years	$	JA and NSAS governments	JA annual reports Government reports International organisation reports	
3b.3	**Undertake research on assessment of likely human migrations and associated consequences in the NSAS.**						
3b.3.i	Establish expertise on identification and assessment of driving forces for migration of the NSAS-dependent population in the NSAS.	Trained experts available	3- 5 years	$	JA, NSAS governments and international organisations	JA annual reports Government reports	
3b.3.ii	Assess the likely impacts of transboundary migrations of the NSAS-dependent population on the aquifer resources and associated risks of transboundary conflicts and high socio-economic costs.	Reports & workshops	3 years	$	JA, NSAS governments and international organisations	JA annual reports Workshop reports International organisation reports	
3b.4	**Achieve higher effectiveness in the placement of water access points.**						
3b.4.i	Apply NSAS aquifer model and other scientific resources to assist international aid organization to determine the locations and depths of future water	Advise from model use	2 years & on-going	$$$	JA and national institutes, international organisations	JA annual reports. Reports from international aid organisations	

	Management Target / action	Planned outputs	Time frame	Estimated Budget	Reforms required / responsibilities	Indicators / source of verification	Links
	points.						
3b.5	**Ensure the prompt and adequate provision of funding for actions to enable identification and assessment of potentials and opportunities for transboundary human migrations in the NSAS region.**						
3b.5.i	Assess investments needed to address research on the potential and impacts of likely human migrations within the NSAS region.	Database of investment for research	2 years	$	JA and national institutes. International organisations	JA annual reports Reports from international aid organisations	
3b.5.ii	Prioritize actions and identify financing arrangements and possible sources for funding including donors and non government organizations.	Prioritised list	2 years	$	JA and national institutes. International organisations	JA annual reports Reports from international aid organisations	
3b.5.iii	Procure necessary equipment and facilities to undertake assessment on migration and associated pressures on the NSAS and its related ecosystem.	Equipment available	3 years	$$$	JA and national institutes. International organisations	JA and national institutes. International organisations	
3b.6	**Gain regional experience on reducing water dependent migration through targeted pilot demonstration projects.**						
3b.6.i	Identify and implement pilot projects that will mitigate the pressure for population migration or to alleviate the pressures caused by migration on water resources	Experience from projects Reports & workshops	3 – 8 years	$$$	JA and national institutes. International organisations	JA and national institutes. International organisations	3b.6.ii
3b.6.ii	Develop replication/sustainability strategy to enable pilot projects to be applied across the NSAS	Experiences lead to new projects	> 5 years	$	JA and national institutes. International organisations	JA and national institutes. International organisations	3b.6.i

Annex 2 Outlines for Pilot Projects

The Nubian countries, Chad, Egypt, Libya, and Sudan, developed and discussed project ideas from the Management Action Tables that could be implemented early in a follow-on SAP project. The results of these discussions are provided in this annex.

Chad Pilot Project Concepts

Chad Project 1: Protection of the water quality in Guelta Archei and Bachikite.

Project Description

Guelta Archie and Bachikile are two sites where the water seeps naturally from the contact zone between the bedrock formation and the Palaeozoic sandstone formation (Figure A2.1). This discharge forms streams and pools which flow to a distance from their sources .Cattle breeders come to water their camels and sheep in these pools (Figure A2.2), resulting in pollution from animal waste. The risk of pollution by nitrate and related compounds is very high .In summer the color of water is almost red from the high concentration of nitrogen compounds.

Objective

The objective of the project is to protect the quality of water by providing alternative watering locations for the camel breeders away from the main sources thereby preventing damage to the biodiversity in the area.

Actions

1. Drill boreholes to supply water for camels at reasonable distances;
2. Assess the quality of water and take necessary measures to protect the groundwater which is polluted by the circulation of surface water;
3. Protect the biodiversity in these unique sites. The sites are unique and have a sort of biodiversity in the heart of desert (crocodile ,fish, birds , variable plants) which must be protected;
4. Select cautiously locations of boreholes. When drilling the boreholes, their locations must be selected cautiously with an impact assessment on the environment which might be damaged in consulting the users in the places which have great number of cattle causing over grazing in the area resulting in disastrous effects and outcomes

Expected Outcomes

1. Water and environment protected
2. Biodiversity conserved
3. Practices of camel breeders changed

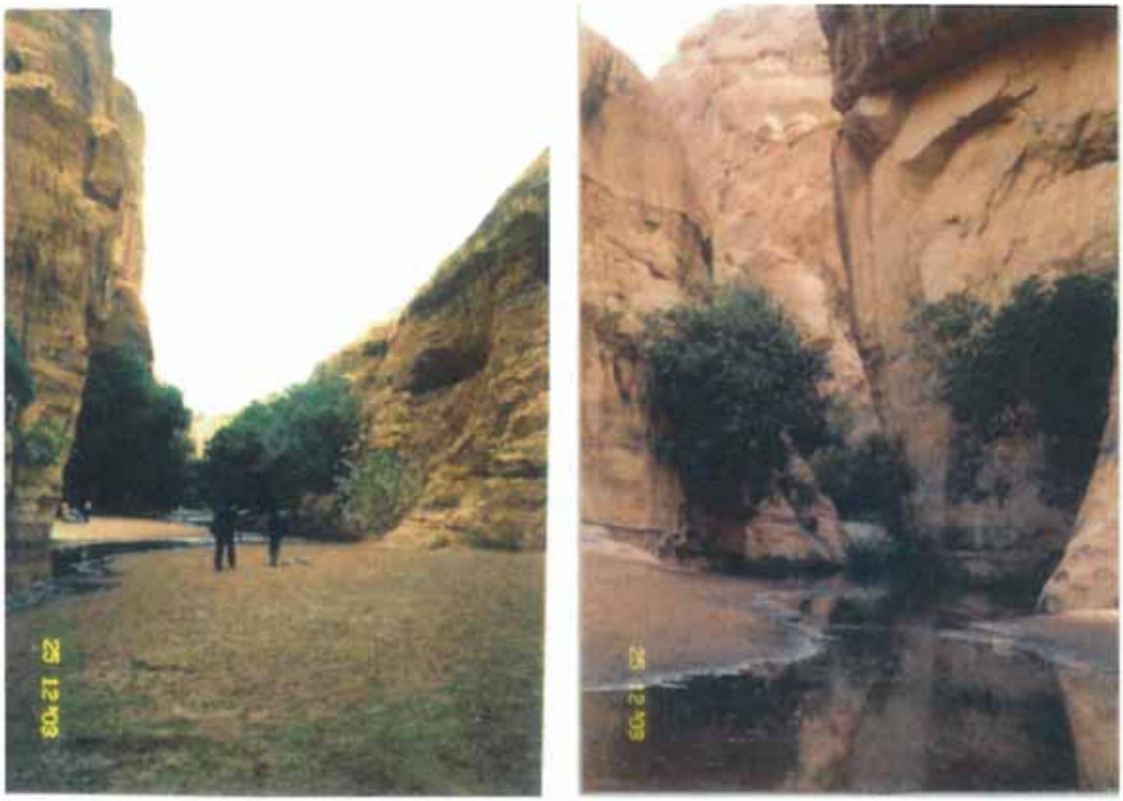

Figure A2.1 Entry of Archei (Lef t) and entry of Bachikilé (Right).

Figure A2.2. Animals in contact with surface waters in Guelta Archei.

Chad Project 2: Estimation of the recharge of the NSAS at the southern boundary and the mechanism of water flowing at the contact zone between the bedrock and the paleozoic formation

Project Description

At the southern boundary of the NSAS in Chad water seeps naturally from the rock in the contact zone between the bedrock formation and the Palaeozoic sandstone formation. The origin of these waters is thought to be the fossil Nubian aquifer, but this area receives annual precipitation between 50 and150 mm. Some wadis, such as Aroué, Sala, Chili, Amher, Haouache, and Garat, are incised in the sandstone and sustain discharge events three or four times a year .The plateau of Ennedi acts as a water divide, distributing the water in three basins: (1) Nile Basin (Ouadis Erdebé, Amdjaras, Kaora, and others), (2) Mourdra Basin (Ouadi Mourdi and Chibi), and (3) Djourbe Basin (Aroué, Sala, Chibi, Amher, Haouache, and others). The massif rock is porous and heavily fractured which permits water to percolate and become absorbed by the rock matrix. The rock acts as a reservoir which releases water slowly in the contact zone. It is noticed that the flow is continuous even in the consecutive years of drought. Please see the hydrographic map of Ennedi (Figure A2.3).

Objectives

1. Assess and study the mechanism of recharge of the aquifer in this part using isotopic techniques.
2. Determine the origin of waters flowing out in the contact zone using isotopic methods.

Actions

1. Water sampling and analysis
2. Numerical modeling
3. Geophysical studies
4. Acquisition of satellite images and aerial photos and their analysis

Expected Outcomes

1. Understand the origin of waters and the area of recharge in the southern part of NSAS and calibrate the IAEA Nubian groundwater model in the light of these new data.
2. Use the IAEA Nubian groundwater model to the East (Sudan) and the west (Tibesti) to estimate the general recharge and discharge areas in the southern region of the NSAS.

Partnerships

- European Union
- UNESCO
- IAEA
- GTZ[9] (German Technical Cooperation).

[9] http://www.gtz.de/en/index2.htm

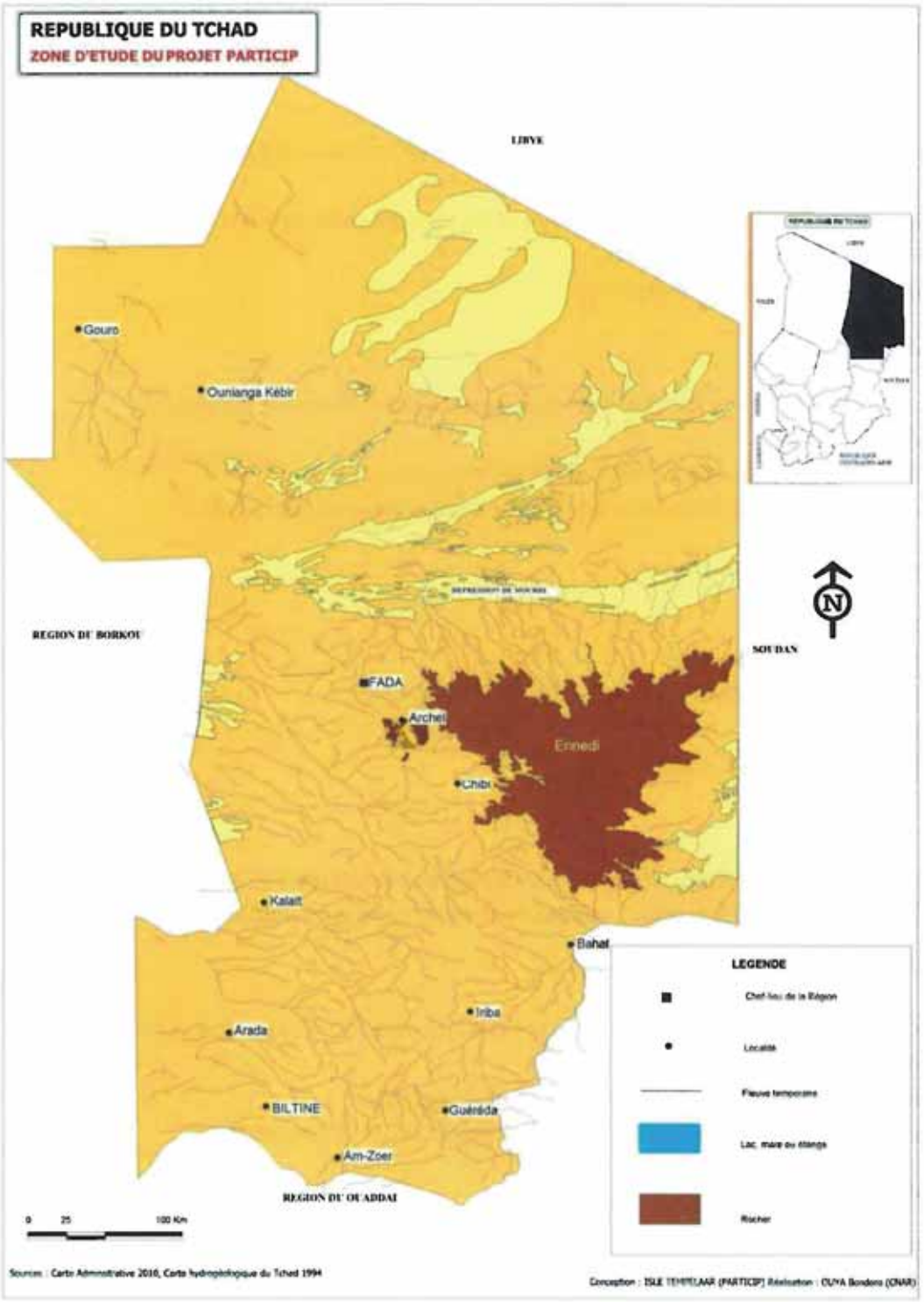

Figure A2.3. Hydrographic map of Ennedi.

Egypt Pilot Project Concepts

Egypt Project 1: Assessment of Transboundary environmental impacts of large-scale groundwater development projects: "The East Ewinut, Egypt".

Objectives

1. To study sensitivity, magnitude and patterns of induced transboundary groundwater fluxes using modeling techniques.
2. To identify effects on groundwater quality and fluxes ecosystem due to border based groundwater development projects.
3. To develop sustainability indicators.

Expected Outcomes

1. A systematic approach to the assessment of transboundary fluxes using modeling techniques.
2. Guidelines for transboundary protection of the ecosystem.
3. Sustainability indicators for border-based groundwater development projects.

Partnerships

- Joint Authority
- Ministry of Agriculture, Egypt
- Ministry of Water Resources and irrigation (WR and I), Egypt
- Private Investors
- Irrigation Sector / Groundwater sector

Egypt Project 2: Environmental impacts of climate change on the coastal aquifer in northwest Egypt "Siwa and East Katara Depression", post-Nubian aquifer and wadi aquifer.

Objectives

1. To assess the impacts of sea level rise on the salt intrusion and groundwater quality by using models and isotopes.
2. To identify the impacts of climate change on fauna and flora.
3. To assess the recharge mechanism in coastal deposit by using isotopes.

Expected Outcomes

1. Mitigation measures to control the impacts of movement of the saltwater / freshwater interface.
2. Maintaining the ecosystem as a study area.

Partnerships

- Joint Authority
- Ministry of Agriculture, Egypt
- Ministry of Water Resources and irrigation (WR and I), Egypt
- Ministry of Environment, Egypt
- National Water Research Center (NWRC), Egypt

Egypt Project 3: Application of water use association for pumping well in el Kharga Oasis.

Objectives

1. To use the experience of canal water-use associations in the desert area.
2. To introduce the governance of irrigation water.
3. To identify the impact of application of groundwater use associations.
4. Protect the environment, lands, water and ecosystem in el Kharga Oasis

Expected Outcomes

1. Guidelines of irrigation practices through formulating water use association.
2. Conservation of irrigation water.
3. Participation of farmers in the groundwater management matrix.

Partnerships

- Ministry of Water Resources and Irrigation (WR and I), Egypt
- Groundwater sector
- Ministry of Agriculture and Land Reclamation, Egypt
- NGOs, stakeholders and investors.

Libya Pilot Project Concepts

Libya Project 1: Possibilities of Recent NSAS Recharge

Estimation of Recharge to NSAS along the Libyan / Chadian borders at Tibesti Mountain ranges in conjunction with the ease of flow along the buried paleodrainage shown in Figure A2.4.

Project Description

The area located along the Libyan / Chadian border has an average rainfall of 50 mm per year. The area also shows a paleodrainage system that extends all the way to the Great Sand Sea between Libya and Egypt. These conditions even with a small amount of rainfall in such a large area might produce a significant recharge to the Aquifers below.

Objectives

1. Measure and assess the rainfall quantities, distribution and frequency.
2. Measure and assess evaporation and infiltration in the area.
3. Investigate and delineate the distribution of the buried paleodrainage, its properties (porosity, permeability, flow velocity, etc.) and consequently its contribution to recharge and discharge in the area.
4. Determine the recharge contribution and update the NSAS Numerical Model accordingly.

Actions

1. Acquisition and installations of weather stations in the area to monitor rainfall, evaporation, etc.
2. Acquisition of satellite images and aerial photos and their analysis
3. Water sampling and analysis (Isotopes, analytical, etc.)
4. Geophysical studies

Duration 2 years

Expected Outcomes

1. Determine the recharge to the system in this area.
2. Understand the origin of waters and the area of recharge in the southern part of NSAS.
3. Calibrate the NSAS groundwater model in the light of these new data.

Partnerships

- General Water Authority of Libya
- Government of Chad
- IAEA

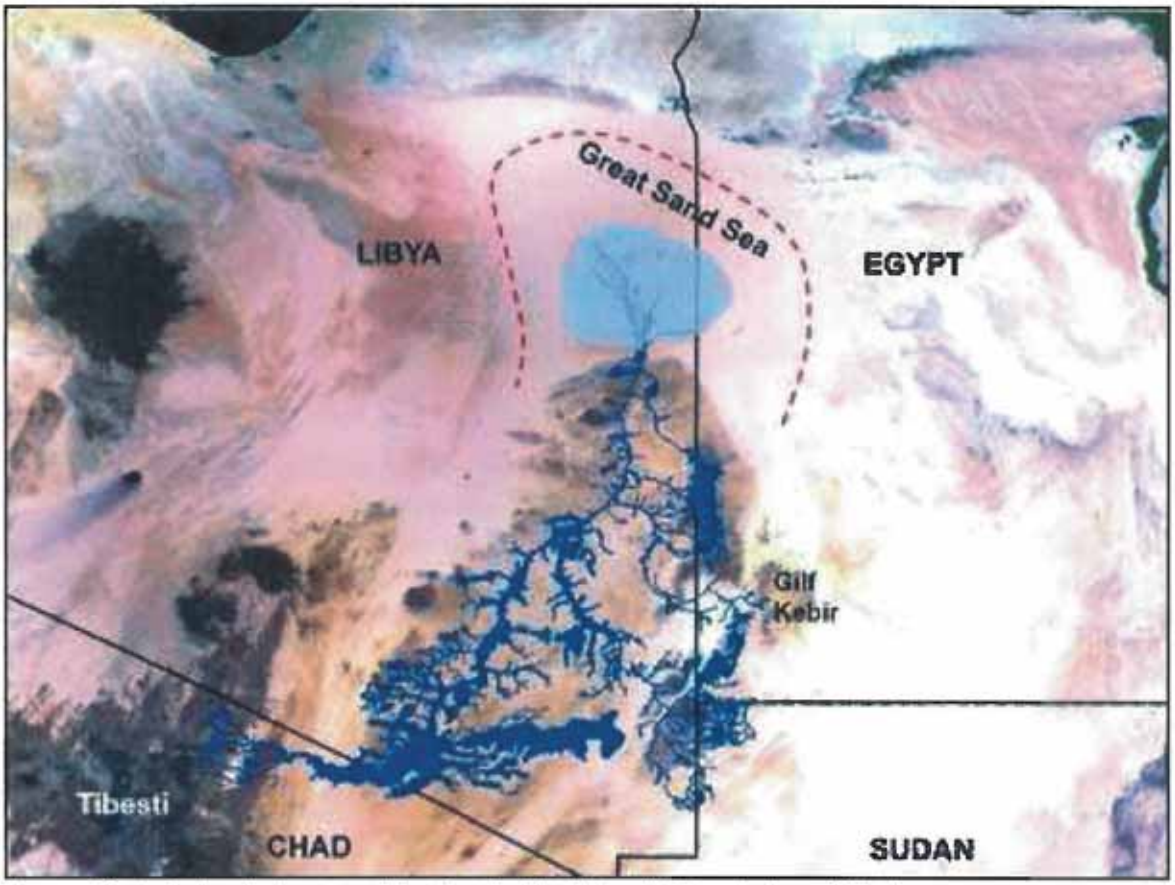

Figure A2.4. Paleodrainage originating in the Tibesti Mountains of Chad.

Libya Project 2: Environmental Impacts of Petroleum Exploration and Oil fields Development on Groundwater in NSAS

Project Description

Adverse effects on groundwater quality as a result of the past, existing and future activities of oil well drilling, secondary recovery of petroleum, and oil spills. These activities are carried out all over the NSAS area.

Activities

1. Field investigations to determine the extent and the nature of these activities.
2. Determine the quantities and qualities of groundwater being used.
3. Assess the methods of disposition and its adverse effects on the fresh water aquifers in the area and on its ecology.

Expected Outcomes

1. Prevention of water quality contamination.

2. Preservation of the environment.
3. Proper utilization of water resources.

Partners

- General Water Authority in Libya
- Ministry of Petroleum in Libya
- Ministry of irrigation and water resources in Egypt
- Ministry of Petroleum in Egypt
- Joint Authority

Libya Pilot Project 3: Environmental impacts of NSAS Development On Existing Lakes

Project Description

Natural Lakes fed by groundwater only or partially are all over NSAS area (Figures A2.5 and A2.6). Development of NSAS groundwater on a large scale will definitely lead to a drop in the water level of these lakes and reduction in their areal extent, which may lead eventually to the disappearance of these lakes completely. Examples of these existing lakes in Libya are Waw An Namous and Puzema lakes, shown below and so many others. These lakes besides their environmental value are of touristic attractions.

Activities

1. Monitoring of water level of the lakes
2. Water quality analysis to determine the source of the water, monitor the water quality change.
3. Investigate the biological species, and the biodiversity, in general.
4. Assess potential threats to biodiversity and ecosystem functions of the area.

Expected Outcome

Preservation of the environment and ecosystem

Partners

- Water Institutions in All four NSAS countries
- Joint Authority
- IAEA

Libya Pilot Project 4: Groundwater Discharge to Natural Outlets

Project Description

Water discharge to the natural outlets, including Lake Chad, Qattara Depression, the River Nile, and depressions and sabkhas in Libya and Egypt, should be investigated, evaluated, and monitored to determine their quantity and the changes if any resulting from developing the groundwater in the NSAS countries.

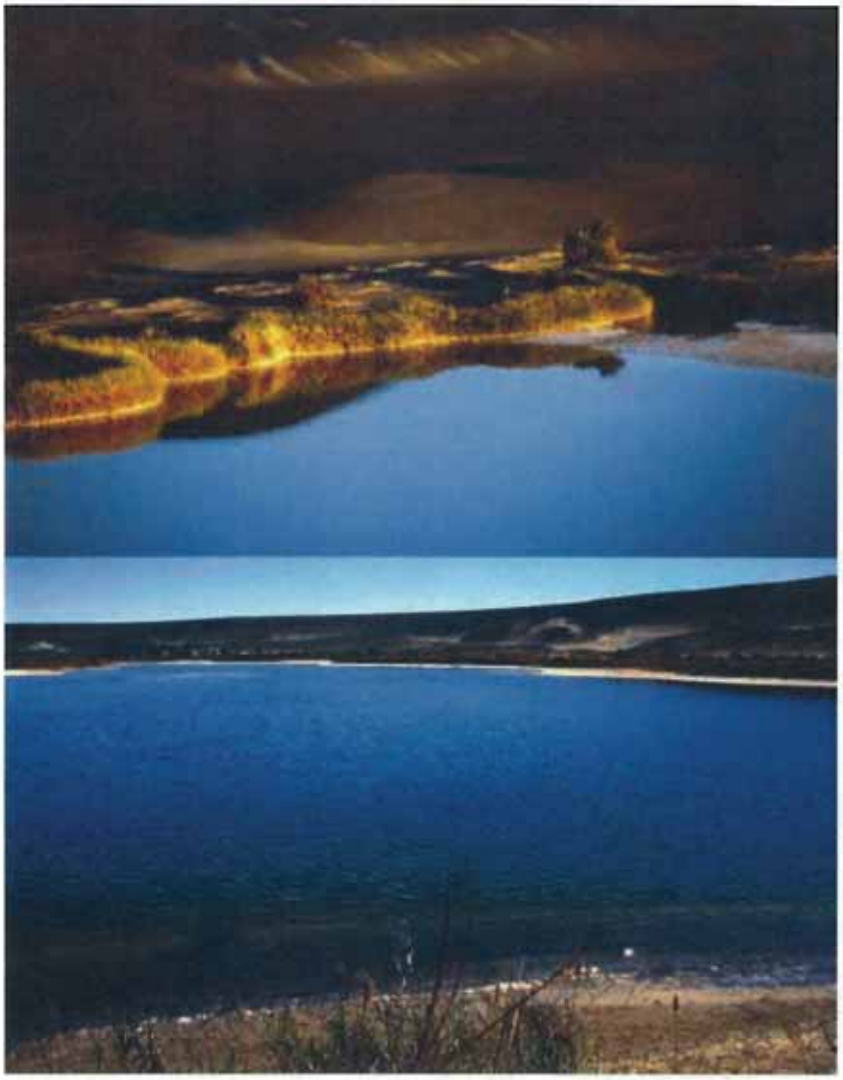

Figure A2.5. Waw en Namus, Libya, Location: 24° 42` 20.42`` N 18° 27` 55.98`` E, Elevation:414m (a.s.l.).

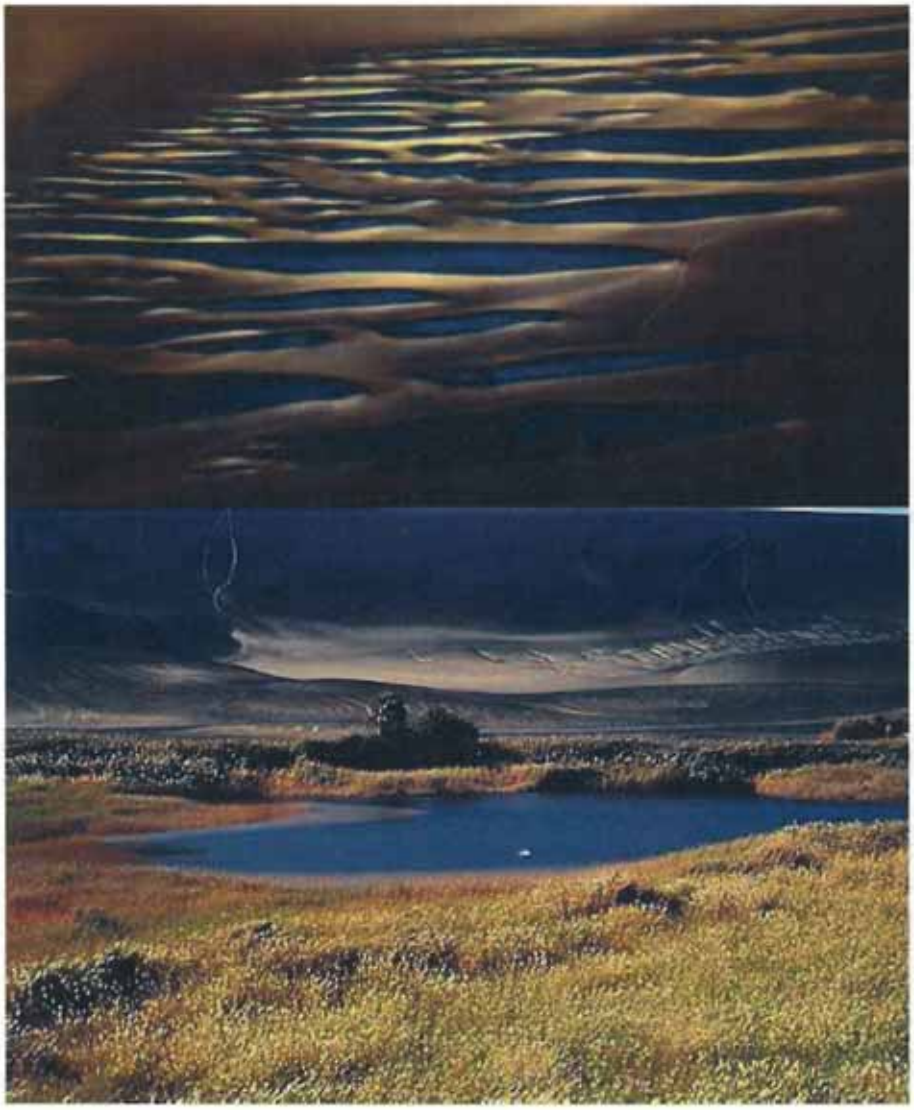

Figure A2.5 (concluded). Waw en Namus, Libya, Location: 24° 42` 20.42`` N 18° 27` 55.98`` E, Elevation:414m (a.s.l.).

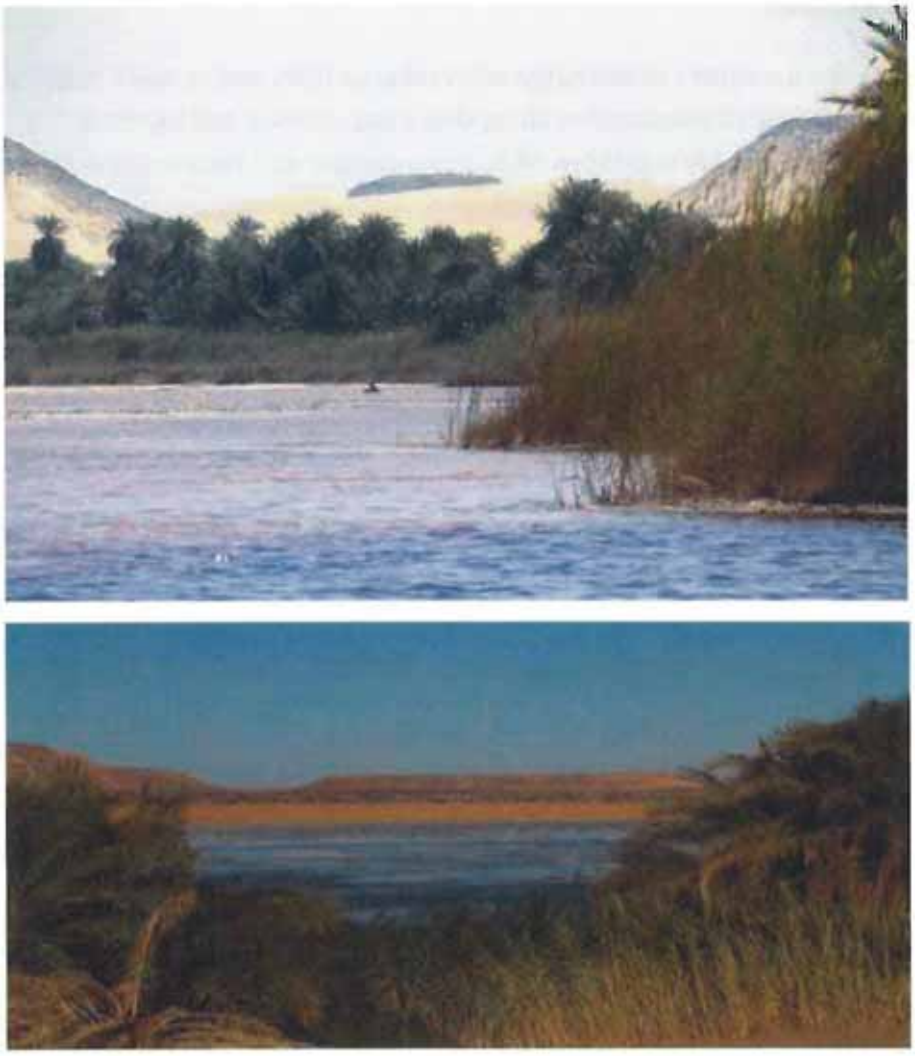

Figure A2.7. Puzema Lake, Libya, Location: 24° 53` 48.9`` N 22 ° 01`55.54`` E Elevation: 314m (a.s.l.).

Activities and Objectives

1. Determine the quantities of discharge and recharge from and to NSAS respectively.
2. Determine the rate of evaporation along these depressions and sabkhas.
3. Determine water quality threats to NSAS groundwater as a result of reverse flow, since most of these areas are highly saline.

Expected Outcome

1. Preservation of the environment.
2. Prevention of groundwater contamination.

Partners

- Water Institutions in All NSAS Counties
- Joint Authority
- IAEA

Sudan Pilot Project Concepts

Sudan Project 1: Groundwater flow modeling at Wadi el Mugadam Area

Objectives

1. Assessment of agricultural development on groundwater resources at Wadi el Mugadam Area.
2. Create groundwater model for future forecasts (local model).

WR/ECO Objectives

1. To implement appropriate agricultural practices to protect the water resources and allow growth.
2. To achieve controlled water-efficient use priorities and activities and to reduce the impacts of anthropogenic activities on water level and quality

Duration

2 years

Budget

$50,000

Co-finance

Government of Sudan

Partners

- Joint Authority
- Ministry of Agriculture, Sudan
- Ministry of Investment, Sudan
- Khartoum State, Sudan
- Northern State, Sudan

Activities

1. Geophysical studies
2. Monitoring: Hydrogeological parameters (Water level, chemical parameters), isotope sampling, wadi flow measurements.
3. Survey of agricultural activities and estimates of water requirements.

Expected Outcomes

1. Proper development in the area (Nomads).
2. Proper utilization of water resources.

3. Presevation of environment by implementation of modern irrigation techniques in management of forests (Pilot project).

Potential M&E Indicators

1. Flourish of environments
2. Modern irrigation techniques
3. Settlement of nomads

Sudan Project 2: Development of Wadi Hawar Area

Objectives

1. Settlement project for nomads (Stakeholders).
2. Study of interactions between surface water and groundwater using isotopic techniques.

WR/ECO Objectives

To allow for socio-economic development activities.

Duration

2-3 years

Budget

$500,000

Co-finance

Government of Sudan

Partners

- Ministry of Social Affairs, Sudan
- Ministry of Agriculture, Sudan
- Ministry of Environment, Sudan
- North Darfur State, Sudan
- Northern State, Sudan
- North Kordofan State

Activities

1. Drilling of water wells.
2. Agricultural scheme projects.
3. Fodder projects (Animals).
4. Monitoring activities: Isotopic sampling, analysis, and interpretation.

Expected Outcomes

1. Peaceful settlement.
2. Socioeconomic development.
3. Development of agricultural resources.
4. Enrichment of environment.

Potential M&E Indicators

1. Settlement of nomads.
2. Increase of income

Sudan Project 3: Development of Salima Oasis

Objectives

1. Creation of Green oasis.
2. Development of Camel route.

WR/ECO Objectives

To allow for integrated transboundary NSAS based socio-economic development activities.

Duration

2-3 years

Budget

$200,000

Co-finance

Government of Sudan

Partners

- Ministry of Agriculture, Sudan
- Ministry of Environment, Sudan
- North Darfur State, Sudan
- Northern State, Sudan
- North Kordofan State

Activities

1. Drilling of water wells (Water supply).
2. Fodder projects (Animals).
3. Mining activities (Atron, Sodium chloride)

Expected Outcomes

1. Enrichment of environment.
2. Preservation of Salima Oasis.
3. Socioeconomic development
4. Animal resource development
5. Activation of trade between Sudan and Libya

Potential M&E Indicators

1. Settlement of nomads.
2. Increase of income.
3. Regional cooperation.