GROUNDWATER NEED ASSESSMENT
Nubian Sandstone Basin

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**Acronyms**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AMCW</td>
<td>African Ministers Council on Water</td>
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<tr>
<td>AGWC</td>
<td>Africa Ground Water Commission</td>
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<td>AU</td>
<td>African Union</td>
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<tr>
<td>GEF</td>
<td>Global Environmental Facility</td>
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<tr>
<td>GMRP</td>
<td>The Great Man-made River Project</td>
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<td>GW</td>
<td>Ground Water</td>
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<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<td>IFAD</td>
<td>International Fund for Agriculture Development</td>
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<tr>
<td>IDB</td>
<td>Islamic Development Bank</td>
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<tr>
<td>JASD-NSAS</td>
<td>Joint Authority for the Study &amp; Development of the Nubian Sandstone Aquifer System</td>
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<td>FAO</td>
<td>Food &amp; Agriculture Organisation</td>
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<td>NARIS</td>
<td>Nubian Aquifer Regional Information System</td>
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<td>NBI</td>
<td>Nile Basin Initiative</td>
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<tr>
<td>AQUASAT</td>
<td>Nubian Sandstone Aquifer System</td>
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<tr>
<td>SADA</td>
<td>Shared Aquifer Diagnostic Analysis</td>
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<tr>
<td>SAP</td>
<td>Strategic Action Programme</td>
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<tr>
<td>SWOT</td>
<td>Strength Weakness Opportunity, Threat</td>
</tr>
<tr>
<td>TBA</td>
<td>Trans Boundary Aquifer</td>
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<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
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<td>UNGA</td>
<td>United Nations General Assembly</td>
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1. Introduction

The Nubian Sandstone Aquifer System (NSAS) at the North Eastern part of Africa is a Trans Boundary Aquifer shared between Chad, Egypt, Libya and Sudan with almost comparable surface areas in each of four countries.

A huge water basin lies under all four countries, which unilaterally place greater emphasis on the NSAS groundwater resources to satisfy national water needs in the future.

Similar climates prevails all basin parts in the riparian countries, where water resources are scarce and groundwater need to be explored to meet increasing needs. As a result all countries have attached top priority in their respective national development plans to address water shortages and explore for alternatives. The NSAS provides a unique opportunity.. Each of the respective aquifer countries is pursuing different development strategies, however the degrees of implementation is linked to the each country financing capacity, obviously poor in Chad and Sudan compared to Egypt and Libya..

Since early seventies, Egypt and Libya have implemented large scale projects to develop the shared NSAS and the overlying arid land. The two countries have expressed their interest in bilateral cooperation, and have agreed to form a joint Authority to study and develop the NSAS and to seek international assistance to establish a regional strategy for the utilization of the NSAS water resources.

A Key challenge in developing an adequate management strategy in the NSAS case is to gain sufficient knowledge about the transboundary aquifer within the hydro-geological boundary.

Achievements of the JASD

From 1998-2002 through IFAD has supported an important initiatives and baseline activities to implement a joint survey of the socio-economic development policies and plans in the countries sharing the Nubian aquifer and the establishment of a NSAS Regional Information System (NARIS) database. NARIS is expected to facilitate data sharing/ storage, processing, display and analysis and became instrumental in the preparation of data for a regional model to simulate NSAS groundwater flow under different scenarios. The modeling scenarios have been based on a survey of socio-economic development strategies related to the aquifer resources in the riparian countries. Modeling results provides indication of the impacts of NSAS development on water levels and water quality over a period of 60 years of abstractions. The model has been upgraded during the GEF project in 2009 to include additional NSAS areas in Sudan & Chad, and to apply 3D simulation to aquifer areas of high levels of abstraction in Libya and Egypt. However, the model cannot yet be employed for operational use or for monitoring and evaluation of future impacts.

The NSAS model has not covered the all NSAS areas up to the southern Boundaries in Sudan and Chad due to lack of data. It uses hydraulic boundaries conditions at the southern border of the basin in Chad and Sudan, and did not cover the upstream physical boundaries, an important input for accurate water balance estimation and future reliable model predictions. To achieve equal benefit from such projects, data gaps that facilitate the joint management of the NSAS, including additional mechanisms for sustainable operation and inter-country communication, need to be addressed as an important component/ output.
The NSAS countries have identified the need for the expansion of aquifer monitoring and observation-well networks. There are, however, important capacity gaps. Efforts to bridge these gaps have begun under a regional Programme for the Development of the Nubian Sandstone Aquifer System, supported by International Fund for Agriculture Development (IFAD), the Islamic Development Bank (IDB) and the riparian countries as well as the UNDP GEF. This initiative was a phased programme. The first phase aimed at the development of a Regional Utilization Strategy of the NSAS. The second phase aimed at the integration of the socioeconomic aspects within a vision for basin development. The programme started in 1998. Agreements were signed between the four countries for regular monitoring and continuous exchange of information.

The latter programme has contributed to the capacity of the four countries for better management of the aquifer. Regional thematic maps, regional mathematical model, and a regional information system were developed and the role of the Joint Authority for the Study and Development of the NSAS was revitalized. However the project was not successful in formulating the regional development strategy, and all planned activities remained only on papers by the end of the project.

In 2006, GEF financed a Medium Sized Project (MSP), namely: The Regional Formulation of an Action Programme for the Integrated Management of the Shared Nubian Aquifer. The overall objective of the project is to develop the framework for the sustainable management and use of the Nubian Aquifer System in the four riparian countries. The project is to expand and consolidate the technical and scientific knowledge base regarding the Aquifer System. A Shared Aquifer Diagnostic Analysis (SADA) followed by a Strategic Action Programme (SAP) were the main components financed by the GEF International Waters Focal Area.

2. Objectives

The Objective of the current study is to assess the institutional capacity of the Joint Authority to manage groundwater within L/ROBs. To that end a SWOT analysis will be carried out and recommendations on needs in four focus areas will be made. The output of the study is expected to identify key actions addressing needs for enhancing GW management through:

a. Monitoring, data and knowledge generation
b. Institutional/organizational/legal aspect
c. Financial aspects
d. Capacity building aspects

3. Basin Profile

a. Bio-physical conditions

The Nubian sandstone aquifer system (NSAS) is a large regional groundwater basin extending across the border of four African countries, namely Chad, Egypt, Libya and Sudan. It covers a total area of 2,200,00 km² (1,430,000km² without post Nubian, CEDARE, 2002) and encompasses the major part of Egypt (29%), and eastern part of Libya (32%), the northern part of Sudan (29%) and the northeast of Chad (10%) (MoIWR, 2009). The Nubian
Sandstone Aquifer (NSAS) area extends between latitudes 13°-26° North and longitudes 19.4°-34.5° East. It lies within dessert, semi-dessert, and low rain savanna zones (figure 1).

**Climate Features:**
The climate of the region is characterized by low irregular rainfall, persistent drought, land degradation and desertification. The rainfall generally occurs between June and October at an average of less than 25 mm annually in the most northern part. It generally increases towards the south averaging 200 mm around Khartoum but it is very erratic in distribution. In recent years a significant delay of rainfall is recorded as well as general decrease in the amount of precipitation. Winter season, which is characterized by dry wind, begins in December and ends by February. The summer season dominates the rest of the year.
The mean daily temperature is fairly high with the maximum in the hottest months above 40° C. The absolute maximum average temperature is usually recorded in May-September. The minimum average temperature below 15° C recorded in December-March. The wind is mostly North to South.

**b. Hydrogeology conditions**
The regional geological framework (Figure 2) of the NSAS area was originally established in the Late Proterozoic times and was governed by the former plate tectonics affecting the area between Africa, Europe, and Asia. The effect of the resulting stresses on the North African plate was the formation of basins, troughs, grabens, ridges, blocks and uplifted areas with different orientations. Volcanic eruptions followed many of the old lines and intrusion of granitic magma took place in the Lower Paleozoic.

Hoggar1-Red Sea Massif areas form the backbone of the Arabian Nubian Shield2. All the Basement rock exposures are associated with that shield which tapers almost to the south and slopes regionally northward. Older Paleozoic rocks crop out near the basement contacts in South Egypt, South Libya, North West Sudan, and North Chad.

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1 Highland region in central Sahara, along the Tropic of Cancer.
2 The Arabian-Nubian Shield (ANS) is an exposure of Precambrian crystalline rocks on the flanks of the Red Sea. The crystalline rocks are mostly Neoproterozoic in age. Geographically - and from north to south - the ANS includes the nations of Palestine, Jordan, Egypt, Saudi Arabia, Sudan, Eritrea, Ethiopia, Yemen, and Somalia. The ANS in the north is exposed as part of the Sahara Desert and Arabian Desert, and in the south in the Ethiopian Highlands, Asir province of Arabia and Yemen Highlands.
Precambrian Basement outcrops immediately to the South, East, and Southwest of the Basin. Local exposures are also found at Oweinat area at the border between Egypt, Libya, and Sudan. The Basement rocks are dominated by granites and granodiorites in addition to an association of metasediments, metavolcanics, metagabros and serpentines.

The Nubian formation is flat lying to gently dipping rocks made up of continental sediments including sandstones, grits, mudstones and conglomerates, overlain by alluvial deposits. The Nubian Sandstone beds have minor intercalations of siltstone and kaolinitic sandstone. Nubian Sandstones derive from Precambrian and reworked sandy Palaeozoic deposits, not altered by metamorphic processes. Libyan part from late Jurassic to early Cretaceous, Egyptian part from Palaeocene. In Sudan the Basement rocks are unconformably overlain by the Paleozoic sediments which outcrop in SE Libya, NW Sudan, and NE Chad. The maximum recorded thickness of the Paleozoic sediments is 1500 meters in Ennedi in Chad. The Paleozoic succession is dominated by fluvialite sand facies.

**Hydrogeology**

The Nubian Groundwater system is characterized by deep Sandstone aquifer of sedimentary origin. The hydraulic gradient is from the south-west to the north-east. The Basin thickness varies between 500m – 3500m, with saturated thickness between 100m – 650m. Transmissivity of Nubian Sandstone ranges from 2.72 m²/d to 72.4 m²/d (Müller, et al, 2009).
The Nubian basin is composed of hydraulically connected groundwater sub-basins where different uplifts subdivide the aquifer system and thereby shape it (Wycik 2004). The boundaries of sub-basins are not well defined and are overlapping in different literature. These include but not limited to the following:
1) Kufra Basin in Libya, Chad and Sudan
2) Dakhla Basin in Egypt
3) Sarir Basin in Libya
4) North Darfur Basin in Sudan
5) Main Nile Basin in Sudan and Egypt

The NSAS is overlain by a number of surface drainage basins, not clearly defined. The regional hydrology and the interaction of surface water systems with the NSAS need to be understood to enable integrated management of basin.

The NSAS is, in most of its parts non-renewable. Age determination of the Nubian sandstone water with C14 at Kufra (Libya) and Kharga (Egypt) indicate that groundwater in the area was originated by Pleistocene recharge between 40,000 and 20,000 years ago, or by Holocene recharge during the last Pluvial period (6,000 B.C).

Some studies concluded the existence of recharge to the NSAS from the Nile River in a few areas at the eastern boundary, by precipitation in some mountain regions and by groundwater influx from the Blue Nile / Main Nile Rift system. The infiltration rate is estimated to be small compared to the natural groundwater flow due to discharge in depressions, evaporation in areas of low depths to groundwater table and leakage into confining beds. It is thus considered to be a non-renewable groundwater resource under current climate conditions. Maxwell, 2011, concluded that “the recharge is so negligible and localised that for purposes of crafting a treaty, the NSAS should be considered a non-recharging aquifer”.

c. Transboundary groundwater basins, uses/users, conflicts

It is worth noting that good-quality groundwater such as that of the NSAS is a precious water resource that would optimally used to satisfy basic human needs for drinking water supply. On the contrary the Nubian basin superior quality groundwater is predominantly used for irrigated agriculture in a harsh desert environment. Whether this is considered as wasteful, efficient or beneficial should be a subject of valuation according to internationally agreed water management principles, justified regional priorities and options set by the riparian countries.

According to CEDARE/IFAD (2002), the NSAS is the Africa's largest fossil aquifer system with its reserves estimated at 259.293 km$^3$ (372,960 km$^3$ with post Nubian). However, NSAS groundwater resources are under threat of degradation by inappropriate use (mismanagement) in some riparian countries.

In the arid desert areas of the countries that share the aquifer, groundwater is a primary source of water for human populations and the indigenous ecosystems.

There is hardly accurate information on the use of the NSAS groundwater resources. Different figures are found in some country reports and regional studies carried within the JA projects. DIE (2008) have attempted to describe the type of use in each country, but the exact volumes remains inaccurate..
According to Maxwell (2011), 85%–90% of the Nubian states’ general water withdrawal goes to agriculture.

The status of development of the NSAS is characterized by very high intensity of national use in Libya and Egypt, where the planned mining of aquifer reserves is contemplated from the outset. The Great Man-made River Project, Libyan Sarir sub-Basin; and Western Desert Irrigation project in Egypt are typical examples of a use race. Most of the water extracted from the aquifer system is used for agriculture, either in intensive projects in Libya or for private farms in Egypt (http://www.dundee.ac.uk/cepmlp/car/html/CAR9_ARTICLE28.pdf)

This has led to declining groundwater levels in Egypt and Libya, and pollution in Libya. Sixty (60) meters decline in groundwater level was reported in year 2000 at the oases of Egypt leaving all free-flowing wells and springs been replaced by deep wells (CEDARE, 2000). Transboundary impacts have not been reported, but most likely in Sudan & Chad (DIE, 2008).

The way in which the NSAS groundwater is utilised in the last five decades could lead to incidental depletion of aquifer reserves. Reports on planned developments in some countries highlights increasing pressure to enhance the abstraction of the NSAS tremendously valuable resource that appears to be only marginally rechargeable. This potentially could cause harm to other uses and lead to transboundary conflict.

The development of mostly “non-renewable” NSAS groundwater resources will imply the mining of aquifer storage reserves, such that they will not be available for future use. As such it has special social, economic, and political sensitivity compared to other water resource development.

Such mining strategies should include a plan to guide the utilization of available resources with a view to making use-communities better prepared socio-economically to cope with increasing water stress as aquifer storage is depleted. Alternative water sources for the aquifer States need be explored. According to Pete Louks (2009) comments on the Libyan GMRP (figure 3), the cost of Europe pipeline (0.74 m$^3$/dinar), Desalination (0.80 m$^3$/dinar) or Ship transportation (1.05 m$^3$/dinar) is worth considering as an alternative to the Desert Pipeline that costs (14.7 m$^3$/dinar).

Figure 3: Great Man-made River Project in Libya (Louks, 2009)
d. Water governance framework & Stakeholder involvement

The four NSAS countries have already embarked on cooperation on the management of the NSAS water resources. Egypt and Libya initiated the process in the early 1970s and formalized it in 1992 with the creation of the Joint Authority for the study and development of the NSAS – JASD-NSAS. Sudan joined the Joint Authority in 1996 and Chad followed in 1999.

The Joint Authority

The Joint Authority of the Nubian Sandstone Aquifer System (JASD-NSAS) is the initial setup agreed between the riparian states for “the study and development of the Nubian Sandstone Aquifer System” based on specific terms of reference. JASD-NSAS was institutionalised as part of the implementation of a project component supported by IFAD (1998-2000) with a mandate to fulfil specific objectives.
Based on the bilateral agreement of 1992 between Egypt and Libya, the JASD-NSAS has the following mandate:

1- carry out studies and research and collect information
2- implement study projects for groundwater development and management, and rational use of groundwater resources
3- Study the environmental impacts of the aquifer development, and combating desertification through the use of renewable energy/ resources.
4- Supervise joint regional projects and provide technical advisory needed for the NSAS basin.

JASD-NSAS has since then continued to lead the implementation of the UNDP/GEF/IAEA (2006-2009). As the JASD-NSAS function has been limited to joint projects implementation, it has been operating as a typical regional expert group with project based terms of reference.

Legal framework

The Joint Authority of the Nubian Sandstone Aquifer System (JASD-NSAS) was first established on 29th June 1991 as a bilateral organisation between two out of four basin countries (draft internal regulation – hard copy, Arabic version). Libya and Egypt, the largest users of the Nubian basin water resources were the first to lead bilateral collaboration on the Nubian Sandstone Basin.. In response to uncoordinated large abstractions by Egypt and Libya, the two countries recognised the need for a joint studying development of the basin to avoid depletion and what could be disastrous consequences on both countries.. Sudan and Chad has joint on 18th April 1996 and 18th March 1999 respectively (CEDARE, 2000). No public document (agreement signed by member countries) is available to indicate the establishment of the JASD-NSAS.

There are no accessible legal documents on the establishment of the JASD-NSAS (Joint Authority for Study and Development of the Nubian Sandstone Aquifer System). However, the JASD-NSAS website (http://www.jasad-nsas-ly.org/en/index.php) briefly describes the institutional structure of the JASD-NSAS without reference to any articles of association, vis-a-vis a governance systems for the regional organisation; criteria (made public) for the
regional partners and focal institution; or indicators and performance assessment criteria for the regional authority and its partners etc.

Typically, the Joint Authorities can be described as an organisation with an executive mandate, i.e. a mandate to implement and operate projects on the ground. JASD-NSAS mandate is limited to project implementation, coordination and they do not play a major role in interstate relations or policy formulation.

JASD-NSAS principal and legal role/mandate does not include management functions wrt. the basin groundwater resources. Accordingly, the JASD-NSAS has no role to allocate GW, to oversee GW management, to monitor TBAs in basin or to advise riparian states on issues related to GW. The main role now is to implement joint studies to strengthen member countries’ capacity for future joint management of the Basin.

Basin-wide agreements between the four countries sharing the NSAS were first signed in October 2000 (FAO website), to mark the start of tangible regional collaboration. The agreements were part of the institutional component of the IFAD project, which put in place the first basis for multilateral collaborate on the NSAS monitoring and data sharing (JASD-NSAS website, 2009). However, the sustainability of the later agreements was not carefully considered after the completion of the project.

The two agreements signed by the NSAS countries, Include (http://www.fao.org/docrep/008/y5739e/y5739e05.htm#bm05):

- Agreement No. 1 – established terms of Reference for the Monitoring and Exchange of Groundwater Information of the Nubian Sandstone Aquifer System.
- Agreement No. 2 – established Terms of Reference for Monitoring and Data Sharing.

The above two agreements represent the only governing framework of the Nubian transboundary Basin.

The agreement No. 1 aimed at developing a Regional Information System called the “Nubian Aquifer Regional Information System” (NARIS), to support the implementation of the programme for the Development of a Regional Strategy for the utilisation of the Nubian Sandstone Aquifer System. This agreement is however time bounded by the implementation of the “Programme for the Development of a Regional Strategy for the Utilization of the Nubian Sandstone Aquifer System”

Although not explicitly referred to surface water, the data sharing agreement emphasised storing and documenting “different data covering all fields relevant to the Nubian Sandstone Aquifer System” Agreement 1, 2000.

Agreement No. 2 aimed at maintaining “continuous monitoring of the aquifer to observe the regional behaviour of the NSAS”. It involves consent of riparian countries to share monitored parameters of the aquifer for sustainable development and proper management of the Nubian Sandstone Aquifer System.

**Institutional structure of the JASD-NSAS**

JASD-NSAS (Figure 4) is composed of a Board and a Secretariat and operated according to an internal constitution establishing the purpose of the joint corporate, the structure and the operational rules as approved by the governments of Egypt and Libya.
The Authority Board comprises delegations from each country. The members of each delegation are trusted professionals predominantly geologists and hydrogeologists from each country. Surface water is not considered in JASD water management structure or in implemented actions programmes. A permanent Secretariat (based in Tripoli, Libya) provides administrative support and overall coordination of the JASD-NSAS activities. Only the Secretariat staff is full-time whereas the members of the Board are delegates from Member States ministries whose duties at JASD-NSAS form only a part of their job description. The Board Chair as well as the Executive secretary positions are rotational among member countries.

The JASD-NSAS is financed by the riparian countries and from grants from regional and international organizations, according to the annual budget approved by the board. Countries financial contributions are 35% Egypt, 35% Libya, 20% Sudan, 10% Chad. 70% of the countries contributions are managed by the JADS-NSAS through its bank account. 30% of the countries' contributions are allocated to country activities through separate accounts in the countries.

Formation of the JASD-NSAS Board

The Board was initially composed of six members: three from Egypt and three from Libya selected by their government, with a lead member for each country. Later on, Chad (1999) and Sudan (1996) were equally represented at the JA-NSAS. The Board is composed of twelve part-time members, three from each member country selected by the water ministries. Board members are granted representation allowance on the JASD-NSAS relevant budget-element/ line.

The board competencies include:

1. Ensure the achievement of the purposes of the JASD-NSAS
2. Pay initial costs necessary to the establishment, registration and general administration of JASD-NSAS.
3. Review and approve the annual budget of the JASD-NSAS
4. Develop an annual report on the activities of the Authority during the financial ended year and present it to the Member States,
5. Establishing branches/ offices in the member countries and outside,
6. Appoint and decide the mandate of a director for the JA-NSAS
7. Approve the appointment of the branches/ offices managers in accordance with the JA-NSAS Regulation and in coordination with the competent authorities of Member States
8. Issuing internal regulations and instructions for the conduct of administrative and financial affairs.
9. Adoption of an organizational structure and functional structure of the body that is being proposed by the Executive Director.
10. Build bridges of cooperation with institutions and international and regional bodies
11. Determine the remuneration of the Chairman and members of the Board of Directors

**Stakeholders Participation**

Stakeholder participation is not yet envisaged by the JASD-NSAS. All projects/ activities are carried in an environment where organizational or office politics often appear to cloud a project's progression. The JA-NSAS is an inter-governmental setup with limited involvement outside the Ministries of Water in the riparian countries. Within the GEF project, stakeholders’ identification represented part of the SADA. This could be considered as a step towards future involvement of stakeholders.

**4. Interviews**

The study relied on direct interviews with Joint Authority staff at the Board level as well as at country offices. Responses were only possible with Sudanese staff as detailed in table 1. Authority staff from Chad, Egypt and Libya as well as IAEA project have chosen not to participate or share inputs to the assessment due to undeclared reasons. Interviews feedback were incorporated in the different sections of the report.

**Table 1: Interviewed JSD-NSAS staff at the Authority board and country branches**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Organisation</th>
<th>Address</th>
<th>Questionnaire Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Osman Mustafa Ahmed</td>
<td>NPC National Coordinator, and Board member</td>
<td>JSD-NSAS Khartoum, Sudan</td>
<td>+249 912 910034 <a href="mailto:omaburi@hotmail.com">omaburi@hotmail.com</a></td>
<td>A</td>
</tr>
<tr>
<td>Mr. Mostafa Abdel Rahim</td>
<td>Board Member; Director Groundwater</td>
<td>Ministry of Irrigation &amp; Water Resources, Sudan</td>
<td>Khartoum, Sudan +249 912 147907 <a href="mailto:mayousif52@yahoo.com">mayousif52@yahoo.com</a></td>
<td>A</td>
</tr>
<tr>
<td>Ms. Miyada Monjid</td>
<td>Database</td>
<td>Ministry of</td>
<td>Khartoum, Sudan</td>
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5. SWOT analysis
The SWOT analysis results are based on the feedback to the questionnaire/ interviews conducted during October/ November 2011 with the JASD-NSAS Board members and the national office in Khartoum.

**Strength**

<table>
<thead>
<tr>
<th>GW governance in JASD-NSAS (Institutional/ legal/ financial aspects)</th>
<th>Collaboration with riparian states</th>
<th>GW data management/sharing (Monitoring, data and knowledge generation)</th>
<th>Capacity building aspects</th>
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<tbody>
<tr>
<td>• Agreement on cooperation through the establishment of a Joint Authority for the study and development of Nubian Sandstone Basin among the four riparian states.</td>
<td>• JASD-NSAS has initiated technical cooperation on groundwater and raised awareness of state ministries of water resources which predominantly emphasise surface water management.</td>
<td>• Agreements on dada sharing and aquifer monitoring are in place.</td>
<td>• International recognition of the JASD-NSAS and interest in supporting understanding the Nubian basin as an important water resource in a climatically vulnerable and water stressed region.</td>
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<td></td>
<td>• JASD-NSAS enjoys balance of power of the two major users of the Basin, namely: Libya and Egypt.</td>
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<td>• Raising the visibility/ profile of groundwater sub-sector in member countries, bringing high professional interest in previously marginalised groundwater issues.</td>
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<td></td>
<td>• The NSAS groundwater represents a backup for possible surfaces water shortage due to growing need &amp; climate change.</td>
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<td>• This has in turn influenced the commitment of the JASD-NSAS countries to integrate groundwater in the national water strategies.</td>
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**Weakness**

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<thead>
<tr>
<th>GW governance in JASD-NSAS (Institutional/ legal/ financial aspects)</th>
<th>Collaboration with riparian states</th>
<th>GW data management/sharing (Monitoring, data and knowledge generation)</th>
<th>Capacity building aspects</th>
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<tr>
<td>• Lack of shared vision for the management of the Nubian sandstone basin</td>
<td>• Sole focus of JASD-NSAS on the technical</td>
<td>• Information collection and sharing are project-based, and</td>
<td>• Status of institutionalisation of NSAS</td>
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<td>Lack of legally binding resource management agreement among NSAS countries based on international water law.</td>
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<td>Agreement 1 on data sharing is only limited to the implementation of the IFAD project (1998-2002).</td>
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<td>Agreement 2 on monitoring the NSAS abstraction, does not define mechanisms of sharing, or feed back into the NARIS regional database.</td>
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<td>Limited JASD-NSAS mandate, and inadequate institutional framework, compared to RBO functioning indicators.</td>
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<td>JASD-NSAS sole emphasis on technical cooperation, with vague basing management framework</td>
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<td>no responsibilities in water resources management and in the decision making process due to the lack of JASD-NSAS mandate.</td>
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<td>Lack of involvement of stakeholder at all levels of operation and decision making and low transparency / high confidentiality of the JASD-NSAS work and products.</td>
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<td>works only with the national groundwater authorities, which is institutionally separate from the surface water management.</td>
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<tr>
<td>No supportive government- society-science interfaces or exchange processes (Turton, 2006) to ensure effective allocation and aspects of the aquifer characterisation.</td>
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<tr>
<td>Lack of mandate in inter-state relations or policy formulation</td>
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<tr>
<td>Lack of local ownership (an important catalyst for an IWRM process) of JASD-NSAS projects, and high influence of UN-associated organisation and cartel in the consulting studies compromising ownership of the basin management.</td>
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<tr>
<td>No adoption of principle of international law governing NSAS groundwater allocation, e.g. utilize NSAS water in an equitable and reasonable manner.</td>
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<tr>
<td>preliminary level of multilateral cooperation and absence of typical basin organization institutional and legal framework, thus stopped at an initial phase with currently weak implementation of agreed NARIS guidelines,</td>
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<td>Static groundwater levels as well as water quality parameter are the data collected by the Joint Authority. Surface water component is not yet foreseen</td>
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<tr>
<td>the NARIS databases is not operational.</td>
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<td>monitoring networks are national responsibility with varying density in different member states.</td>
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<tr>
<td>sharing of data within the riparian states' national groundwater departments is in place, but not according to guidelines</td>
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<tr>
<td>preliminary level of multilateral cooperation and absence of typical basin organization institutional and legal framework,</td>
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<tr>
<td>monitoring &amp; evaluation of basin abstraction, groundwater quality and levels is a national responsibility; Thus regional monitoring remains a blue print, never implemented by the JASD-NSAS.</td>
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<tr>
<td>No willingness to exchange knowledge, experience with other L/RBOs such as NBI.</td>
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<tr>
<td>Poor information/ knowledge on surface drainage, and watershed characteristics within the NSAS.</td>
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<td>transboundary water management is at initial stage.</td>
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<tr>
<td>Failure to adopt IWRM principles on the basic management scale and linking all components of the hydrological cycle both surface and ground water within the basin physical boundaries.</td>
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<tr>
<td>Vague institutional mechanisms to sustain agreed technical cooperation</td>
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<tr>
<td>The present human capacity of the JASD-NSAS is not sufficient to address groundwater management appropriately</td>
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<tr>
<td>Poor projects’ funding restricted the scope of capacity building plans and achievement of objective</td>
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</table>
management of NSAS groundwater resources in different basin countries.

- No supporting governance systems to link government, civil society, and science community in a set of partnerships (Ashton & Turton, 2006) to promotes their close collaboration and interactions.

### Opportunities

<table>
<thead>
<tr>
<th>GW governance in JASD-NSAS (Institutional legal/financial aspects)</th>
<th>Collaboration with riparian states</th>
<th>GW data management/sharing (Monitoring, data and knowledge generation)</th>
<th>Capacity building aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Current international legal development is an opportunity to establish a Basin Commissions for the Nubian sandstone aquifer to deal with the broader basin planning aspects beyond the donor-controlled project-implementation.</td>
<td>- The ongoing NBI projects provide a great opportunity to support integrating surface water in the NSAS management. The Nubian basin and the Nile basin overlap at considerable areas, and hence both JASD-NSAS and NBI can benefit from integrating efforts to contribute develop accurate estimates of the hydrological cycle components.</td>
<td>- Multilateral/bilateral projects addressing IWRM &amp; transboundary water management. - AMCOW work plan to promote the institutionalisation of groundwater management by river basin organisations</td>
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### Threats

<table>
<thead>
<tr>
<th>GW governance in JASD-NSAS (Institutional legal/financial aspects)</th>
<th>Collaboration with riparian states</th>
<th>GW data management/sharing (Monitoring, data and knowledge generation)</th>
<th>Capacity building aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Mismatched power position of riparian countries in the JASD-NSAS. - Absence of stakeholders involvement and</td>
<td>- Limited recharge to NSAS, and sole resources in scarce water regions. - Hydrogeologically, there is foreseen impact or conflict between the major users on the aquifer resources.</td>
<td>- Unbalanced development and know-how of the basin in different member countries - Lack of credible/accurate information</td>
<td>- significant disparities between member countries in infrastructure development stage at national</td>
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<tr>
<td>Local ownership of decisions on JASD-NSAS actions</td>
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<tr>
<td>• Lack of sufficient commitment of the riparian states to include surface water on the Authority agenda</td>
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<tr>
<td>• Efforts/ plans of the Joint Authority to strengthen the participation of the riparian states are threatened by lack of formal structures, like stakeholder forums, with clear roles</td>
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<tr>
<th>Simulated flow pattern shows that the abstraction by either Egypt or Libya can only harm Sudan and Chad safe reserves/ yield, which have not yet developed due to economic conditions.</th>
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<tbody>
<tr>
<td>• Dominant disparity in power between the south (upstream) countries and the North (downstream) countries</td>
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<tr>
<td>• Wasteful usage of the NSAS fossil groundwater.</td>
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<tr>
<td>• Domination of national supply oriented strategy in managing NSAS water resources, with emphasis/ race on building infrastructure for maximum exploitation in Egypt &amp; Libya (more economically able basin states).</td>
</tr>
<tr>
<td>• Some of the largest schemes in the world are underway to cultivate the desert in Egypt &amp; Libya – the long term impact on aquifer resources and the related socio economic benefits are yet to be evaluated.</td>
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<tr>
<td>• Unilateral national scale development planning/ project preparation with considerable disparities in the level of advancement in different member countries,</td>
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<tr>
<td>• great disparities in the level of groundwater development and management</td>
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</tbody>
</table>

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<tr>
<th>on the major uses of groundwater within the basin, created by inadequate mechanisms for the exchange of knowledge/data and collaboration between JASD-NSAS and the riparian states’ water management structures.</th>
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<tbody>
<tr>
<td>• Challenges to the Nubian Sandstone Basin is groundwater pollution, high level of groundwater abstraction at the downstream North, inadequate institutional framework</td>
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</table>

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<th>scale.</th>
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<tbody>
<tr>
<td>• Great disparity in capacity, conditions and challenges in the riparian states, creating power imbalance in the basin countries.</td>
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<tr>
<td>• Low political will in the riparian states to influence the functionality of the Joint Authority</td>
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### 6. Conclusion

The interviews carried under the current study results a number of conclusions on the JASD-NSAS and the status of Nubian Basin management. Key conclusions are summarised hereafter.
a. Governance (Institutional/ legal/ financial aspects)

The Situation / Achievement
The Joint Authority for the Nubian Sandstone Aquifer System (JASD-NSAS) evolved from bilateral to multilateral organization, and has the opportunity to form an RBO if succeeded to build necessary capacities for the transition. With its current scope to implement multilateral projects on the ground, JASD-NSAS does not represent a typical RBO with a basin management role.

The present status of the Nubian sandstone aquifer management can be described as fully based on administrative boundaries with agreed technical collaboration efforts within time-bounded project framework.

The Challenges
Generally, institutional development is tied to the level of transboundary water management and development in the basin (SOFRECO et al., 2011). The JASD-NSAS immediate challenge is to improve its governance systems to reflect the state of groundwater development in the basin as well as to respond to the future priorities.

a) Basin Management Policy
According to the reported state of the basin, the NSAS is currently heavily stressed in its non-renewable downstream parts with propagating cross-border impacts. Major risks are aquifer depletion and quality deterioration.

The status of NSAS regional governance lags behind sustainable development considerations. A regional policy framework with long-term goals need be formulated, together with a strategy to develop responsive institutions, effective regulation, and stakeholders’ participation; with the goal of environment sustainability, economic efficiency and social welfare.

b) Institutional reform
The transition of the Joint Authority for the Nubian Sandstone Aquifer System (JASD-NSAS) to a formal RBO as defined by IWRM concepts is an immediate challenge for institutional development. If succeeded to build necessary capacities for the transition, possible future change of the Joint Authority includes among others establishing required amendment on its regional roles/ mandates and scale of activity in the management of the Nubian basin.

Immediate conclusion to take forward that the JASD-NSAS needs to invest further on strengthening the Joint Authority institutional framework in line with integrated basin management and sustainability principles. To achieve this, a transboundary IWRM plan is needed to identify strategic options for institutional and legal reforms.

c) Legal reform
Apart from the two terms of references for data sharing and monitoring signed under the IFAD project, there is no cooperative agreement on the Nubian basin management between the four riparian states.

Existing multi-lateral terms of reference for the implementation of the IFAD project (in 2000) on the basin monitoring and data sharing agreed by the riparian countries lack adequate enabling system to enforce them.
The NSAS needs to proceed to a higher phase in the cooperation ladder towards enabling effective collaboration among the basin countries. It is high time to build legal capacity of the JASD-NSAS to play a major role in the implementation of basin management policy, guided by the principles of the International law of transboundary aquifers adopted by the United Nations General Assembly (UNGA) in 2009.

d) Stakeholder participation
A major shortcoming of the JASD-NSAS is related to the lack of mechanisms to involve stakeholder, along with formal platforms and a communication strategy. Access to basin information is limited to country delegates representing the states’ ministry of water, and regarded as the expertise in charge of the JA-NSAS decisions. Local research on the NSAS is subject to high restrictions in all basin countries, alienating the relevant scientific community form contributing to the basin problems, and further monopoly of knowledge by internationally recruited scientists. Furthermore, some countries prohibit staff responses for assessment purposes as was the case in this survey.

e) Surface water consideration
There is internal strength of the JASD-NSAS to enhance the integration of groundwater and surface water through existing agreements on data sharing. The scope of the JASD-NSAS emphasises the study and development of the basin implicitly, also implies considering surface water, which is the source of recent recharge as indicated by some Basin hydrogeology studies. Institutional barrier at national level has led to lack of communication among surface/ groundwater professionals, and hence affects integration at policy level regionally and nationally.

b. Collaboration with riparian states

The Situation / Achievement
The NSAS is a cross-border interconnected groundwater system, which results in inevitable interdependence of all its users and stakeholders. Water-related activities in one State are likely to impact the water situation in another one and water-related problems such as depletion and pollution can often only be solved through transboundary cooperation. Therefore, the need to cooperate on NSAS issues beyond the borders of States has been broadly accepted for many years.

Results of the survey has shown that the 20-years project-based technical cooperation of the NSAS States has succeeded in initiating cooperative action in the basin, and has established a common understanding of the shared system and its developmental role in the riparian countries. The achievements of the JASD-NSAS are mainly:
- Facilitating sharing of information and performing joint analysis to reach common understanding of the Nubian system.
- Operating as a typical regional expert group with project based terms of reference.
- Facilitate nationally based monitoring and data sharing.

The Challenges
A number of shortcomings were identified as to the sustainability of the current approach for collaboration on the NSAS.
a) Sustainability
A major issue is related to the sustainability of the cooperative framework set between the riparian countries, and limited to short-term technical coordination.

b) Disparity between countries
Varying economic power of riparian countries has indirectly shed the collaboration mechanism. While all basin states have joined the JASD-NSAS, all project outcomes are highly influenced by the relatively economically powerful countries (Libya and Egypt). This was obvious in some projects results hardly addressing equal opportunities/benefits to all basin countries.

Key issue is ignoring the basin upstream physical/hydrogeological boundaries, using estimated hydraulic boundaries, and covering non-basin parts such as the “Post Nubian” aquifer in Egypt & Libya. As a result, the main output under the two joint projects (IFAD, GEF) could not contribute to improved understanding of the upstream system and recharge mechanisms taking place in Sudan & Chad. Similar post-Nubian formations exist in Chad & Sudan was not included in the projects studies.

The levels of NSAS development/exploitation vary in the four countries resulting different levels of knowledge. Through JASD-NSAS, the capacity of the four countries was empowered to varying degrees for better management of the aquifer. However, the extent of benefit to each country has been influenced by the existing capacity.

Currently, plans for the expansion of national aquifer monitoring and observation-well networks have been considered. These have to address the significant inconsistencies between countries. Efforts to bridge key gaps among riparian states are essential for improved regional collaboration.

c) SAP development – Process and Content
The implemented SADA was envisaged as valuable vehicle in the cooperative process and multilateral exchange of perspectives, as well as for stakeholder consultation as a precursor to the eventual formulation of a SAP. However, that process has not taken place as envisaged. The project activities and products remain undisclosed, limiting the potential of SADA for capacity building among NSAS stakeholders to agree on SAP, specifically at political and decision making levels.

c. GW data management and knowledge generation

The Situation / Achievements
Data and technical capacity will continue to be major challenges to gain up-to-date sufficient knowledge about the Nubian aquifer and develop a regional strategy for the utilization of the NSAS water resources. Since the launch of the JASD-NSAS the main efforts were concentrated on understanding the regional aquifer system. To that end the following components were supported under the IFAD & GEF funds:

- The establishment of a NSAS Regional Information System (NARIS) database.
- A joint survey of the socio-economic development policies and plans in the aquifer areas.
- Numerical model simulating various scenarios based on a survey of the countries' socio-economic development plans; and providing indicative impacts on water levels and water quality over a period of 60 years of development and abstractions.

The Challenges
The conducted interviews on the data and knowledge generated and the capacity of the Joint Authority helped identifying a number of key issues concluded from the responses as well as reviewed publication.

a) Communication and effectiveness
Although not open to non-Authority staff, regional thematic maps, regional mathematical model, and a regional information system were developed and the capacity of the JASD-NSAS has improved. However, some concerns were raised about the outcome, vis-à-vis:
- Level of accuracy of estimates adopted by the JASD-NSAS and propagated in all international publications.
- Highly technical information hardly informed strategic decision level or operational level, due to lack of adequate communication of produced technical information to different stakeholders to influence implementation of management strategies.
- need to be customised to support a SAP process and adaptive planning
- The member states remain uneven in the level of NSAS data, knowledge, and system understanding still varies in different countries. This situation has further empowered economically able Libya and Egypt to continue with what can be described as unreasonable and unsustainable use of NSAS groundwater.
- The NARIS as well as the Nubian model results remain highly confidential, with a controversial model final draft report still under discussion since 2009.
- Poor management of the regional projects, and lack of ownership by national authorities.

b) Sustainability
To this point, the main interventions/investment considered by JASD-NSAS were the short term capacity building and information/knowledge management. The sustainability of the projects’ based outputs was not considered. As a result the NARIS has not been used after the end of the project; and the groundwater flow model has not been adapted for operational use or the joint management of the NSAS. Additional mechanisms for effective use and inter-country communication need to be addressed.

The latest modeling efforts to simulate NSAS flow system put more focus on refining the grid in the Egyptian & Libyan parts, with less accurate extrapolation at the southern parts of the NSAS in Sudan and Chad. Again, the model was not based on natural boundaries upstream the system contributing to less accurate results. The outcomes of the two modeling efforts (IFAD & GEF) are still short of accurately simulating the basin in Sudan & Chad and contribute to knowledge on cross-border capture zones and the basin hydrological cycle/water budget of the Nubian basin, an important input to establish the basis for shared aquifer management.

The NARIS database initiated by the Joint Authority is not operational, and monitoring is not evenly distributed in different member states due to varying financial capacities. Irregular
exchange of data is done through email, and the guideline developed for data sharing within the national groundwater departments remains a blueprint.

c) Surface water
Surface water has not been considered in JASD-NSAS implemented actions, due to lack of capacity to integrate surface water management within the Nubian Sandstone Basin. There is an evident need for collaboration with organisations and projects that have a surface water component (e.g. NBI, AU, AMCOW, regional networks, etc.) to foster surface water management within the Nubian Sandstone Basin.

Static groundwater levels as well as water quality parameter are the data collected by the Joint Authority related to groundwater. Surface water component is not yet foreseen in the regional database and the NSAS monitoring is under the national groundwater authorities, which is institutionally separate from the surface water management.

d) Balanced benefits
The NSAS has been studied in more details in Egyptian and Libyan territory due to the intensive large scale development of the basin in the two countries. On the contrary, few scattered local studies exist in Chad and Sudan due to poor development finance. According to reviewed project outputs, this situation has led to limited benefit of Chad and Sudan from the regional projects activities that entirely relied on existing knowledge to analyse and model the regional aquifer. The consequence has been clear in outputs such as the NSAS database, the simulation model, and diagnostic analysis reflecting little knowledge on the basin boundary and hydrogeology in Chad and Libya.

The NSAS characteristics such as total area, percentage of area in each country, thickness of water-bearing strata, total volume of water stored, recharge, transmissive properties, the rate of groundwater flow, and total annual extraction from the Aquifer are reviewed in different report (CEDARE, 2002; country SADA, 2009; published report) as well as through interviews. Contradicting figures are noticed between national estimates and those produced through regional projects after the formation of JASD-NSAS. There is hardly an official record for reliable groundwater information in some riparian countries such as Chad and Sudan, and most estimates were made by unverified publications from localised degree research. Wide variations of estimates were reported by different sources on the NSAS aquifer properties.

d. Capacity building aspects

The Situation/ Achievements
JASD-NSAS capacity has been developed in many aspects. Special focus was on the understanding of the hydrogeological system of the Nubian Basin. Human capacity though only target the JASD-NSAS staff, it addressed important technical issues regarding hydrogeologic characterisation and groundwater hydrodynamic.

Apart from IFAD/CEDARE project reports, the survey could not assess all knowledge produced by the JASD-NSAS still not disclosed for stakeholders. The outcomes of the latest project plans on the development of SADA and SAP were not published; and thus could not be assessed.
The Challenges
The implemented capacity building actions were ultimately aimed at a second phase integrating the socio-economic aspects within a vision for development of the NSAS; and the development of a framework for the sustainable management and use of the Nubian Aquifer System in the four riparian countries.
The conducted interviews on the capacity of the Joint Authority helped identifying a number of key issues concluded from the responses as well as reviewed publication. Typical capacity challenges include – Inadequate institutions, – Insufficient financial resources, – Inadequate human resources.

a) Institutional capacity
- The current situation of groundwater governance nationally is not enabling the JASD-NSAS to implement its ToR according to Agreements 1 & 2. Key issues are:
  - Poor integration of all factors affecting groundwater, environmental and developmental/socio-economic.
  - Lack of sector coordination and Basin view.
  - Lacking institutional interaction/communication at all levels of national water resources management.
  - Insufficient stakeholder involvement.
  - Absence of agreed allocation principles; and the preparation of Regional Utilization Strategy of the NSAS planned under the IFAD project in 2000 has not been realised.
  - To develop a sustainable SAP, the SADA process was expected to carry out a cross sectoral and a full stakeholders’ consultation, focusing on NSAS transboundary problems without ignoring national concerns and priorities. It has however hardly included a detailed ‘governance analysis’ which considers the local institutional capacity, legal and policy environment.
  - Actions to address institutional problems should represent the core of the planned SAP and future investment projects for institutional capacity-building.

b) Human Capacity
- The present human capacity of the JASD-NSAS is not sufficient to address groundwater management appropriately.
- The technical core of the JASD-NSAS staff is predominantly hydrogeologists. They lead country branches/operations as well as represent their countries at the Authority Board on part time basis. They also take over any expert/advisory assignments within the implementation of funded projects.
- Poor education on groundwater and capacity to manage in the NSAS countries is an important factor contributing to the existing professional capacity.

c) Financial Capacity
- Financial capacity is the main obstacle in the low achievements of the JASD-NSAS. By the end of the GEF medium sized funding in 2009, the JASD-NSAS remains only dependant on member states shares with no funds to capacity building..
- Entirely dependent on the member countries contributions, financing shares may cause unbalanced control on the JASD-NSAS decisions, and on the process of making prioritisation in the Joint Authority actions.
A major obstacle in strengthening JASD-NSAS institutions is the limitation and conditions of international funds. Funding requirements predominantly focused on activities assumed to expand and consolidate the technical and scientific knowledge base regarding the Aquifer System. An example is the GEF International Waters Focal Area (Operational Programmes 8 and 9), where a Shared Aquifer Diagnostic Analysis (SADA) is required before formulation of a Strategic Action Programme (SAP).

Past projects’ activities, vis-à-vis database, basin model, diagnostic analysis, and associated human capacity building have stopped by the end of the financial support in 2009.

Lack of political commitment may affect financing of activities in some countries.

d) Technical capacity

- The planned capacity building only addressing groundwater part of the basin water budget, and no serious attention to surface water component.
- Lacking capacity regarding surface water is particularly regarding surface water groundwater interaction, as well as NSAS water balance.
- Insufficient information on and communication of critical NSAS transboundary management issues and parameters.
- Level of accuracy of estimates adopted by the JASD-NSAS and propagated in all international publications. Although has been the main emphasis of previous efforts of the JASD-NSAS since 1998, identification, delineation, diagnosis, conceptual/numerical model are still at a preliminary stage at the upstream parts in the South and Southeast.

7. Recommendations

Key priorities for the NSAS Basin to progress into the next phase of visioning the basin development goals are recommended.

a. Monitoring, data and knowledge generation

- To support data management in basin areas in Sudan and Chad to enable equal benefits/opportunities in basin development.
- To support operationalising regional agreements on Basin monitoring and data sharing especially at highly stressed areas such as the “Greater Man-made River” and the “New Valley” projects.
- To implement the guidelines for regional database development.
- To design a regional monitoring network, and integrated transboundary system to measure cross-border capture zones as an important input to establish the basis for shared aquifer management.
- To customise information to support political commitment, responsive institutional development and long-term strategic planning with cyclic and adaptive process (Gleeson et al., 2012).
- To agree on and develop a reference record of NSAS information to support true/correct knowledge and to avoid the inaccurate figures spread all over online publication on the Nubian basin characteristics and status.
b. Institutional/ organizational/ legal aspect

Within the existing technical cooperation framework, a number of urgent actions need be implemented. A key priority is to implement the planned formulation of a SAP embodying specific harmonised actions (policy, legal, institutional reforms or investments) that can be adopted nationally. The developed SAP should be based on a reasoned, holistic and multi-sectoral consideration of the problems associated with the state of and threats to transboundary water systems.

It is recommended that the SAP addresses appropriate institutional capacity measures such as:

- To adopt a regional policy framework for the development and management of the NSAS guided by the UNGA resolution 63/124, on “the law of transboundary aquifers” (2009),
- Endorse AMCOW Groundwater Resolutions (Brazzaville, May 2007) “to promote the institutionalisation of groundwater management by river basin organisations to ensure regional ownership of the initiative”.
- Build capacities in the legal field with emphasis on the UN resolution 63/124 on “The law of transboundary aquifers”.
- Endorse the Africa water vision and AMCOW regional development goal in NSAS regional policy and strategies.
- Extend the mandate of the JASD-NSAS to further emphasise regional transboundary aquifer management role.
- Strengthen groundwater management emphasising the policy, institutional and operational aspects at national levels, parallel to L/RBO institutional development..
- Adopt urgent strategies needed to stabilize heavily stressed Aquifers in Libya and Egypt including demand-side management interventions.
- Consider options for reducing NSAS groundwater used for irrigated agriculture is of paramount importance in the NSAS region, and investing in virtual agriculture in water abundant countries.
- Carry out GW vulnerability assessment is to provide policy makers with groundwater regions most susceptible to depletion, degradation or contamination.
- Implement and enforce policies restricting harmful groundwater use at the country level and the municipal level.
- Define groundwater protection strategies that accept trade-offs between competing interests.
- Engage relevant local academia/ research institutions to strengthening their scientific capacity in support of the NSAS issues;
- Put in place a transparent and equitable process to engage local private sector and to ensure the relevance of the capacity building actions by the JASD-NSAS.

c. Collaboration with riparian states

Key recommendation to enhance transboundary collaboration on the NSAS includes:

- The JASD-NSAS needs to address the economic gap between the Nubian States that hinders equitable benefit from the basin resources and prompt risks of conflicts.
- Implement measures to ensure a more transparent/ involving process of technical cooperation in place.
- Start a dialogue among the NSAS countries on the recognition of the international legal principle of "equitable and reasonable utilization" to govern NSAS States in their utilization of non-renewable groundwater.
- Support research to define "Equitable and Reasonable Use" in the NSAS, regarding excessive uses by adopting the principles of socio-economic sustainability to stop the wasteful usage of the NSAS.
- Construct a cutting-edge definition of beneficial use in the doctrine of waste (Nicholas Maxwell (2011) relevant to the Nubian states.
- Reverse unbalanced status of the riparian countries in joint projects across the organizations and geographical span of the Basin.

**d. Financial aspects**
- Develop basin plans, together with strategies for achieving effective and sustainable cooperation.
- Based on AMCOW recommendation, JASD-NSAS needs to put efforts to secure core financial support from the African Water Facility that could be leveraged to raise additional resources from development cooperation partners, such as the European Union.
- Secure impartial / reasonable funding for the capacity building of the Joint Authority.
- Political buy-in and support towards implementation of the AMCOW Brazzaville decisions.

**e. Capacity building aspects**
A number of key recommendations come out from the conducted survey. The following is recommended:
- strengthen knowledge/awareness on current international development in transboundary management knowledge and systems as well as Africa wide initiatives such as the AMCW work plan and any activities.
- build Knowledge on the UNGA resolution on transboundary aquifers and similar frameworks as well as their application to the NSAS.
- build local capacities on developing relevant definition of “sustainable” management for the NSAS, systems for valuing and managing NSAS groundwater development, and developing indicators to monitoring the implementation of such systems.
- develop reliable Basin information system to provide accurate information on the basin physical characteristics, level of use in different countries, transboundary impacts (including social and environmental);
- enhance the level of understanding on transboundary water management parameters such as water balance components, groundwater-surface water interaction and aquifer pollution and depletion risks across riparian territories.
- establish formal institutional structures for stakeholder participation, with clear roles and responsibilities in the basin water resources management, in the decision making process, and regular meetings.
- develop effective system for the NSAS basin monitoring system.
- conduct regional, sub-regional, national and local workshops to raise awareness and enhance stakeholder participation
- Awareness and education on the economic dimension as part of an integrated system
– enhance the use economic analysis/instruments (reduction and targeting of fuel subsidies) to recognise the economic value of SAP options.
– Agree on a NSAS development strategy options, namely: planned mining with exit strategies considering balanced socio-economic choices; or unplanned situation with a management goal. Typical goals include hydraulic stabilisation of the aquifer, more reasonable utilisation of aquifer reserves, minimising quality deterioration, maximising groundwater productivity and promoting social transition to a less water-dependent economy (UNESCO, 2006).
– enable equal opportunities for the riparian countries to participate in defining the Basin and its sustainable management strategies vis-à-vis legal, institutional as well as sustaining the technical cooperation initiated by past projects.

8. References:


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Jonah Davids, 2005. Is it reasonable to use the Nubian Sandstone Aquifer System unsustainably under international law?.


MoIWR, 2009, SADA country report, Sudan.


### Appendix 1 Table of basic data for the NSAS

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Nubian Sandstone Aquifer System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major tributaries</td>
<td>Erdis, North Darfur, Nile Nubian, Kufra Basin, Dakhla Basin, Sirt Basin, ..</td>
</tr>
<tr>
<td>Riparian states</td>
<td>1. Chad 2. Egypt 3. Libya 4. Sudan</td>
</tr>
<tr>
<td>Upstream riparian states</td>
<td>Chad, Sudan</td>
</tr>
<tr>
<td>Downstream riparian states</td>
<td>Egypt, Libya</td>
</tr>
<tr>
<td>Total basin area (km²)</td>
<td>2,200,000</td>
</tr>
<tr>
<td>Mean annual runoff (mill. M³/year)</td>
<td>Estimated storage: 259.293 Km³</td>
</tr>
<tr>
<td>Total population (mill.)</td>
<td>139.394</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Riparian state</th>
<th>Share (%) of basin area</th>
<th>Share (%) of population</th>
<th>Mean annual runoff (million M³/year)</th>
<th>Average rainfall in riparian basin part (mm/yr)</th>
<th>Primary land uses/cover in basin part</th>
<th>Primary water uses in basin part</th>
<th>Major cities in basin part (Mill. pop.)</th>
<th>Protected areas, national parks in basin part</th>
<th>Major water transfer schemes between states</th>
<th>Transboundary conflicts over rivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chad</td>
<td>10</td>
<td>7.85</td>
<td>322</td>
<td>Domestic</td>
<td>N’Djamena</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Egypt</td>
<td>29</td>
<td>57.19</td>
<td>51</td>
<td>Agriculture</td>
<td>Cairo</td>
<td></td>
<td></td>
<td></td>
<td>New Valley project</td>
<td>Depletion, water quality</td>
</tr>
<tr>
<td>3. Libya</td>
<td>32</td>
<td>4.49</td>
<td>56</td>
<td>Domestic, Agriculture</td>
<td>Tripoli</td>
<td></td>
<td></td>
<td></td>
<td>GMRP</td>
<td>Depletion, water quality</td>
</tr>
<tr>
<td>4. Sudan</td>
<td>29 (634,000 km²)</td>
<td>30.47</td>
<td>200</td>
<td>Domestic, Agriculture (637 Mm³)</td>
<td>Khartoum</td>
<td>Oasis, Wadi Howar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Year of formal recognition of Lake/Basin Org.</strong></td>
<td>1999 (earlier agreements were not involving all Basin Countries)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **Primary mandate of Lake/Basin Org.** | The Authority has been established to carry out the following objectives:  
1. Study, development and investment of water resources in the Nubian Sandstone Aquifer System and strengthen the regional corporation between member states (NSAS website, last visited Jan 2012),  
   (i) to oversee strategic planning,  
   (ii) to develop a NSAS monitoring programme and  
   (iii) to exchange data and information on the respective water resources and extraction. |
| **Type of Lake/River Org.? (see /2/)** | ✓ Lake/River Basin Authority |
| **Name of treaties or legally recognized agreements governing water mgt. in the basin** | Project based agreements include:  
3. Agreement No. 2 – established Terms of Reference for Monitoring and Data Sharing. Between (states): Chad, Egypt, Libya, Sudan. |
<table>
<thead>
<tr>
<th>River Basin</th>
<th>Nubian Sandstone Aquifer System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major shared aquifers / surface water in the basin</td>
<td>1. Nile River</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aquifer no.</th>
<th>Shared between which riparian states</th>
<th>Approximate area (km²)</th>
<th>Geological formation of aquifer (e.g., sandstone, karst, limestone, volcanic, sedimentary)</th>
<th>Depth location of aquifer: Shallow (0-20 m), Intermediate (20-100 m), Deep (&gt;100 m)</th>
<th>Estimated storage (mill. M³)</th>
<th>Estimated annual recharge volume (mill. M³)</th>
<th>Primary recharge mechanism (rainfall, irrigation, river/lake, pre-historic)</th>
<th>Principal use/users of aquifer (Give order: agriculture, domestic, industry, mining)</th>
<th>Primary GW management issue(s)</th>
<th>Are there already known transboundary conflicts over this aquifer?</th>
<th>Level of TBA mgt. Note: A, B, C, D, E, F according to what has been achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Egypt, Sudan</td>
<td>656,398 km²</td>
<td>River</td>
<td>Deep</td>
<td>1.1-2.4×10⁷ m³/year</td>
<td>river</td>
<td>agriculture, domestic</td>
<td>ABCD (at Project level)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*A. Identification, B. Delineation, C. Diagnosis, D. Conceptual/numerical model, E. Allocation principles, F. Implementation of joint infrastructure project*
Appendix 2 *Transcripts of interviews*