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MINISTRY OF WATER RESOURCES AND IRRIGATION (MWRI)
JUBA

Preliminary Water Information Assessment Study
(Funded by the World Bank)

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# Table of Contents

**Acronyms**

**Executive Summary** ................................................................................................................................. 1

**Preamble** ...................................................................................................................................................... 4

1. **Introduction** ................................................................................................................................................. 6

1.1 Background ..................................................................................................................................................... 6

1.2 Objectives ....................................................................................................................................................... 7

2. **Assessment of Current Status of Water Resources** ................................................................................... 8

2.0 Introduction .................................................................................................................................................... 9

2.1 Meteorological Data ..................................................................................................................................... 10

2.2 Surface Water Hydrology ........................................................................................................................... 10

2.2.1 Data on Surface Water ............................................................................................................................. 10

2.2.2 Challenges of Surface Water Resources of Southern Sudan ................................................................. 12

2.3 Groundwater Information in Southern Sudan ............................................................................................. 12

2.3.1 Data Situation ............................................................................................................................................ 13

2.3.2 Groundwater Resources Development .................................................................................................. 14

2.4 Water Quality Information ........................................................................................................................ 14

2.4.1 Sediment load and turbidity ................................................................................................................... 14

2.4.2 Bacteriological quality ............................................................................................................................ 15

2.4.3 Salinity and Salts Content ....................................................................................................................... 15

2.4.4 Oil Pollution from Exploration activities ................................................................................................ 15

2.4.5 Facilities for Water Quality Analysis .................................................................................................... 16

2.4.6 Monitoring Water Quality .................................................................................................................... 17

3. **Existing Capacities and Enabling Environment** ...................................................................................... 18

3.1 Enabling Environment ............................................................................................................................... 19

3.1.1 Development of policies ......................................................................................................................... 19

3.1.2 Legislation, Organization and Coordination .......................................................................................... 21

3.2 Institutional Capacity .................................................................................................................................... 22

3.2.1 Strengthening Institutional Capacity ....................................................................................................... 22

3.2.2 Responsibilities of water resources planning, monitoring, assessment, development and management ... 24

3.2.3 Drinking water responsibility ................................................................................................................ 24

3.2.4 Sewage and Sanitation, Availability and Responsibility ........................................................................ 25

3.2.5 Involving the Stakeholders .................................................................................................................... 25

3.2.6 Role of Community ................................................................................................................................ 26

3.2.7 The role of women in water resources planning, management, and water user organizations ...... 26

3.2.8 The role of the private sector ................................................................................................................ 27

3.3 Human Resource Development ............................................................................................................... 28

3.4 Capacity Assessment .................................................................................................................................. 30

4. **Existing Financing Mechanisms and Sustainability Options** ............................................................... 32

4.1 The Role of Economics: Cost Recovery, Water Pricing, Water Charging Systems ................................... 33

4.2 Existing Development and on-going Initiatives ....................................................................................... 35

4.2.1 Water Supply and Sanitation Project ..................................................................................................... 35

4.2.2 CP19-Upstream Downstream ................................................................................................................. 36
4.2.3 Nile Trans-boundary Environmental Action project (NTEAP) ..........................36
4.2.4 MWRI – GoSS WASH ..................................................................................37
4.2.5 SSWICH project .........................................................................................37
4.2.6 GoSS Irrigation and Water Resources projects ...........................................37

5. Water Information System (WIS) ......................................................................40
   5.1 Existing Water Information System ...............................................................40
   5.2 Data Available in SSWICH ...........................................................................40
   5.3 Assessment of the Existing Water Information System (WIS) .....................42
   5.4 The Proposed Water Information System (WIS) ...........................................43
       5.4.1 Hydrological Information System (HIS) ..................................................44
       5.4.2 Other Components of WIS ...................................................................45

6. Data Analysis and Gaps ....................................................................................49
   6.1 Meteorological Data ....................................................................................49
   6.2 Surface Water Hydrology Data ....................................................................50
   6.3 Groundwater Hydrology Data .....................................................................50
   6.4 Water Usage ................................................................................................51
       6.4.1 Water for agricultural Use ....................................................................51
       6.4.2 Water for Urban Municipal Use ............................................................52
       6.4.3 Rural Water Supply ..............................................................................52
   6.5 Water Quality Data Collection Including Sediment ....................................52
   6.6 Gaps in Capacity Development ..................................................................53
       6.6.1 Capacity Development ........................................................................53
       6.6.2 Needs Assessment ................................................................................54

7. Recommendations .............................................................................................59

8. References ..........................................................................................................60

9. Bibliography .......................................................................................................63

ATTACHMENT: Terms of Reference for the Design and Operation of a Water  
Information System for Southern Sudan ............................................................... 67

ANNEXES

Annex (I.1): Meteorological Stations & Rain Gauges Stations .................................
Annex (I.2): Studies on the hydrology of the Nile River system ..............................
Annex (I.3): Discharge Gauging Stations .................................................................
Annex (I.4): Groundwater Basins ...........................................................................
Annex (I.5): Water Usage Information ..................................................................
Annex (II.1): Legislation, Organization & Coordination .....................................
Annex (II.3): Capacity Assessment .......................................................................
Annex (II.5): Policy & Strategy Future Directions ...............................................
Annex (III): Preliminary Terms of Reference for the Water Resources Assessment of  
Southern Sudan ..................................................................................................
Annex (IV): Main calls of the United Nations Water Conference (Mardel Plata, 1977)  
Resolution I “Assessment of Water Resources” ................................................
Annex (V): WIS as described by WMO ................................................................
Acronyms

AEZ: Agro Ecological Zone project
AICD: Africa Infrastructure Country Diagnostic
CA: Capacity Assessment
CBO: Community Based Organization
CCM: China Construction and Machinery Company
CES: Cooperation for Ecosystem Services
CPA: Comprehensive Peace Agreement
DFID: Department of International Development (U.K)
DIM: Dam Implementation Unit
DSDS: Data Storage and Dissemination System
DRWSS: Directorate of Rural Water Supply and Sanitation
EFS: Environmental Feasibility Study
EIA: Environmental Impact Assessment
ENSAP: Eastern Nile Subsidiary Action Program
ENTRO: Eastern Nile Technical Regional Office
ENSAP: Eastern Nile Subs Daily Action Plan
EPA: Environmental Protection Act
FAO: Food and Agriculture Organization
GIS: Geographical Information System
GoNU: The Government of National Unity
GoSS: Government of Southern Sudan
GTZ: German Technical Cooperation
HIS: Hydrological Information System
HQ: Headquarters
IAS: International Aid Services
ICSS: Interim Constitution of Southern Sudan
IHP: International Hydrological Program
IMS: Information Management System
INC: Interim National Constitution
IOM: International Organization for Migration
JICA: Japan International Cooperation Agency
MCRD: Ministry of Cooperation and Rural Development
MDGs: Millennium Development Goals
MDTF: Multi Donor Trust Fund
MHPPE: Ministry of Housing, Physical Planning and Environment
MOH: Ministry of Health
MWRI: Ministry of Water Resources and Irrigation
NBI: Nile Basin Initiative
NEPAD: New Partnership for Africa’s Development
NGO: Non-Governmental Organizations
NTEAP: Nile Trans-boundary Environmental Action Project
ODI: Overseas Development Institute
OHP: Operational Hydrological Program
PCM: Project Cycle Management
PJTC: Permanent Joint Technical Committee
PMT: Project Management Team
PS: Private Sector
RCMRD: Regional Center for Mapping of Resources for Development
RoS: Republic of Sudan
RS: Remote Sensing
RWSS: Rural Water Supply and Sanitation
SFM: Swedish Free Mission
SMA: Sudan Metrological Authority
SMEC: Snowy Mountains Engineering Corporation
SSLA: Southern Sudan Legislative Assembly
SSMO: Sudanese Standards and Metrology Organization
SSUWC: Southern Sudan Urban water Corporation
SSWICH: Southern Sudan Water Clearance House
SSWSSP: Southern Sudan Water Supply and Sanitation Project
SSWSSSC: Southern Sudan Water and Sanitation Sector Steering Committee
SWOT: Strength, Weakness, Opportunity, Threat
TDS: Total Dissolved Solid
TOR: Term of Reference
UN: United Nations
UNECA: United Nations Economic Commission for Africa
UNESCO: United Nations Educational, Scientific and Cultural Organization
UNICEF: United Nations Children’s Fund
UNOPS: United Nations Office for Projects Services
UN-Water: A coordination body for 27 UN agencies working in Water Programs
USAID: US Agency for International Development
UWC: Urban Water Corporation
UWSS: Urban Water Supply and Sanitation
UWSSP: Urban Water Supply and Sanitation Project
WBT: World Bank Team
WHO: World Health Organization
WIS: Water Information System
WMO: World Meteorological Organization
WRA: Water Resources Assessment
WRM: Water Resources Management
WTP: Water Treatment Plant
Executive Summary

This report contains the findings of the Southern Sudan Preliminary Water Information Assessment Study prepared for the Ministry of Water Resources and Irrigation (MWRI) of the Government of Southern Sudan (GoSS), under Technical Assistance funded by the World Bank (WB). The main objective of the study was to prepare a stocktaking of the water sector in Southern Sudan and to prepare terms of reference for the design and operation of a Water Information System (WIS) and to test its functionality within the framework of the facility available at the "Southern Sudan Water Information Clearing House – SSWICH", utilizing the information collected from a small pilot scale sub-basin.

Southern Sudan region extends over an area of about 640,000 square kilometers representing approximately 27% of the total area of the Sudan before the separation. Geographically, the region expands on the clay plains that extend southward with gradual uphill slopes to the mountains on the Sudan frontier with Ethiopia, Kenya and Uganda; and to the water divide which represents the southern boundary with Democratic Republic of Congo and Central African Republic. The region also expands from the borders with Central African Republic in the west, passing through low lands of the White Nile Valley and the Sudd wetland to the Ethiopian highlands in the east. Altitudes in Southern Sudan range from 600 to 3000 meters above sea level. Most of Southern Sudan has a sub-humid climate. Rainfall is high, with Western Equatoria and highland parts of Eastern Equatorial receiving 1,200 to 2,200 mm of rainfall annually. The lowland areas of Eastern Equatoria, Jonglei, Upper Nile, and Bahr el Ghazal receive between 700 and 1,300 mm of rainfall annually.

Southern Sudan is rich with water resources. The major water resources are the Nile, its tributaries, and groundwater. Groundwater is found in the Um Ruwaba, Nubian and basement complex formations. Water resources in Southern Sudan, however, are unevenly distributed across the region and vary considerably from year to year. Water demand for domestic and productive uses has been growing rapidly due to prevalence of peace, and this trend is expected to continue, placing even greater pressure on water availability. Other emerging issues and challenges pertaining to water resources management in Southern Sudan are lack of monitoring and Water
Information System (WIS), inadequate capacity development and lack of comprehensive plans of action for sustainable water resources development and management. Two promising directions that created an enabling environment are: (i) the establishment of MWRI as the sole custodian of water resources in Southern Sudan; and (ii) the issuing of a National Water Policy in 2007. The policy is currently being under translation into a water strategy and a relevant plan of action.

The MWRI/GoSS acknowledges that the establishment of an adequate water information system (WIS) is a prerequisite for any successful assessment, planning, design, operation and rational management of water resources. Substantial effort has been made by the MWRI in this direction and a new water information system called the Southern Sudan Water Information Clearing House (SSWICH) has been established. The key tasks of SSWICH are to collect process and store data, undertake surveys, and disseminate all information related to water resources.

However, rational water resources management in Southern Sudan calls for a much more comprehensive WIS covering all water related data, including not only the characteristics and availability of water resources but also data on existing and anticipated demands in all sectors, supporting data from satellite imageries, aerial photography, topographical maps, ground surveys, and data on capacity development, knowledge base and socioeconomic information. In developing the (TOR) for the establishment of such a WIS for Southern Sudan, SSWICH should be considered as a nucleus of the proposed system and as a testing platform for the operation of the main components of WIS.

One of the main components of the proposed WIS is an upgraded hydrological Information system (HIS). The main tasks of HIS will include the collection of meteorological, surface and groundwater field data at the required intensity and frequency from an upgraded and adequate network, time-effective transmission; data checking, collation, processing and analysis. A Spatial Data System (SDS) is proposed to be interfaced with HIS as well as an Information Management System (IMS) containing Knowledge base, water use data and Hydrological Design Aids necessary to produce information products for ready use in water resources planning and management. Other components of WIS are Knowledge Management System (KMS), Decision Support Systems (DSS) and the Data Storage and Dissemination System (DSDS).

The functioning of any Water Information System will not be adequate without key information obtained through proper assessment of the water resources, their characteristics, extent, dependability, quantity and quality which are the major entries for the evaluation and utilization of WIS as a Decision Support facility. That is why the developed TOR for WIS consultancy for
Southern Sudan includes a component for comprehensive assessment of water resources in a pilot sub-basin (Crunue in the Upper Pibor Catchment in Eastern Equatoria), to be considered as a platform for testing the functioning of HIS/WIS, develop capacity in system operation and get first hand experience on equipment and data dissemination and exchange protocols to be elaborated on in the larger WIS system in future.

The developed TOR for the pilot sub-basin identifies the required tasks to be undertaken by the consultant for a comprehensive water resources assessment for the pilot sub-basin and for the design of appropriate HIS/WIS for Southern Sudan. Testing of the functionality of HIS/WIS would be carried out using the data collected from the pilot sub-basin. The final product would be a full design of WIS with capacity needs, operation manuals, data exchange protocols, and a fully functioning HIS/WIS with SSWICH as testing platform tested through the information collected from the pilot sub-basin.

The proposed consultancy would be carried out in two phases, each with 6 months duration (total duration 12 months). The project will require a total of 89 man months of consulting services divided between the two phases of the project as 51 man months for phase 1 and 38 man month for phase II. Additional financial resources would also be required for data acquisition, travel and accommodation and field work. The proposed consultancy team consists of 15 specialists with considerable experience in the areas needed for the project such as development of HIS/WIS, surface water, groundwater, instrumentation, IT, communication, RS/GIS, training and institutional aspects and water resources assessment.

It is anticipated that efforts will continue by the MWRI/GOSS to conduct a comprehensive water assessment study for the whole region. HIS/WIS could then be expanded to cover all basins in the region. Again, the present report and its annexes contain extensive amount of information that would provide a good background for the forthcoming consultant to build on it. A proposed TOR for the wider water resources assessment is also attached which could be modified or updated as needed in the future.

Since the availability of relevant information from the sub-basin is an essential entry for testing the functionality of HIS/WIS, it is strongly recommended that MWRI take an immediate action to review the availability of monitoring networks within the selected sub-basin and take immediate action to reinforce the networks particularly for meteorological, hydrological and groundwater data.
Preamble

This is the Final Report of the assignment: “Preliminary Water Information Assessment Study”. The major tasks performed included the compilation and enhancement of the stocktaking, rapid assessment, identification of gaps, and preparation of the final report. Various correspondences were undertaken with the relevant colleagues at Ministry of Water Resources and Irrigation (MWRI-GoSS), the World Bank Team (WBT) and relevant entities in Khartoum and Juba (Government, Academic centers and NGOs) and meetings held with the corresponding focal experts and decision makers. Search has also been made in the literature and the internet to strengthen the stocktaking of the subject issues.

It is obvious that Southern Sudan contains a wealth of water resources in the form of rainfall, surface water (in rivers, lakes, and swamps) as well as groundwater resources. However, the monitoring systems of these resources and their data processing, analysis, storage, and dissemination of the information need considerable attention to develop a sustainable hydrological information system (HIS) contributing to an effective Water Information System (WIS). To reach that goal considerable financial and human resources are needed in order to develop an adequate capacity to manage the resources and provide the necessary infrastructure and equipment.

It is very much appreciated that a water policy has been developed, but its impact can only be realized effectively when the current efforts for developing a water strategy and plan of actions are completed. It is however, rewarding that the progress in this direction is given a priority by MWRI and partners; such as World Bank (WB), United Nations Children’s Fund (UNICEF) and International Aid Services (IAS).

The stocktaking of water information is divided into key components, namely: (i) Assessment of current status of water information (hydrometeorology, surface water, water quality, groundwater and water uses); (ii) existing capacities and enabling environment, and (ii) existing financing mechanisms and sustainability options. Separate chapters are devoted to the Water Information System (WIS) and data analysis and identification of gaps. The
information gathered is utilized for producing a TOR for the forthcoming deeper study. This TOR covers three main areas, namely; assessment of water resources and utilization needs, assessment for capacity development and design of the water information system (WIS).

The Draft Final Report and the Draft TOR were discussed in a stakeholders workshop organized in Juba on May 2010. The feedback from the stakeholders at the workshop has been incorporated in the Final Report and the TOR. However, it should be noted that subsequent to the workshop there have been several back and forth communication between the MWRI and the World Bank team. The final TOR attached to this Report is the one which has been finally agreed between the MWRI and the World Bank. This TOR has been used by the MWRI under the ongoing Water Supply and Sanitation Project as the basis for inviting expressions of interests from prospective consultancy firms to develop the water information system.
1. Introduction

1.1 Background

1. The southern Sudan region expands on clay plains that extend to the south with gradual uphill slopes to the mountains on the Sudan frontier with Ethiopia, Kenya and Uganda; and to the water divide which represents the southern boundary with Democratic Republic of Congo and Central African Republic. At the southern frontier the mountains series of the Imatong, Didinga, and Dongotono rise to more than 3,000 meters. The region also expands in the west from the borders with Central African Republic eastward passing through low lands of the White Nile Valley and the Sudd wetland to the Ethiopian highlands. The region extends from latitude 3° 30” N to approximately latitude 10° N and from longitude 24° E to longitude 36° E. Southern Sudan makes up about 27% of the total land area of Sudan, covering about 640,000 km² (NEPAD/FAO, 2005).

2. The average annual rainfall approximately ranges from 500-600 mm/year to more than 1500 mm in the south western part of the region. On the other hand, potential evaporation decreases from a maximum annual value of 2400 mm to a minimum annual value of less than 1400 mm in the south-western part of the region. Another important observation is that rainfall in Southern Sudan suffers noticeable decreasing trend accorded to climate change though it is relatively less in comparison to northern part of the country [Yousra & Magdoleen, 2009]

3. Southern Sudan is rich with its surface water resources. Figure I.2.1 (in Annex I.2) gives a broad picture of its major surface water resources components. Numerous studies have been made on the hydrology of the Nile River system in general and of the Equatorial Lakes in particular. One of the most comprehensive studies on the hydrology of the Nile River system was made by H. E. Hurst and his co-workers (Hurst, et al., 1946; Hurst, 1951; Hurst, 1957; Hurst et al., 1965; Hurst 1965). More elaboration on this can be found in Annex I.2.

4. Groundwater could be an important source for water supply for southern Sudan if linked with the rich surface water resources and water harvesting. A huge part of the region is
underlain by the water rich Umm Ruwaba sedimentary formation, while in other parts search for groundwater should concentrate on fractured and weathered zones of the basement complex. The relation between Umm Ruwaba formation and the overlaying surface water, particularly in the swamps zones, is poorly understood and more information could be reached through the development of more accurate water balance studies. Though there are many hydrogeological maps developed within the last decades for the Sudan as a whole, more detailed studies may be needed in the south for identifying the characteristics of these formations, quality of their water, their source of recharge and discharge, and the availability of groundwater in time and space for various uses (domestic, agriculture, industrial, environment … etc).

1.2 Objectives

5. For the efficient exploitation and effective management of the water resources in Southern Sudan (surface water and groundwater) a comprehensive Water Information System (WIS), covering all water-related data, should be developed. WIS needs to be supported by an upgraded hydrological information system (HIS), to collect: Field data at required intensity and frequency and time-effective transmission; spatial GIS datasets; data from bathymetric and environmental surveys. This should be supported by adequate resources for processing, modeling, and institutional strengthening.

6. Thus the main objective of this study is to prepare a stocktaking of the water sector in Southern Sudan, followed by rapid assessment and analysis, identification of gaps and preparation of a TOR for a deeper study aiming toward the Design of a Water Information System (WIS) for MWRI-GoSS.

7. The overall approach to achieve the above mentioned objectives includes the following:

- Review of previous studies, data, and works from publications, files, visits and consultations (stocktaking).
- Rapid assessment and preliminary analysis of the stocktaking material to identify gaps that can be utilized to prepare a relevant TOR for the development of a water information system.
• Development of Terms of Reference (ToR) for a more expanded study for the development of WIS.

• Reporting to the MWRI-GoSS & WB Team as stated in TOR of this study.
2. Assessment of Current Status of Water Resources

2.0 Introduction

8. There are signs of decreasing trend in the rainfall in the Sudan, including the South, which might be due to climate change. The changes have been felt by most stakeholders in Southern Sudan, particularly the farmers. Though there is no conclusion as yet from the international research whether there will be an increase or decrease in the total rainfall within the upper parts of the Nile, yet no doubt there would be changes in the timing of rainfall and perhaps more frequent incidences of floods and droughts. Therefore, it is very important that this issue be given due consideration by MWRI in its ongoing preparation of its water strategy.

9. Groundwater has been increasingly tapped from various formations for various uses, particularly domestic needs. A word of warning from now: This withdrawal must be linked to close monitoring of groundwater levels and quality. The slogan should be “Groundwater Protection is a Must” in order to avoid risks of pollution and/or over-abstraction.

10. A proper water resources assessment, for the quantity and quality, is a pre-requisite to water resources management or development whether for urban and rural water supply, agriculture, industry, energy and other uses. The United Nations Water Conference (Mardel Plata, 1977) recognized this fact and issued its Resolution I "Assessment of Water Resources". See in Appendix D the main calls in this resolution and the works that followed, for the attention of the forthcoming consultancy.

11. This rapid assessment was aimed at identifying the main gaps that would help in formulating an adequate TOR for the elaborative future consultancy. These rapid assessments will follow the same headlines as those approved in the inception and interim reports.

12. This chapter summarizes information collected and reviewed with respect to the current status on the information on water resources. The chapter is subdivided into five subsections, namely:

- Hydrometeorology
- Surface Water Hydrology.
- Ground Water Hydrology.
2.1 Meteorological Data

13. Meteorological data is an essential element for any study on water resources assessment and management. Therefore the establishment of an effective monitoring system for meteorological data collection, processing and dissemination is of prime importance. The main source of meteorological data is the Sudan Metrological Authority (SMA) which is under the umbrella of the Presidency of Council of Ministers. Until the late seventies, the department used to have a meteorological network of more than 300 stations well distributed all over the Sudan. Unfortunately, the network has suffered great deterioration over the past few decades and the number of working stations in the whole country is now not more than 30 stations. Accordingly, the number of stations in Southern Sudan was 29 stations but most of them have stopped functioning during the eighties, and only five of these stations are currently working. More details on the rain meteorological stations can be found in Annex (I.1).

14. The parameters that are measured are rainfall, evaporation, temperature, relative humidity, soil moisture, sunshine hours and wind speed and direction. The data is published in different format such as those shown in Tables I.1.3 –I.1.5 in Annex I.1. The data sample is presented as an example of the SMA disseminated format. We assume the proposed responsible WIS data custodian (SSWICH) will be able to detect any errors and rectify them.

15. Another important source of data is the FAO website, which have a database with climatic data for more than 30,000 stations from all over the world including Southern Sudan. This database was initiated in 1980 within the framework of the Agro Ecological Zone project (AEZ) aimed at assessing agricultural production in developing countries (Gommes et al, 2004).

16. Yousra & Magdoleen (2009) show that annual rainfall isohyets in Sudan are shifting towards the south indicating decreasing rainfall which may be due to climate change. As an example a trend test of annual rainfall has been conducted by the consultant, within this study, for 58 years of annual rainfall (1943-2000) for Wau station and the results showed a declining trend with 95% confidence. However, the declining trend is less steep than stations
in Northern Sudan (Yousra & Magdoleen, 2009). This issue however, needs further investigation in the forthcoming study.

![Graph showing decreasing trend in Wau annual rainfall](image)

**Fig. 2.1: Decreasing Trend in Wau Annual Rainfall**
2 Surface Water Hydrology

2.2.1 Data on Surface Water:

17. The gauging of the River Nile in the Sudan started since 1869 on a very limited scale. In 1955 a Hydrological Station was established as a scientific data collecting and advisory organization within the Sudan Irrigation Department. This department conducted hydrological studies in various tributaries of the Nile by systematic collections, analysis and publication of data.

18. After the ratification of the 1959 Nile Water Agreement between Egypt and Sudan and the eventual setting up of the Permanent Joint Technical Commission (PTJC) for Nile Waters, the two organizations namely, the Egyptian Irrigation Services in the Sudan and the Hydrology Section of the Sudan Ministry of Irrigation have been dedicated as executive organs for the hydrological studies in the Nile Basin within the Republic of the Sudan.

19. The following table shows the number and distribution of gauging stations of hydrological network of the Nile system in side the Sudan:

<table>
<thead>
<tr>
<th>River</th>
<th>Number of gauging stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Nile</td>
<td>16</td>
</tr>
<tr>
<td>Blue Nile and its tributaries</td>
<td>21</td>
</tr>
<tr>
<td>White Nile and its tributaries</td>
<td>203</td>
</tr>
<tr>
<td>River Atbara and its tributaries</td>
<td>10</td>
</tr>
<tr>
<td>The Lake Plateau</td>
<td>21</td>
</tr>
</tbody>
</table>

All the above network of the gauging stations was operated jointly by the Hydrological Departments of both the Egyptian and the Sudan Irrigation Services within the framework of the PTJC. More details on the discharge gauging stations are presented in Annex (I.3).

2.2.2 Challenges of Surface Water Resources of Southern Sudan:

20. The surface water resources of Southern Sudan are abundant, diversified and appears distributed uniformly in space during the wet season, thus constituting a great asset for development. However, there are many challenges involved, including the fact that this
resource is spatially unevenly available during the dry season; in addition to the weakness in the availability of reliable hydro-meteorological information system, which is the main challenge in the development of the surface water resources in Southern Sudan.

21. This would require the importance of giving due priority to following information needs:

- Establishment of a reliable Water Information System.
- Rehabilitation of all the gauging stations (Fig. I.3.1 of Annex I.3) and their reinforcement with new stations with a redesigned hydrological network. The new network should include autographic recorders, data loggers and telemetric facilities.
- Enhancing the quality of data in terms of accuracy, continuity and consistency.
- Enhancing capacity development in terms of human resources, infra-structures, enabling environment and institutional aspects.

2.3 Groundwater Information in Southern Sudan

2.3.1 Data Situation:

22. Reports that are specific to Southern Sudan discussing groundwater basins, their detailed hydrogeologic characteristics and resource potentialities are very limited. Consequently there is a problem of data scarcity. Most of the data and information collected for the purpose of this report have been gathered from general literature that discuss hydrogeology and groundwater in Sudan as a whole rather than provide separate information for Southern Sudan such as Whiteman (1971), Salama (1977), and Salih et al (1984). More elaboration are presented in Annex (I.4). As can be seen the references themselves are rather old and therefore whatever data and information obtained from them should be verified and/or updated before using them for further studies. During the mission to Juba in mid February, it was learned that there is a report prepared by Euro-consult on the hydrogeology and groundwater in Southern Sudan. Unfortunately, it was not possible to obtain this document till the time of the preparation of this report.

23. Currently groundwater development and information are scattered among many governmental authorities and NGO’s such UNICEF. According to MacDonald (2009), UNICEF has developed a draft management information system with a database that contains basic well data such as coordinates, drilling depth, drilling dates, static and dynamic water levels, well yield, pump type, pump setting depth and water suitability (see Table I.5.1 in
Annex I.5). The database was handed over by UNICEF to MWRI. However, the Database is not fully functioning as planned. Data entry is incomplete due to insufficient technical know-how of the existing manpower to enter data. The database could not tell us how many boreholes are actually functioning in any given state. Also, many NGOs have not submitted their drilling data to the database due to poor communication and reporting systems. Very important information is not included in the database such as well lithology, water quality parameters and pumping test data, although plans have been made to collect such information from newly drilled boreholes. It is therefore suggested that efforts should continue to examine and verify the present contents of the database first and then proceed with further data collection and entry.

24. An important issue of concern is that of groundwater monitoring. Generally the water resources monitoring system in the South has suffered great deterioration and under established in the past due to many factors. At present, there is no groundwater monitoring system where real time measurements are regularly taken such as water level fluctuation in observation wells, groundwater abstraction and water quality measurements. Such data are very important for proper assessment, development and management of groundwater.

2.3.2 Groundwater Resources Development:

25. Deep boreholes were drilled in Sudd region, Southern parts of Baggara and Eastern Kordofan basins where as slim shallow wells fitted with hand pumps were drilled in the fractured aquifer of basement and in the alluvial aquifers underlying seasonal Wadis. Borehole depths ranged between 25 m in the alluvial and fractured aquifers to more than 300 m in the central and northern parts of the Sudd basin. Well yield also varies considerably depending on the location and aquifer type. For the distribution of wells with recorded coordinates see Fig. I.4.2 of Annex I.4.

26. At present there is no exact figure about how much groundwater is abstracted from the different basins in the South. However, from the limited information available, there is large groundwater potential and current abstraction is only a small fraction of the resources available. To have a true picture, database completion and monitoring are essential.
2.4 Water Quality Information

27. Occurrence of cholera and spread of other water-borne diseases such as guinea worm as epidemics (2005-2006) and as endemic emphasizes the lack of water quality monitoring and other preventive mechanisms.

28. The significance of the quality of water is tightly related to its anticipated use and the available sources. In general the main categories for water use that demand quality requirement and protection are domestic, recreation, industrial, aquatic (fish), agriculture, navigation and oil exploration. Currently in Southern Sudan the biggest share of water resources use is for navigation and municipal water supply in the rural and urban centers, though plans are underway for increasing hydropower generation and agricultural water use. Use of water supply for industrial consumption is very limited. In the light of this and the detailed presentation in Annex (I.5), the main concerns of water quality in Southern Sudan are:

1. Sediment load and turbidity
2. Bacteriological quality
3. Salinity and salts content
4. Oil pollution from exploration activities

2.4.1 Sediment Load and Turbidity

29. While adjustments in river morphology are a natural phenomenon, human activity in altering stream discharge and sediment loads has played a significant role in accelerating the process. The main impacts include watershed degradation from deforestation, overgrazing and poor farming practices that increase stream turbidity. The removal of riverbank vegetation through fires or grazing further aggravates the problem, as it weakens the banks’ ability to withstand the erosive power of flood peaks.

30. Suspended sediment content as measured at Juba Water Treatment Plant is very moderate throughout the year with highs in the range 40-50 ppm in the rainy season and lows in the range 2-5 ppm. It was observed that Bahr el-Jebel gets most of its sediments after it crosses the border at Nimule from streams that originate from mountains front at the border (meeting with UWC, Mr Samuel).
2.4.2 Bacteriological Quality:

31. Pollution by animal and human waste is responsible for the majority of the microbiological degradation of surface water\(^1\). The cholera outbreak in 2005-2006\(^2\) was the clearest manifestation of such microbiological pollution. In 2007, International Teams\(^3\) established a bio-sand water filter micro-enterprise. Four nationals were trained in the construction of bio-sand filters and in business management. They are building and selling bio-sand filters and bottled water. In addition, a water quality team was trained to test for contaminants in area wells.

2.4.3 Salinity and Salts Content:

32. The majority of drinking in populated towns in Southern Sudan is supplied from rivers and limited quantities from groundwater. As expected surface water has no salinity problem in Southern Sudan. However, most of the groundwater around Malakal and isolated spots in villages has high salinity. As an ad-hoc example a sample of tap water (supplied from a groundwater well) at the Sunshine hotel north of Juba, taken during the February visit to Juba, had total dissolved solids (TDS) of 3576 ppm (see Table I.5.2 in Annex I.5) for complete chemical analysis made in the Sanitary Engineering Laboratory of the University of Khartoum). The high salinity makes the water unsuitable for human consumption. Though it is recognized that is an isolated test, yet its high salinity result calls for wider analysis in Juba and could be else where.

2.4.4 Oil Pollution from Exploration activities

33. From an economic consideration it is a blessing that Southern Sudan possess considerable deposits of oil resources. However, the production and processing of this resource could have considerable negative environmental impacts on the ecosystem and water resources (surface and groundwater). Such problems are not unique to Southern Sudan alone but they certainly require adequate preparedness and mitigation actions. Though such impacts have received considerable attention worldwide, one would recommend in both Sothern and Northern Sudan that more attention and support should be given to studies and researches that could lead to their mitigation. One may report in this occasion that there are few studies and ongoing researches in various Sudanese universities particularly the

\(^1\) [http://postconflict.unep.ch/sudanreport/sudan_website/index_photos_2.php?key=water%20pollution]
\(^2\) [http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5813a3.htm]
\(^3\) [http://www.iteams.ca/impact_southern_sudan.php]
2.4.5 Facilities for Water Quality Analysis:

34. Very limited historical quality data is available. Following is an itemized list of sources of the little available data on the quality of water supply. These include:

1- A laboratory at Juba Water Treatment Plant: The treatment plant has a small laboratory facility attached to it. Among the parameters measured at the plant are pH, turbidity, residual chlorine, and TDS.

2- Laboratory at Malakal Water Treatment Plant: There are two small laboratories attached to the new treatment plant. One laboratory specializes in bacteriological water characteristic and the other deals with parameters needed for the treatment plant operation such as pH, turbidity, residual chlorine, and TDS.

3- Laboratory at Juba Central Hospital: Since the onset of the Cholera epidemic in 2005 the hospital laboratory was approached to measure the bacteriological quality of water samples. The samples are routinely sent by the water treatment plant and the city's government to this laboratory for bacteriological analysis.

4- UNICEF Laboratory. Besides the UNICEF water quality testing laboratory in Rumbek (which is in fact being operated now by MWRI-GoSS), other existing water quality testing facilities include:

   o Sudanese Standards and Metrology Organization (SSMO) testing laboratory in Juba,
   o Swedish Free Mission (SFM) water quality testing laboratory in Juba,
   o International Aid Services (IAS) water quality testing laboratory in Yei,
   o Several NGOs in different states have field kits for water quality monitoring,
   o Under the projects of technical cooperation with Egypt, a small Central Water Quality Testing Laboratory has been setup in Juba by MWRI, capable of testing physical, chemical and microbiological profiles of all types of water samples.
2.4.6 Monitoring of Water Quality from Water Tank

35. Existing water supply facilities does not cater to the needs of entire towns and this leads to purchase of water from water tanks by the users. Most of these water tanks are privately owned and these tanks are filled up using water from Rivers directly. While filling up the tanks, liquid chlorine is also added to the tanks. However, there is no agency that monitors the water quality supplied by these tanks. It is advisable that water quality from these tanks be monitored to avoid any outbreak of diseases.
3. Existing Capacities and Enabling Environment

36. The role of capacity development and enabling environment is receiving growing attention world-wide for securing sustainable development. This requires a change in the past focus on developing infrastructure while overlooking the need for a strong knowledge base and capacity to plan, manage and utilize the infrastructure towards a proper governance of the water sector (Salih, 2009). As presented in the UN-word Development Report2 (2006), "knowledge takes a variety of forms: as databases; as the competence to integrate and interpret data and create meaningful information that can inform decisions; as
3.1 Enabling Environment:

37. Enabling environment is one of the three pillars of the triangle of capacity development, together with human resources development and institutional capacity. It consists of the policy, legal, regulatory, and administrative frameworks that serve as boundary conditions for the organizational and functions of the agency. The related policies should aim towards sustainable water resources development, cost effectiveness and should be supported by adequate legal and financial frameworks that could ensure the implementation of these policies. Similar to the previous sides of the triangle, research and development are key for improving the policies and legal frameworks for better enabling environment.

3.1.1 Development of policies

38. In this section an introduction will be made to policies at both the level of GoSS and GoNU with rapid assessment.

3.1.1.1 Southern Sudan Water Policy of 2007

39. Following the formation of GoSS and the southern state governments, the need arises to develop sectoral policies and strategies in order to maximize the impact of reconstruction and development efforts. The conflict in Southern Sudan resulted in a complete breakdown of basic infrastructure and institutions of governance. While there were a number of different agencies and organizations including governments and non-governmental actors, working in the water sector, no coherent policy existed to guide the use and management of water resources. The Interim Constitution of Southern Sudan provides the Government of Southern Sudan (GoSS) with a clear mandate for establishment and development of a basic policy; framework to guide future aspects of water resources other than interstate waters which is left for the Federal Government.

40. UNICEF, in collaboration with ODI and Save the Children-UK, have supported and facilitated two workshops to discuss policy and institutional issues faced in the water sector and reviewed relevant regional (Uganda) and international (South Africa) experiences in water sector development. In addition, the process from the beginning involved various
actors, including representatives from non-governmental and governmental agencies, professional associations, UN agencies, etc.

41. Formulation of Southern Sudan water policy of 2007 was done through participation and wide consultation including groups that are representative of political, technical, managerial and key stakeholders. Consultation with policy groups has been carried out at all stages to secure their involvement and optimal contribution. This included contacts with the Federal Ministry of Irrigation and water Resources to ensure coordination and harmonization regarding interstate waters. This has been followed after identification of a broader range of water policy options to avoid crises crash programs.

42. The draft policy received invaluable constructive comments and recommendations from both the Honorable Council of Ministers and the Southern Sudan Legislative Assembly (SSLA) that consolidated the final policy document.

43. The water policy presents a shared vision for water sector development and management led by the Ministry of Water Resources and Irrigation (MWRI) and reflects broad consensus on the basic objectives and principles which should guide exploitation and harnessing of the resource.

44. The aim of the existing water policy document at this stage is not to arrive at a comprehensive policy for the entire water sector but instead to set out the basic elements necessary to maximize the impact of recovery efforts and promote greater policy coherence in the context of rapid scaling-up. It also, represents an important first step towards the establishment of a regulatory framework for rational utilization and management of water resource; in addition to the effective delivery of water services in Southern Sudan. Therefore, it is a significant achievement.

45. The core water related Ministries led by the Ministry of Water Resources and Irrigation in close collaboration with Ministry of Cooperatives and Rural Development (MCRD) and the Ministry of Housing, Physical Planning and Environment (MHPPE), provided joint guidance and support to the policy development and formulation process.

46. To establish organizational arrangements within the public sector to ease implementation of plans and translate the water policy into actions on the ground, the MWRI, with the help of UNICEF is now embarking on formulating the appropriate strategies and legislative frameworks. Some of the major legislation in key areas includes but not limited to:
- Water quality, conservation and environment
- Water resource assessment and monitoring and
- Water resource allocation and use

3.1.1.2 The National Water Policy of Sudan:

47. The Government of National Unity (GoNU) has recently updated the water policy of 2000 and formulated a new national water policy to guide water resources planning, protection, development and management of the resource in a sustainable manner. The recent water policy document is formulated through intensive stakeholder participation and consultation with the relevant water related groups. The updated policy has removed inconsistencies, redundancies and contradictions of the old policies based on the Comprehensive Peace Agreement (CPA) and subsequent Interim Constitution of Southern Sudan (ICSS) and Interim National Constitution (INC) of 2005.

48. The previous national water policy of Sudan of 1992 had adopted a top-down approach to water sector development with very limited stakeholder involvement in Southern Sudan. This approach largely proved ineffective and unsustainable mainly because water resource development did not correspond to the needs and priorities of end users. Institutional arrangements for managing water resources were unable to prevent degradation and pollution of the resource base and levels of access to water supply and sanitation services remained unacceptably low.

49. The new constitution has allowed the regional governments to develop their own water policies to respond to the needs of their local people and resources.

3.1.2 Legislation, Organization and Coordination:

50. Both at the level of GoNU and GoSS various acts and regulation orders are being issued with regard legislation, organization and coordination. An elaborated explanation of these issues has been included in Annex II.1.
3.2 Institutional Capacity

3.2.1 Strengthening Institutional Capacity:

51. Well developed human resources by itself cannot achieve capacity development without an adequate institutional capacity. Institutional capacity relates to the overall performance of the organization and its capacity to function properly, as well as its ability to forecast and adapt to change (World Water Development Report 2, 2006). Its resource base is made of the organization’s personnel, facilities, technology, knowledge and funding, while its management capacity is determined by its procedures, programs and external relationship. Both the resource base and management capacity make up the overall institutional capacity of the organization. A successful organization should develop: An efficient, effective and expedient decision making organizational structure, an effective partnership with all stakeholders, “a spirit of transparency, sharing responsibility and delegation with accountability; sense of ownership by all involved and attractive term of services for its employees”.

52. In the institutional level, three capacity developments needs stand out, in particular (WWDR2, 2006):

- A clear mandate for managing agencies, water providers, and policy-making bodies that promote and enhance the institutionalization of good water management and water use throughout all levels of society.

- An organizational system conducive to effective and efficient management decisions.

- Improved decision support mechanism through research on lessons learned and indigenous knowledge.

53. Relevant research and development could greatly enhance the institutional capacity and improve its performance and running cost. Successful organization invests in research (R) and development (D) in order to keep competitiveness in the market and attract better human resources.
54. Judging from the gathered experience, it is unfortunate that this is not taken seriously in many developing states leading in most cases to poor performance of the water sector and in creating wider divides.

55. The Government of Southern Sudan has a constitutional mandate to establish appropriate institutional and legal frameworks for water resources management within its territory. Institutional arrangements under the former governments were generally inadequate to meet the complex challenges of water resources management in Southern Sudan and institutional functions were not always clearly defined. The CPA of 2005 represented an important opportunity to review and update existing institutions in the light of the new Federal structure to ensure:

- Integration of decision making processes surrounding management of water resources on the basis of hydrological boundaries;
- Separation of institutional roles relating to water resources management, including development and enforcement of regulatory standards, from those relating to resource development and service delivery;
- Decentralization of responsibility for resource management to the lowest appropriate administrative level and
- Participation of water users including women and children in decision making processes surrounding planning, development and management of water resources.

56. It is proposed that the GoSS establishes an independent authority at GoSS level to oversee water resources management in Southern Sudan with gradual decentralization of regulatory responsibility, where capacity allows, to Basin and Sub-Basin levels. Institutional mechanisms for coordination with other sectors such as education, health, environment, agriculture, livestock, fisheries, transport and industry could also be established. The roles and responsibilities of government and non-government stakeholders under the new institutional framework should be clearly defined in future implementation strategies. Following the formulation of the Water Policy, the GoSS is now embarking on the necessary steps to establish a supporting regulatory framework to enable efficient and effective functioning of the established water resources management institutions in Southern Sudan.
3.2.2 Responsibilities of Water Resources Planning, Monitoring, Assessment, Development and Management:

57. In the previous setup of GoSS, rural water was designated to the Ministry of Cooperatives and Rural Development and urban water was a jurisdiction of the Ministry of Housing, Lands and Public Utilities (now the Ministry of Housing, Physical Planning and Environment, MHPPE). The Ministry of Water Resources and Irrigation (MWRI) is left with water for productive use and the overall management of water resources in the South. In 2008, the Presidential Decree that reorganized functions and duties of the Government of Southern Sudan (GoSS) Ministries has transferred the Directorate of Rural Water Supply and Sanitation (DRWSS) and the Department for Programming Urban Water Supply to Ministry of Water Resources and Irrigation (MWRI), making the MWRI the sole custodian of water resources in Southern Sudan. For cross-cutting aspects, the sector still retains through Southern Sudan Water and Sanitation Sector Steering Committee (SSWSSSC) the membership of MCRD, the MHPPE that is responsible for urban affairs and Ministry of Health (MoH) for sanitation and hygiene. This is attributed to the GoSS policy in moving towards an integrated approach to water resources planning, monitoring, development and management which bring together multiple different sectoral interests in the development of water use strategies and plans.

3.2.3 Drinking Water Responsibility:

58. No support has been given to the rural communities to take an active role in planning, managing and financing Rural Water Supply and Sanitation (RWSS) schemes on a sustainable basis. Implementing agencies are also not supporting communities to make informed choices based upon the full range of available technologies including hand dug wells and springs (not just list boreholes).

Drinking Water Quality Guideline Values of Test Water Quality Parameters

59. The drinking water quality guideline values of the test parameters, which were proposed for Southern Sudan by UNICEF on October 2008, are summarized in table 3.1.
Table 3.1: Drinking water quality guideline values of the test parameters

<table>
<thead>
<tr>
<th>Test Items</th>
<th>WHO GV (mg/l)</th>
<th>S. Sudan GV (mg/l)</th>
<th>Rationale for proposed Southern Sudan Guideline Value (GV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.5 – 8.0</td>
<td>6 – 8.5</td>
<td>No health effects and aesthetically acceptable.</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>NS</td>
<td>150 (mS/m)</td>
<td>Insignificant effects on sensitive groups.</td>
</tr>
<tr>
<td>TDS</td>
<td>600</td>
<td>1,000</td>
<td>Water tastes good and has an insignificant effect on sensitive age groups.</td>
</tr>
</tbody>
</table>


3.2.4 Sewage and Sanitation, Availability and Responsibility:

60. The majority of the population in the South lacks access to a reliable supply of safe water and even fewer have access to basic sanitation facilities. Providing access to poor and vulnerable groups is a particular challenge to the MWRI. In addition, providing sanitation services with concurrent sanitation and hygiene education is important in order to maximize the social and economic benefits of rural water supply development.

3.2.5 Involving the Stakeholders:

61. Because of the nature of water, the resource planning and development affects everyone and shall be undertaken at the lowest appropriate administrative level with active participation of water users and stakeholders from different sectors in all relevant aspects (i.e. catchment area to be the basic unit for planning and managing water resources). In Southern Sudan, lack and limited participation of users in planning, management and financing of water resources management and development undermines sustainability of the resource.

62. Historically water resources development in Southern Sudan has often been carried out without due consideration of needs and priorities of different stakeholders. Mechanisms for involving water users and stakeholders from other sectors in planning water development remain undeveloped. The result is inadequate planning frequently leading to poorly designed projects which are inefficient or unsustainable and often have unintended negative impacts on people and environment.
63. In future, an integrated approach to water resources planning should be developed on the basis of natural hydrological boundaries. The river basin or catchment area should be the basic unit for planning and management of water resources and clearly delineated. Specific measures should be taken to enable active involvement of water users and stakeholders from other sectors in planning processes to lead to the development of catchment management strategies.

3.2.6 Role of Community:

64. Experience has shown that the sustainability of community-based water supplies depends on the active participation of user communities in planning, design, operation and maintenance of schemes. Where water users are not adequately involved in the process and schemes do not reflect the needs and priorities of end users, including women and children, there is less incentive for user communities to invest time and money in maintaining them. Community-based approaches are well-established in Southern Sudan due to the absence of effective government for long periods of the conflict. However, the role of communities as legal owners and managers of rural water supply schemes has not yet been formally recognized.

65. The respective roles and responsibilities for communities and local authorities regarding the planning, financing and management of infrastructure development and subsequent operation and maintenance should be clearly defined within the institutional framework and legally recognized. Guidelines should be developed to encourage the participation of user communities in all aspects of the RWSS project cycle, including planning, design and construction, and empower them to make informed decisions regarding selection of different technology options. User communities should be mobilized and trained to gradually take over full responsibility for management and financing the operation and maintenance of RWSS schemes. Procedures should be developed to facilitate registration of water user groups as legal owners of rural water supply facilities in order to empower communities to manage schemes themselves.

3.2.7 The Role of Women in Water Resources Planning, Management, and Water User Organizations:

66. To promote active participation of water users, including women and children, in all aspects of planning, design, operation and maintenance of water resources schemes and to
support communities to take ownership of rural schemes, it is important to mainstream gender issues in water and sanitation services.

67. Women and children of Southern Sudan have suffered from the effects of war through heavy workload of water fetching and lack of basic sanitation. Although responsible for most of the agricultural and domestic work, women in many parts of Southern Sudan have limited access to safe drinking water, lack basic sanitation and spend long hours collecting water. This situation has also impacted negatively on the survival and development of children. In order to improve quality and sustainability of rural water supply and sanitation services, specific measures should therefore be taken to promote active involvement of women and children in planning and design of rural schemes which are appropriate to their own needs and priorities. GOSS has recently started to encourage women employment in the water sector in an effort to empower and evolve women in the planning, management and development of water resources in Southern Sudan.

3.2.8 The Role of the Private Sector:

68. The private sector has played an important role in the development of rural water supplies to-date. This is in the form of construction of water projects like hydraulic structures, water supply facilities and provision of water through tankers to areas deprived from water services. Working in partnership with government or NGOs to develop and operate water supply infrastructure, the private sector offers a number of potential advantages in terms of efficiency and flexibility despite the difficulties of access in the Southern Sudan mean that competition is far from perfect. Regulation is mostly through contracts but there is currently no mechanism for independent monitoring and enforcement, resulting in significant variation in the quality of services currently provided. Despite growing demand, the number of private operators equipped and capable of providing quality services in Southern Sudan remains small. The majority is based in neighboring countries and employs a small number of local staff on the ground. The number of Southern Sudanese private sector operators is expected to increase in future. Significant opportunities exist to increase private sector involvement in scaling up delivery of rural water supply and sanitation services in Southern Sudan. There is a need to build the capacity of government to work in partnership with the private sector to enhance development and sustainability of RWSS services (e.g. strengthening supply chains). To this end the role of the private sector within the institutional framework for RWSS service
delivery should be legally recognized and procedures and guidelines developed for monitoring the performance of private operators.

69. On the other hand, opportunities exist for private sector participation in different aspects of UWSS planning and service delivery with potential benefits in terms of efficiency gains and technological innovation. In addition to capital intensive works and the supply of goods and services to UWSS utilities, there are opportunities for private sector to operate and manage UWSS infrastructure on behalf of government. Apart from the large urban centers there are significant opportunities for private sector involvement in development and operation of small water supply and sanitation schemes in semi-urban areas and small towns. However there are some obstacles to private sector involvement in the existing legal and regulatory framework.

70. It is important for GoSS to explore the potential for private sector participation in the provision of UWSS services in Southern Sudan. In order to create a more conducive environment for private sector participation there is a need to legally recognize the role of private sector within the institutional framework for UWSS and establish procedures and guidelines for monitoring performance of private operators. Additional measures should be taken to promote the development of local private sector and to build the capacity of government to work effectively in partnership with private operators.

71. Hence, active involvement of the private sector and NGOs in the management, development, and delivery of goods and services for RWSS and UWSS should be promoted, encouraged and supported wherever appropriate.

### 3.3 Human Resource Development

72. The long time conflict in Southern Sudan has resulted in the breakdown of organizational structures and caused a shortage of core technical and administrative skills. Hence, a vital need arises to build capacity and develop human resources at all levels.

73. Lack of staff with adequate skills and technical qualifications to fulfill different water resources management functions presents a major constraint. As GoSS seeks to reverse the effects of conflict and long term under development in the South, there is a need for intensive training and human resource development in order to enable water sector stakeholders at all levels of government to understand and fulfill their new roles and responsibilities specified in the water policy. The core functions of water resources management outlined above require a
range of specialized technical qualifications as well as strong planning and management capabilities. In order to have an adequate number of appropriately qualified staff in the water sector short, medium and long term strategies shall be developed for human resource development and training through technical collaboration with relevant institutions in the Federal Government (GoNU) and other countries. In parallel GoSS shall work to strengthen and capacitate water resources management institutions at all levels through programs of technical and financial assistance.

74. The water policy of the South emphasized capacity building & human resource development at all levels throughout the RWSS, and UWSS sub-sectors and promoted the technical and management training of staff working at all levels in services so as to improve the overall quality and effectiveness of institutions.

75. There is a general lack of staff with adequate skills including technical and administration qualifications to implement different UWSS and RWSS functions. As Southern Sudan emerges from decades of conflict, a deliberate strategy is needed in order to develop the necessary manpower across a range of different fields for effective and efficient service delivery. A comprehensive and detailed training needs assessment should be undertaken to reflect the changing role of government from direct implementation to regulation and supervision, and build the capacity of government to develop effective partnerships with non-state partners including NGOs and private sector.

76. A Project Cycle Management (PCM) workshop was organized by JICA for each department of UWC, in order to analyze problems and objectives of the department. In the workshop, basic theory of PCM planning method was also presented to the participants. As a result of the problem analysis, the core problem was summarized in Table 3.2.
### Table 3.2: Core Problem of Each Department

<table>
<thead>
<tr>
<th>Department</th>
<th>Core Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purification</td>
<td>Capability of producing safe drinking water is not enough</td>
</tr>
<tr>
<td>Distribution</td>
<td>Capability of distributing water is not enough</td>
</tr>
<tr>
<td>Financial</td>
<td>Capability of selling water at reasonable tariff and manage under self-autonomous accounting is low</td>
</tr>
<tr>
<td>Human Resources</td>
<td>Capability of employing and developing human resources are not enough</td>
</tr>
<tr>
<td>Administration</td>
<td>Capability of office administration is not enough</td>
</tr>
</tbody>
</table>

77. Alternative analysis was also carried out by identifying and encircling project components. As a result, 33 project alternatives were identified in the study by JICA Study Team based on PCM workshop held during 17 – 25 Sep. 2008. Although they should be reviewed in consideration of overlapping, available resources, cost-benefit, sustainability, etc. they are regarded as necessary action plans to achieve desirable future situation of UWC.

78. Human resource development and capacity building should be achieved through a combination of study tours, vocational training and university scholarships both from within and outside the country, and the establishment of water resources research and technological development centers in Southern Sudan. Emerging organizational structures for RWSS service delivery should be strengthened and capacitated at all levels through programs of technical and financial support from government, external donors and collaboration with relevant institutions in the Federal Government and other countries and networks of experienced water sector professionals.

### 3.4 Capacity Assessment

79. Capacity Assessment (CA) and identification needs are important prerequisites for establishing strategy and a plan of action to fill the identified gaps in capacity. GoSS, through its partners, has initiated capacity assessment exercise which could be a preliminary direction for a comprehensive assessment of capacities. Annex II.2 gives a summary of these achievements together with few international directions towards the identification of capacity elements, particular education and training.

80. In conclusion, it can be stated that:
• There is good achievement in the policy side and there is progress in legislation and organization side.

• There is some progress with the incentives side but more is needed particularly in the working environment.

• The forthcoming deeper study should give this area more elaborate attention in identifying ways and means to enhance the enabling environment, human resources and institutional capacity.
4. Existing Financing Mechanisms and Sustainability Options

81. Constrains for faster progress in closing the divide in water supply and sanitation in Africa include inadequate capacity development and poor financing. Inadequacy in human to meet MDG7 for Africa has been hinted at in reports from WHO, UNESCO and DFID (DFID, 2009). On the finance side, Africa Infrastructure Country Diagnostic (AICD) has reported that “Africa water spending needs amount to over US$30 billion a year to meet the MDGs; with 2/3 of this sum for water supply and sanitation” (Foster et al, 2009). Similar situation would exist in Southern Sudan in this side.

82. Financing the water sector is a long-term committee that must be consistently secured. Indeed, its effectiveness requires significant investment in producing skilled, knowledgeable and trained human resources; obtaining specialized equipment, building infrastructure, providing access/logistical equipment; producing and implementing policies, legal frameworks and regulations; and in setting up institutions. These are vital requirements and processes associated with resource assessment; monitoring of its abstractions and changes in its quality; and development and enforcement of the standards. This entails capital investment plus recurrent expenditure to cover the costs of operation and maintenance of the equipment and the established facilities; collection and processing of data; and dissemination of information.

83. Water resources management is costly and must be properly funded. Effective management of water resources requires significant investment of financial and human resources in the various technical, logistical, administrative and legal activities associated with resource assessment, monitoring of resource abstractions and effluent discharges, and development and enforcement of standards. For example, continuous monitoring of water resources requires capital expenditure in specialized equipment plus recurrent expenditure to cover the costs of operation and maintenance of the equipment and the established facilities including staff involved in collection, processing and dissemination of information. This huge investment necessitates the importance to mobilize sufficient finances from public and private sources to cover capital and operational expenditure and develop a sector-wide financing strategy to ensure long term sustainability.
84. A small proportion of these costs will be recovered through fees and levies charged to water users for specific services such as delivery of irrigation water, operation of dams/reservoirs and issuing of abstraction/discharge permits. It is important that the GoSS allocates the appropriate support for water users to make informed technology choices which take account of local needs and priorities and existing capacity for management and financing of O & M. Private sector investment will be actively encouraged wherever possible (for example in catchment rehabilitation and management) but the day-to-day costs of managing water resources require significant ongoing public investment. Government of Southern Sudan recognizes the central importance of water resources management for development in Southern Sudan and is committed to developing an effective strategy for sustainable financing of associated capital and recurrent expenditures in the long term.

4.1 The Role of Economics: Cost Recovery, Water Pricing, Water Charging Systems

85. The economic value of water is considered to be a major parameter in the water resources management whereby users are expected to contribute towards the costs of managing and supplying water according to the volume and quality used.

86. In order to improve the service levels across Southern Sudan, substantial investment in the resource is required. The GoSS is required to increase investment in WSS as a basic need, especially in rural areas, but will also need to solicit additional funds from public donors in order to support achievement of targets. A sector-wide financing strategy shall be developed in order to ensure mobilization of adequate financial resources to meet RWSS sub-sector objectives and targets. The GoSS, State and Local Governments are supporting rural communities in meeting the capital costs of infrastructure development. Following years of protracted conflict, rural communities have only limited capacity to contribute towards capital costs. However, it is generally agreed that communities can reasonably be expected to contribute towards the costs of operation and maintenance. In many cases they are already doing so either in cash or kind but there is a need to formalize such arrangements in order to improve the financial sustainability of scheme operation and maintenance. To this end, guidelines shall be developed for progressive involvement of user communities in financing the cost of operating and maintaining RWSS schemes while ensuring that poor and vulnerable groups are not disadvantaged.
87. The UWSS facilities in Southern Sudan have suffered from decades of underinvestment as a result of conflict. Levels of capital investment have been insufficient to keep pace with demand, and systems for billing and payment have broken down making revenue collection difficult. The net result is that UWSS utilities have a very weak financial resource base. Nevertheless, the Urban Water Corporation has set nominal prices for water services in the four major cities in Southern Sudan (Juba, Malakal, Wau, and El Renk). They are unable to operate commercially or to invest adequately in maintaining existing assets and providing quality UWSS services on sustainable basis.

88. In addition of the income from water sales and installation fee for new connection, UWC earns from the government support. Since water meters are currently not installed to customers, flat rate is applied depending on category of customers, as water tariff shown in Table 4.1. Tariff is proposed by UWC and approved by the Board of Directors of SSUWC and be taken into effect after decision by Assembly.

Table 4.1: Water Tariff for Fiscal Year 2008 (The case of Juba town)

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of customers</th>
<th>Tariff (SDG/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First class</td>
<td>316</td>
<td>18</td>
</tr>
<tr>
<td>Second class</td>
<td>1037</td>
<td>15</td>
</tr>
<tr>
<td>Third class</td>
<td>800</td>
<td>9</td>
</tr>
<tr>
<td>Stand pipes</td>
<td>38</td>
<td>60</td>
</tr>
<tr>
<td>Hospitals</td>
<td>44</td>
<td>56</td>
</tr>
<tr>
<td>NGOs</td>
<td>79</td>
<td>100</td>
</tr>
<tr>
<td>Restaurants</td>
<td>29</td>
<td>100</td>
</tr>
<tr>
<td>Schools</td>
<td>20</td>
<td>56</td>
</tr>
<tr>
<td>Hotels</td>
<td>68</td>
<td>56</td>
</tr>
<tr>
<td>Government Units</td>
<td>36</td>
<td>56</td>
</tr>
<tr>
<td>New connection</td>
<td>298</td>
<td>255 (per connection)</td>
</tr>
</tbody>
</table>

Source: SSUWC (CES) Juba Financial Department

89. The SSUWC is financially dependent on subsidy from GoSS. GoSS is committed to increasing investment in UWSS. Strategies will be developed for mobilizing the financial resources necessary for rehabilitation and extension of UWSS infrastructure and sustainable operation and maintenance, in line with operational capacity. GoSS, State and Local Government will continue to meet the capital costs of infrastructure development and will actively solicit additional funds from public donors. Consumer contributions towards the costs of managing and supplying UWSS services shall be progressively introduced in order to
promote financial sustainability. Transparent mechanisms will be established for setting and regulating tariffs for UWSS services, with special provision for low income groups. GoSS will support progressive financial autonomy for decentralized UWSS utilities to enable them to apply for credit and attract external investment.

4.2 Existing Development and on-going Initiative

90. It is necessary to attract investment required to finance water resources projects for effective management of water resources and delivery of sustainable water supply and sanitation services. Most of the water resource management and sanitation in the area are implemented and financed by regional and international organization, in collaboration with the GoSS and local administrations. Examples of these are presented below.

4.2.1 Water Supply and Sanitation Project:

91. The Water Supply and Sanitation Project (WSSP) is implemented by Ministry of Water Resources and Irrigation (MWRI) and consists of two phases.

92. Phase I of RWSSP: US$30 million was approved for financing by the MDTF on a 50:50 cost sharing basis with GoSS, to respond to the immediate provision of improved water supply and sanitation to rural areas of Southern Sudan and alleviate the low capacity for implementation and coordination of infrastructure projects. This project was considered Phase I of RWSSP and is at an advanced stage of implementation. Under the RWSSP, as of July 2010, 450 New Boreholes fitted with Hand Pumps, rehabilitation of about 290 boreholes, Construction of 6 small distribution systems, 56 institutional latrines, and 762 Household latrines have been completed and these interventions are estimated to benefit more than 372,000 people. Package of contracts are ready to commit the remaining funds and the project is close to completion. The initial proposal was that a Phase II of RWSSP would scale-up Phase I activities across all the ten states and would also support assessment of the water resources of Southern Sudan at a scope of US$56 million.

93. Subsequent to the rehabilitation of water supply and sanitation in Juba town as part of the Sudan Emergency Transport and Infrastructure Development Program (SETIDP), an Urban Water Supply and Sanitation Project (UWSSP) was developed in the amount of US$97.65 million, proposed to be financed by GoSS and MDTF at a ratio of two-to-one for the next 4 years, aiming to carry out similar interventions in the other 7 states capitals.
94. However, due to serious funding constraints, largely triggered by the global economic crisis, a total budget of US$30 million only, fully financed by MDTF, has been allocated for water supply and sanitation both in urban and rural areas.

95. This project will focus on the following: (i) development and rehabilitation of water supply facilities in rural areas and villages and trading centres across all States of Southern Sudan, and assessments, feasibility studies and design of water supply and sanitation systems for 7 state capitals (Bor, Rumbek, Yambio, Torit, Kuacjok, Aweil, and Bentiu). (ii) construction of institutional latrines at health centres, schools and other relevant public buildings and promotion of household hygiene, (iii) building the capacities of the PMTs at the National level and in the States, through human resources development based on institutional capacity needs and provision of adequate infrastructure (such as office facilities, office equipment, transport); (iv) on water resources management support through knowledge-based activities, and (v) continuation of development and improvement of an adequate Management Information System and provision of technical assistance to enhance overall execution and management of the Project. There is a security concern on the implementation of the project due to the upcoming election in April 2010 and the planned referendum in January 2011. Given the limited time frame, there is a need to focus more on secured areas and revisit the spatial distribution of the contracts during implementation, to minimize the effects of this practical concern.

4.2.2 CP19-Upstream Downstream:

96. This project aims towards improving agricultural practices and conserving water at all levels by all stakeholders, both within Ethiopia and downstream communities dependent on the Nile. Although its main goal is to study the hypotheses that with increased scientific knowledge of the hydrological, hydraulic, watershed, and institutional processes of the Blue Nile in Ethiopia (Abbavy), constraints to up-scaling management practices and promising technologies within the catchment can be overcome, resulting in significant positive benefits for both upstream and downstream communities, reducing win-lose scenarios.

4.2.3 Nile Trans-boundary Environmental Action project (NTEAP):

97. NTEAP is with National Project Coordination and Micro-grant Coordination offices in each NBI Country, World Bank, and NBI Secretariat the assistance of United Nations Office for Projects Services (UNOPS) as partners. Budget of the project was $180,766 in
2007 and $129,948 in 2008. The main objective of the Nile Trans-boundary Environmental Action Project is to provide a strategic environmental framework for the management of trans-boundary waters and environmental challenges in the Nile River Basin. (NTEAP) was completed in Dec 2009.

4.2.4 MWRI – GoSS WASH:

98. WASH has a total 2010 budget of $52.8 m, funded by MWRI, MDTF, GoSS, UNICEF, EC, GTZ, UNECA, Egypt and China; the main objective of this project is to gain effective management, development and utilization of water resources, to improve welfare and productivity of the people of Southern Sudan. In addition it should draw up policies, guidelines and plans for water resources development, utilization, conservation and management in Southern Sudan.

4.2.5 SSWICH project:

99. Phase I: Relocating the information system offices and providing basic service Infrastructure: This is a short term plan to provide basic infrastructure enabling the resumption of work by information system unit and preparation to the second phase

100. Phase II: Set up infrastructure to run the system and preparation to the next level: with an objective to extend the infrastructure to enable the unit host and run an information clearing house, design and verify data collection and dissemination formats, train information system staff to prepare them work with the implementation team and take over the system.

4.2.6 Irrigation and Water Resources projects:

101. There are many projects that are being implemented and/or supervised by the GoSS which include:

- Embankment of flood control dikes in flood-prone areas of Phom el-Zeraf (Fangak County) and Twic East County, in Jonglei State, so as to protect lives, properties, farmlands and wet season grazing areas from flooding and reclaim lands for returnees;

- Water harvesting constructions (Hafiirs and Barriers), so as to increase spatial and seasonal availability of water for various uses;

- Rehabilitation and construction of rural water supply and sanitation facilities, with emphasis being on guinea worm endemic villages, schools, health centers, market places, administrative centers and other areas where communities congregate;
• In close collaboration with the Southern Sudan Urban Water Corporation (SSUWC) that was established to operate urban water facilities, improve their sustainability and expand the service coverage;

• Operation, maintenance, management, rehabilitation, and provision of Irrigation facilities, in an effort to boost food security;

• Collection and archiving of data pertaining to Water Resources;

• Preparation of Water Resources Management, Rural Water Supply and Sanitation, and Urban Water Supply and Sanitation Strategies for the implementation of the Government of Southern Sudan Water Policy;

• Projects of Investment Cooperation with some Chinese Public Companies: In 2006 the Ministry signed MOU with China Construction and Machinery Company (CCM); and in collaboration with CCM experts, surveys were carried out for the opening of blocked rivers in the Zeraf Island and for the construction of a bridge to allow navigation of the Bahr el-Ghazal at Bentiu;

• Projects of Technical and Development cooperation with Egypt: The Government of Egypt offered and pledged six projects at a value of 26.6 million US dollars, over a period of three years;

• National Projects through the Dams Implementation Unit (DIU): Since October 2006, the Ministry started coordination of DIU activities in Southern Sudan;

• The Nile Basin Initiative (NBI): In collaboration with the Nile Basin Initiative (NBI) Subsidiary Action Programs; namely the Eastern Nile Subsidiary Action Program (ENSAP) and the Nile Equatorial Lakes Subsidiary Action Program (NELSAP); and

• Training and Capacity Building.

102. Annex II.5 summarizes some of the water resources management projects/initiatives in the area. The table and the above review indicate priority possibilities of a joint work with donors to supplement necessary additional finance for the projects of the water sector with clear emphasis on water supply and sanitation. None-the-less the needs of this sectors could be much more and hence a strategy is needed on how to secure GoSS and donors funds for the short and long terms. The strategy should identify priorities and phasing of needs. The Water
Information System (WIS) is certainly an important pre-requisite for any rational water resources development and hence it is hoped to be given an earlier priority.
5. Water Information System (WIS)

5.1 Existing Water Information System

103. The establishment of an adequate water information system is a pre-requisite for any successful assessment, planning, design, operation and management of water resources systems. A substantial effort has been made by the MWRI GoSS in this direction and a new water information system called the Southern Sudan Water Information Clearing House (SSWICH) has been established. The key tasks of SSWICH are to collect and process data, undertake surveys, store, and disseminate all information related to water resources. In particular, their stated goals are:

- Build water information system infrastructure, e.g. hardware, network (LAN and internet) and software tools for data manipulation and retrieval.
- Measure sufficiency and functionality of the information center such as collection, processing, dissemination and geo-coding
- Build human capacity and support to run the information system
- Meet Ministry’s expectation of the center with respect to data handling.

104. Although SSWICH operates under the directorate of Rural Water Supply and Sanitation of the MWRI, in each state government there should be database officer(s). Already some states have their database officers. Component 3 of the Southern Sudan Water Supply and Sanitation Project (SSWSSP) entitled “Water Resources Technical Support” is funding the enhancement made to SSWICH in three phases as mentioned before.

105. Phase I was completed and work is progressing in Phase II with the following achievements:

- The office moved to the new facility located in the Ministries complex in Juba.
- LAN infrastructure has been installed covering all rooms provided (two rooms as servers’ rooms and a shared hall)
- Provided workstations and servers:
  - Four high performance desktop computers were provided
  - Three high capacity servers were installed and configured as 1 database, 1 GIS, and 1 Web servers in a prepared room with air conditioning system and standing
cabinet. The servers are fitted with UPSs for power stability and protection.

- Two laptops were also provided.

- The staff made a site visit to Uganda Ministry of Water and Sanitation and attended the GEONETC as workshop.
- One staff has been trained on ArcGIS software, data processing and product delivery in RCMRD (Nairobi, Kenya).
- Design of the data collection formats and architecture was completed
- Experienced water information experts from UNECA and RCMRD are working together to produce a practical data collection and dissemination formats.
- Eight field Surveys has have been initiated in about 28 counties.

106. It is planned that all information from project implementers, whether governmental or non-governmental, should be submitted to SSWICH, efforts are underway to update the contact list for stakeholder and data sources.

107. Currently there are six professionals serving the SSWICH: Director, Assistant Director, two IT/Water Specialists, Hydrologist, and Assistant to Director. Plans are made to

**5.2 Data Available in SSWICH**

108. The total water points and drilled logs entered in SSWICH database are 9,000, of this number only 44% is confirmed operational water points, the rest are comprised of unsuccessful, dry, low yield, cases of collapsed, and a good number is recorded as unknown or “no information”.

1. Types of water points include: Boreholes - BH, Water yards - WY, springs - SPR, Hand Dug Wells - HDW, Hafirs, Rain Water Harvesting points. There are about nine or more water yards.

2. Location is designated by longitude, latitude, State, County, Payam, Boma, Village and sites. However, points with long & latitude coordinates are about approximately 20% of the stored points. The use of GPS is recently introduced in CPA era.

3. Water levels within boreholes range from 7m to 60m in the records according to the details of drill logs reports from the field. These levels are recorded to only 16% of the existing data records.
4. Facilities equipped with hand pumps are approximately 70%, though most of the equipped facilities are not functional for a reason or the other.

5. No data on stream discharges is recorded yet in SSWICH database. But there are about ten stream gauging Stations.

109. Some of the difficulties facing SSWICH in data collection are:
1- Finance for field survey operations.
2- Currently not enough personnel to undertake all require operations.
3- Security is a major concern during field surveys. However, remote telemetry was not investigated.
4- Space, monitoring facilities, staff and equipment.

110. In spite of these deficits, SSWICH represent a good start for a water information system. However, rational water resources management calls for a more comprehensive water information system (WIS) covering all water related data including not only the characteristics and availability of water resources but also data on existing and anticipated demands in all sectors as well as supporting data from satellite imageries, aerial photography, topographical maps, ground surveys, and data on capacity development, knowledge base and socioeconomic information.

5.3 Assessment of the Existing System

111. Despite the launching of the SSWICH project currently the water resources sector in the Southern Sudan lacks the procedures for systematic assessment and monitoring of water resources development and basic systems (e.g. databases) established for collecting, storing and processing accurate and timely information of surface and groundwater resources with regard to quantity, quality, location, demand and patterns of use and making the same accessible to those tasked with planning and implementing projects.

112. GoSS water related institutions, monitoring networks, databases, and facilities to process and analyze water resources-related information are not well developed or functioning effectively. The data that do exist is mainly information related to groundwater and domestic water in the form of data points, boreholes and hand pumps. Most of the other data and information are often scattered across several government institutions and departments NGOs and IGOs and are difficult to access. Differences in data collection, processing, and record-keeping procedures within the different institutions across Southern
Sudan (and even the Federal Government) mean that data are often inconsistent. This creates problems in providing adequate assessments. As coordination among water related institutions grows across the South, accurate information will be critical for informed decision-making and priority-setting at GoSS and State levels. Integrated water resources management at all levels will depend upon access to reliable information, as well as adequate modeling and decision support tools to analyze the information as per the proposed WIS in the introduction to this chapter.

113. Various different water technologies have been used in Southern Sudan with some proving unsustainable in the long run. Furthermore, integrated water resources management is a complex process which takes into account environmental, ecological and socio-economic concerns in the planning and management of the resource aimed at solving the problems of supply, demand and control. This scenario calls for research and technological innovations for the purposes of allocating the available water resources to the needs of society in an efficient and cost effective manner.

114. There is a need to strengthen information and reporting systems in order to ensure effective monitoring and evaluation of service levels and quality and to provide adequate, affordable and sustainable safe water supply services to the rural and urban population on an equitable basis.

5.3 The Proposed Water Information System (WIS)

115. The features of the proposed Water Information System (WIS) are shown in Fig 5.1 and Fig 5.2. The proposed system has been previously discussed with the undersecretary of the MWRI GoSS and his staff during the visit of the consultant to Juba in February 2010.

116. One of the main components of the WIS will be an upgraded hydrological Information system (HIS). HIS which will include the collection of meteorological, surface and groundwater field data at the required intensity and frequency from an upgraded and adequate network, time-effective transmission; data checking, collation, processing and analysis. A Spatial Data System (SDS) is proposed to be linked to HIS which includes GIS datasets, satellite imageries, areal surveys data from bathymetric and other surveys. Other components of WIS are Information Management System (IMS), Knowledge Management System (KMS), and the Data Storage and Dissemination System (DSDS). HIS data
supplemented by other basin data, is transformed in IMS to higher level standard information products for ready use by water resources practitioners, and transformed in KMS to knowledge products through more complex but standard models and decision support systems (DSS).

5.3.1 Hydrological Information System (HIS)

117. The primary role of the HIS is to provide reliable data sets for long-term planning and design and to frame rules for management of water resources and water use systems and for research activities in related aspects. It would also be desirable that the system functions in such a manner that it provides the information to users both timeously and in the appropriate format. The scope of HIS is also extended to provide real-time data to users for rainfall and flood forecasting for effective flood preparedness. Real or quasi-real time data is also useful for optimizing stations visits in order to carry out timely maintenance, discharge measurements, sediment sampling and to effect maintenance as soon as measurement problems occur.

118. The HIS includes both the physical infrastructure and human resources to collect, process, store and disseminate data on hydrological, geo-hydrological, hydro-meteorological and environmental variables including data on sediment transport. The physical infrastructure includes observation networks, laboratories, data communication systems and data storage and processing centres equipped with databases and tools for data entry, validation, analysis, retrieval and dissemination. The human resources refer to well trained staff with a variety of skills to observe, validate, process, analyze and disseminate the data. The HIS would be demand driven to cater for the expected application, use standard equipment and follow acknowledged and standardised procedures for data collection and processing, develop a computerised, comprehensive and easily accessible database, and appropriate infrastructure and institutional capability to ensure sustainability. HIS should be linked to WIS to the facilitate a holistic approach to Integrated Water Resources Management (IWRM)

Spatial Data System (SDS)

119. SDS would integrate data from satellite imagery, thematic maps, DEM, remotely sensed hydrologic measurements, Aerial surveys, ground surveys, topography, river section, bathymetric surveys, etc.
5.3.3 Other Components of WIS

Information Management System (IMS)

120. Interfacing HIS with Knowledge base, water use data and Hydrological Design Aids (HDAs) would be necessary to produce information products for ready use in water resources planning and management. Development of hydrological design aids in Surface Water (SW), Groundwater (GW) and Water Quality (WQ) domains would use appropriate HIS data for the creation/development of standardized information products using well-established and internationally acceptable methodologies. This would usher in a uniform approach to the hydrological assessment of both gauged and un-gauged catchments including the automatic interpretation of groundwater data where possible. Some possible HDAs could be: Rainfall: Depth-Duration-Frequency (DDF) curves for short-duration rainfall (1, 6, 12, and 24 hrs) and Probable Maximum Precipitation (PMP) estimation using available Autographic Rain Gauge (ARG) data; Probable Maximum Flood (PMF); point rainfall to areal rainfall (Area Reduction Factor, ARF) on a regional basis; estimation of areal rainfall using Thiessen polygon or other methods. Evapotranspiration(PET)/Crop Water Requirements (CWR) and Irrigation Requirements (IR), monthly/seasonal/annual flows of different probabilities at a gauging site; flood magnitudes/frequencies (estimation of mean annual and return period floods); and hydrological assessment of un-gauged catchments.

Decision Support System (DSS)

121. Based on the output of the IMS s decision support system should be proposed which enables the decision maker to investigate various water management scenarios and chose between them.

Knowledge Management System (KMS)

122. Models and DSS proposed by the consultant would be interfaced in the WIS to transform processed HIS and other basin data into knowledge products addressing WIS functions including basin planning and management.

Data Storage and Dissemination System (DSDS)

123. Users would be able to access the raw and processed data, information products and knowledge products through various options eg physical or online through a email/letter
request. The Consultant will be required to make proposals on how the protocols should be established based on an assessment of both needs and international practice.
Figure 5.1 Major Components of a Water Information System (WIS)

- Decision Support System (DSS)
- Knowledge Management System (KMS)
- Information Management System (IMS)
- Stakeholders (End-Users)
  - Portal
  - Physical
  - Online

Data Storage and Dissemination System (DSDS)
- Hard Copies Facility
- Electronic Facility
- Linkage to Other database

- Knowledge Base
- Water Use Data
- Design Aids
- Relevant Publication
- Capacity Development
- Socio-economic
- Relevant Models, DSS
- Others

- Agriculture
- Water Supply &
- Hydropower
- Environment
- Others

HIS
Figure 5.2 Hydrological Information System (HIS)
6. Data Analysis and Gaps

124. The discussions in previous chapters suggest that there should be a review of the current hydro-information networks to establish an effective monitoring system at the field level covering all the basins of Southern Sudan to provide historical and up to date information needed for planning, design and operation of relevant projects and services. This new monitoring system should utilize current developments in data collection and transmission to centers for collation, processing, analysis, storage and dissemination. Current tools such as Remote Sensing (RS), Geographical Information System (GIS), and telecommunication should be utilized where appropriate situations exist. Such a system should be linked to the current development in satellite imagery, data in relevant sites at the internet including publications and guidelines from relevant UN agencies such as WMO, UNESCO, FAO and WHO. The overall system should aim towards establishing an effective Water Information System (WIS) built around an integrated hydraulic information system (HIS) that includes meteorological, hydrological, groundwater, quality, and sediment data. This would also require a survey of needs in capacity, institutional and human resources, as well as infrastructure, equipment and soft- and hard-ware to operate HIS and WIS.

125. Similar to the previous chapters, this chapter is subdivided into the following subsections:

a. Meteorological
b. Surface Water Hydrology
c. Ground Water Hydrology
d. Water Usage
e. Water Quality Data Collection Including Sediment.
f. Capacity Gaps

6.1 Meteorological Data

126. Meteorological data is essential for proper water resources assessment in Southern Sudan. Some data is available from the Sudan Meteorological Department and other sources. However, the data is insufficient and has many gaps. It needs to be completed and thoroughly checked in order to have more confidence in it. As has been mentioned before, the meteorological network has undergone severe deterioration over the past years and most of the stations are not functioning at present. Based on that an adequate meteorological
monitoring network for GoSS should be re-designed to meet the various purposes (Planning, designing and management) of the elements of the water sector. This new exercise should consider the capacity development needs as well as equipment and infrastructures.

6.2 Surface Water Hydrological Data

127. The surface water in Southern Sudan is huge, but its monitoring is a great constrain. There were 85 gauging stations in Southern Sudan operated by the Egyptian Ministry of Irrigation. However, today only five gauging stations are functioning. These include Mellut, Malakal, Hillet Doleib, Joba and Mangala. The non-operating gauging stations include nine stations on the White Nile, six stations on Sobat River, ten stations in Baro, five stations in Pibor, thirty seven stations in Bahr Al-Jabal, ten stations in Bahr Al Zaraf and one station at each of Adora, Aswa, Ateibi and Unyama.

128. A network of hydro-meteorological stations had been established and run by the P.J.T.C. in the Basins of Bahr el Jebel, Bahr el Ghazal, the Sobat and Machar Marches for the finalization of studies relevant to the diversion projects necessary for the reduction of the water losses in the swamps, but they stopped operation. The collected information from these two networks are available with P.J.T.C. Data from these network need to be collected and evaluated with the objective of proposing an adequate monitoring network for the future management and development of the water resources of Southern Sudan. This should include both the capacity infrastructure and equipment needs.

129. Another noticeable gap is in the capacity (particularly Human resources and institutional) to operate, monitor and manage the proposed monitoring network. This could be a more comprehensive assessment for all their needs together with a strategy to meet there requirement, in the short and long terms, including its financial cost and phasing of implementation

6.3 Groundwater Data

130. The groundwater potential in South Sudan is large; however, the data and information required for comprehensive assessment and management is incomplete. In addition to the groundwater database, the proposed Hydrological Information System (HIS) should contain the following information, which at present are not sufficiently available for the different basins in South Sudan:

- Groundwater levels monitoring network
• Groundwater quality monitoring network
• The vertical extent, the thicknesses and saturation limits of aquifers and aquitards in the different basins
• The hydrogeological properties of aquifers and characterization of groundwater flow
• Recharge sources and recharge mechanisms for the different aquifers
• Water balance components and exchange of flow between surface and groundwater or between aquifers themselves in the different basins
• Groundwater exploration potential
• Groundwater quality and vulnerability to pollution risk
• Capacity development needs (Human resources, institutions, enabling environment)

6.4 Water Usage

With reference to the data availability on water usage the data gaps can be categorized based on the intended water consumption type as follows:

6.4.1 Water for agricultural Use:

The water requirement for plant growing is the most needed data parameter for effective irrigation water management and allocation. Water requirements for most of the crops cultivated in large agricultural schemes, such as rice, sorghum, sugar cane, etc., were studied. However detailed data on water/irrigation requirements as function of time, local environment, and cultivation practices are limited or not existing.

More surveys are needed to assess the total existing and proposed future irrigation area, types of agricultural product, irrigation practice, water needs and sources, and irrigation infrastructure (e.g. canals, pumps, well) for all of the Southern Sudan. This data should be utilized to estimate the needed human, institutional and financial resources to plan, design, operate and manage irrigation in Southern Sudan.

6.4.2 Water for Urban Municipal Use:

Though urban water has received a better attention in Southern Sudan since 1937 and more recently through good surveys such as the works undertaken by various donors and UN organizations (JICA, UNICEF), yet accurate or even good estimates of urban population are none-existing for the urban centers of Southern Sudan to identify the supply-demand gap. Consequently data on per capita consumption and total need can only be taken from estimates
in the literature. Metering of individual water consumers in main cities is a farfetched goal at this point, however, metering “water districts” within the distribution network will give some data on the consumption rates and will assist in assessing water losses through leakages or pipe bursts.

135. No facilities or equipments were installed at the water treatment plants or within the distribution network for real time data collection on treated water production losses and consumption.

136. Urban water is supply is not linked to sanitation which is an important consideration. All these gaps need to be considered in the forthcoming water study through surveys and analysis leading to identification of the need resources (human, institutional, equipment, infrastructure…etc) needed for better planning, designing, operating and monitoring the rural water supply in Southern Sudan.

6.4.3 Rural Water Supply:

137. Again more surveys to assess villages water supply level such as the survey made by the International Organization for Migration (IOM) for Northern Bahr El-Ghazal are needed to cover the rest of the villages in the whole Southern Sudan.

138. As mentioned before that even partial data on boreholes maintained with SSWICH contains over 60% of the boreholes locations and operational status as unknown. All the gaps discussed under the groundwater data gap and urban water gaps are applicable to the rural water supply program.

6.5 Water Quality Data Collection Including Sediment

139. Most of the water supply facilities that have been installed over the years (except the mentioned four traditional water treatment plants in Juba, Malakal, Wau, and Renk), have not been monitored regularly to ascertain the level and the trend of water quality and this presents a high risk to increase water related diseases, connected with bad environmental sanitation practices being exercised in most parts of Southern Sudan.

140. Regular water quality monitoring is a very important exercise for emergency preparedness and response to help in determining the level of contamination in the water points especially with regard to bacteriological contamination, which largely is influenced by the sanitation and hygiene practices of the people in water storage, handling and use.
Organized water quality sampling based on a fixed schedule is not started yet within the water resources sector in Southern Sudan. However, number of ad hoc surveys was carried out by GoSS and groups affiliated with different NGOs. For example, in 2007, over 250 water sources have been tested in the Kajo Keji area and more than 171 were found to contain e-coli bacteria\(^4\).

Moreover it is believed that several of groundwater boreholes are microbiologically tainted or have high salinity water. Regular monitoring, after the boreholes are put in use, is of utmost importance to assure sustainability and safe usage.

For the design of dams and their proper operation in the future, sound data on native streams sediment load need to be monitored and kept. Most of the irrigation schemes in northern Sudan suffered from high siltation within the channels and at hydraulic structures. GoSS need to be prepared to factor these problems, preemptively, in the design stage. However, this can only be facilitated by a continuous monitoring program for sediment content of all natural streams and should be incorporated in the proposed Water Information system.

**6.6. Gaps in Capacity Development**

**6.6.1 Capacity Development:**

One of the major causes of the capacity gaps in the water sector and related institutions in Southern Sudan is that the water sector is newly established with a few good experienced staff. However, the small number of newly inexperienced intakes and the available generation gap among the staff already exist in the sector have affected to a large extent the performance of the sector.

The existing training institutions in Southern Sudan lack the sufficient operating funds and the competent staff in water resources science. They need to be consolidated and supported through provision of adequate abroad training for their staff, appropriate working budgets and technical assistance. A recent limited abroad training for professionals in the water sector has been started following the signing of the CPA. This will create opportunities to fill in part of the gap through the available abroad training programs; however, the establishment of a center of excellence of water education and research in Southern Sudan is

\(^4\) http://www.iteams.ca/impact_southern_sudan.php
a necessity at this juncture. Technical assistance is another form of filling the gap in water education and institutional strengthening and could be in the form of expertise in the field of training to help the water sector institutions build and develop in-house training programs, and training of trainers.

145. The Federal water research institutes have suffered greatly in the last decades due to the curtailment of foreign grants and low operational budgets. The suggested center of excellence in education and research needs to be supported in kind of infrastructure equipment, staff, communication with regional and international similar institutes and sufficient budgets.

6.6.2 Needs Assessment:

146. One way of improving water resources management in Southern Sudan is through capacity development programs, in which training is a major component. The training needs and institutional constraint assessment is considered an important phase of identifying the existing gaps in skills among the personnel within an institution. At the GoSS and States level, many difficulties face the institutions involved in the water sectors. The use of new technologies such as electronic equipment for the collection, processing, remote sensing analysis, retrieval and publication of data is becoming a vital necessity for water resources assessment.

147. Remote Sensing and Geographic Information Systems (GIS) have a great role to play in water resources development and management. They provide significant opportunities for improvement in both data acquisition, saving and retrieval. Therefore, a specialist in remote sensing and GIS fields is urgently needed to conduct a training course in Southern Sudan for a group of practitioners that represents the various institutions in the various sectors. This is more favorable because many can be trained locally, perhaps at lower cost than of sending two or three to be trained in these fields abroad. The anticipated outcome from these types of courses will be significant. Also there are urgent needs in training senior staff in some relevant fields. These fields include socio-economic environmental modeling of water resources development programming, negotiations and conflict resolution techniques, water law and various fields of computational hydraulics, in particular, water resources modeling and water resources assessment and management.

148. Few specific gaps can be summarized as follows:
• Southern Sudan Water and Sanitation Sector Steering Committee (SSWSSSC) [comprises in addition to the Ministry of Water resources and Irrigation, the Ministry of Cooperatives and Rural Development (MCRD), the Ministry of Housing, Physical Planning and Environment (MHPPE) that is responsible for urban affairs and Ministry of Health (MoH) responsible for sanitation and hygiene)] is mandated for cross-cutting aspects related to water supply and sanitation. However, there is a need for the establishment of an independent authority at GoSS level to oversee water resources management in the overall Southern Sudan with gradual decentralization of regulatory responsibility. The new body should be mandated to formulate the general water policy of Southern Sudan in addition to the assessment, conservation, utilization and management of water resources and to review the legislations for water utilization and suggest the needed amendments. The body could be headed by the President of GoSS and includes Ministers from different water related disciplines (i.e. water resources, energy, education, health, environment, agriculture, livestock, fisheries, transport, industry, etc) and States Ministers related to water and prominent figures who are concerned with water issues. In the transboundary dimension, the body should be entitled to take decisions and resolutions regarding the mutual water utilization requirements of the transboundary water courses and aquifers.

• An integrated approach to water resources planning should be developed on the basis of natural hydrological basins. The existing situation is that administration boundaries are now governing the management of water basins; however, river basin or catchment area are usually the basic units for planning and management of water resources and should be clearly delineated.

• The involvement of water users in the planning, management and development of water resources in Southern Sudan is not well established in most of the water related sectors. Specific measures should be taken to enable active involvement of water users and stakeholders from other sectors in planning processes that will lead to the development and management strategies. In addition, rural communities should take an active role in planning, managing and financing Rural Water Supply and Sanitation (RWSS) schemes on a participatory basis to ensure sustainability.

• The existing situation related to the institutional issues of water resources in Southern Sudan is that functions related to regulation are interlinked with functions related to delivery. It is necessary to develop an effective institutional framework in which
functions relating to regulation are separated from those relating to delivery i.e. the regulatory and delivery functions for UWSS shall be earned out by separate institutions. Responsibility for regulation, delivery and management of UWSS services shall be decentralized to the lowest appropriate level, in accordance with the principle of subsidiarity.

- Regarding the RWSS, an appropriate institutional framework should be developed that incorporates clear separation of functions relating to regulation and service delivery.

- The roles and responsibilities of government, private sector and NGOs in developing and managing UWSS facilities are not clearly defined, including arrangements for working in partnership and mechanisms for coordination and collaboration with RWSS and other sectors. Where capacity exists, responsibility for development and management of UWSS services shall be progressively decentralized and Urban Water Corporations shall be supported to become semi-autonomous entities. UWSS sector organizational structures at all levels could be strengthened and capacitated in order to fulfill their new roles and responsibilities.

- It is a key priority for the MWRI to establish effective semi-autonomous structures to manage the operation and maintenance of UWSS at decentralized levels. The introduction of efficient management practices and effective revenue generation mechanisms will improve the financial sustainability of UWSS systems. The overall quality and effectiveness of institutions could be improved through technical and management training of staff working at all levels in UWSS services. The private sector could be involved where appropriate in the operation and maintenance of UWSS infrastructure.

- The role of government in the Rural Water Supply and Sanitation (RWSS) sub-sector is direct implementation. This role could be shifted to regulation, facilitation and coordination. GoSS level authorities have an important role to play in development of policies, strategies and guidelines to ensure coordinated development and management of the RWSS sub-sector, but responsibility for planning and managing service provision shall be handed to lower levels of government. State and County level water authorities are suitable to respond to the needs and priorities of their constituents and are expected to take a major role in coordinating and regulating RWSS development activities at a local level.
• The private sector and NGOs are now playing an important role in supporting communities to develop and manage their own RWSS facilities. However, this approach to RWSS service delivery should be institutionalized. Hence, an appropriate institutional and legal framework shall be developed to reflect the role of government and streamline government departments responsible for RWSS to ensure efficient and effective functioning.

• The roles and responsibilities for communities and local authorities regarding the planning, financing and management of infrastructure development and subsequent operation and maintenance is not clearly defined within the institutional framework and legally recognized. Guidelines shall be developed to encourage the participation of user communities in all aspects of the RWSS project cycle, including planning, design and construction, and empower them to make informed decisions regarding selection of different technology options. User communities shall be mobilized and trained to gradually take over full responsibility for management and financing the operation and maintenance of RWSS scheme. This including development of procedures to facilitate registration of water user groups as legal owners of rural water supply facilities in order to empower communities to manage schemes themselves.

• The Water Resources Policy of 2007 was approved as a general framework dealing with issues related to water resources of Southern Sudan. Regulations dealing with groundwater and surface (Wadis) water should be drafted. Now, there are no rules or regulations governing the utilization of both the groundwater and Wadis water resources. Individuals, organizations, and private companies are aggressively exploiting the groundwater resources without having to obtain any permit or authorization. Accordingly, the number of established wells, structures, or installations is not known. Whether these installations comply with the appropriate standards is also not known as well as the uses to which these different installations are put, resulting in a significant water table drawdown in some areas and pronounced water quality deterioration in others.

• The States’ domestic water supply authorities are linked to the Urban Water Supply and Sanitation (UWSS) corporation in the joint management for the implementation of the donor, foreign assistance projects and GoSS financed projects, and the capacity building to improve the efficiency and quality of the water supply industry on a cost
effective basis to ensure sustainability of the water supply utilities. However, there are some major issues in the implementation of the drinking water policies:

- The GoSS role in the supervision and quality assurance inspection of the water utilities at the State level has to be clearly determined and practiced.
- GOSS should not be absent in the establishment of water utilities which are carried out at the State level. GoSS consultation, particularly in low yield streams that run for only short periods of the year with high sporadic, but short duration flows, could lead to over exploitation and full damage to the resource.

• Water Policy: It is worth mentioning that the Water Resources Policy of 2007 is the first great stride on the right track to attain integrated water resources development and management in Southern Sudan. However, policies are dynamic documents which need to be updated regularly. Annex II.5 contains some areas that need to be considered in the future updating of this policy document however we recommend that this should be given due consideration in the current strategy (under preparation) and any related plan of action.
7. Recommendations

149. This report has focused on preparing a stocktaking of the water sector in Southern Sudan, followed by rapid assessment and analysis, identification of gaps and preparation of a TOR for a study aiming toward the design of a Water Information System (WIS) for MWRI-GoSS. For testing the functionality of WIS, it has been required in the TOR to undertake a comprehensive water resources assessment exercise in a pilot sub-basin and incorporate the collected information in the Southern Sudan Water Information Cleaning House (SSWICH) as a platform for such a test. The methodology of assessment in the sub-basin would be a good pilot exercise for undertaking a wider comprehensive water resources assessment covering all the sub-basins of Southern Sudan at a later stage. Thus it is strongly recommended that MWRI undertakes a comprehensive Water Resources Assessment (WRA) covering all basins and sub-basins of Southern Sudan, as soon as funds are available, being an important pre-requisite for any rational management of these resources. Furthermore, the information collected from the WRAs will represent the essential information entry to HIS and WIS. Without such information HIS and WIS would not be operational. A preliminary TOR for the WRA is attached as Annex III.

150. Two other important recommendations, that are added here include:

a. MWRI should immediately search for resources to install monitoring equipment in the proposed pilot-basin linked to the proposed WIS’s TOR in order to provide key data needed for testing HIS/WIS functionality within the facilities of SSWICH. This may include monitoring of meteorological, hydrological and groundwater parameters, including quantity and quality.

b. Since the facilities of SSWICH are proposed as platform for testing the functionality of HIS/WIS, it is also strongly advised to be prepared for the possibility of procurement of additional equipment and facility to make it operational for this testing exercise.
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Site to be visited:
Beside the Websites indicated in the footnotes inside the report
* www.UNESCO.org/water/wwap/

Useful Information
Various MWRI’s internal reports & presentations provided by the Undersecretary
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A. Background

A.1 General: The southern Sudan region expands on clay plains that extend to the south with gradual uphill slopes to the mountains on the Sudan-Uganda frontier to the water divide, which represents the southern boundary. At this frontier the mountains series of the Imatong, Didinga, and Dongotono rise to more than 3,000 meters. The region also expands in the west from the borders with Central African Republic eastward passing through low lands of the White Nile Valley and the Sudd wetland to the Ethiopian highlands. The region extends from latitude 3° 30' N to approximately latitude 10° N and from longitude 24° E to longitude 36° E. Southern Sudan makes up about 27% of the total land area of Sudan, covering about 640,000 km².

The average annual rainfall approximately ranges from 500-600 mm/year to more than 1500 mm in the south-western part of the region. On the other hand, potential evaporation decreases from a maximum annual value of 2400 mm to a minimum annual value of less than 1400 mm in the south-western part of the region. Another important observation is that rainfall in Southern Sudan suffers noticeable decreasing trend accorded to climate change though it is relatively less in comparison to the northern part of the country.

Southern Sudan is rich with its surface water resources. Figure 1 gives a broad picture of its major surface water resources components. Numerous studies have been made about the hydrology of the Nile River system in general and of the Equatorial Lakes in particular.

Fig. 1: Southern Sudan water resources components (IRG, 2007)

Southern Sudan embraces the majority of three main river sub-basins, namely, River Sobat, the Bahr el-Jebel and the Bahr el-Ghazal (see Figure 2). Bahr el-Jebel flows in the center of the valley subdividing the southern Sudan into two regions. The western part of mostly red clay plains is referred to as the Ironstone Plateau (Jabal Hadid), a name derived from its laterite soils and increasing elevation toward the water divide to the Congo-Nile watershed.
Groundwater could be an important source for water supply for Southern Sudan if linked with the rich surface water resources and water harvesting. A huge part of the region is underlain by the water rich Umm Ruwaba sedimentary formation, while in other parts; search for groundwater should concentrate on fractured and weathered zones of the basement complex. The relation between Umm Ruwaba formation and the overlaying surface water, particularly in the swamps zones, is poorly understood and more information could be reached through the development of more accurate water balance studies. Though there are many hydrogeological maps developed within the last decades for the Sudan as a whole, more detailed studies may be needed in the south for identifying the characteristics of these formations, quality of their water, and their source of recharge.

Water resources are underdeveloped with very limited infrastructure and most of them not functional. Water is used to serve various needs: domestic, livestock, wildlife, forestry, agriculture, mining, and ecological needs. Upper catchments degradation result from sediment transported during the flood season. Water Scarcity is also due to prolonged drought and inefficient water use. There are additional issues related to sand dune encroachment in the Nile course and the volume of water that is lost to evaporation in the Sudd region.

The Ministry of Water Resources and Irrigation (MoWRI) is the sole custodian of Southern Sudan water resources. There is a Water Sector Steering Committee consisting of governmental and non-government stakeholders in the water sector. The Water Policy envisages other structures such as a “Water Council”, “Water supply and Sanitation Boards”, etc., as part of an Integrated Water Resources Management (IWRM) implementation strategy. The institutional streamlining is yet to be done from Government of Southern Sudan (GOSS) to state and county levels.

A Water Policy for GoSS was enacted in November 2007. The goals on water resources development have been identified in this policy document as “to promote effective management of quantity, quality
and reliability of available water resources in order to maximize social and economic benefits while ensuring long-term environmental sustainability. The water resource management advocates integration of different aspects of water resources management widely recognized as the key to achieving the overall goal.

Rational water resources management in Southern Sudan sub-basins calls for a sound Water Information System (WIS) covering all water-related data, supported by an upgraded hydrological network (HIS) to collect field data at required intensity and frequency and time-effective transmission; spatial GIS datasets; data from bathymetric and environmental surveys; and institutional strengthening. On water resources assessment and monitoring, the GoSS Water Policy (Nov. 2007), states that “the long term objective is to move towards an integrated approach to water resources assessment and monitoring which brings together multiple different sectoral interests in the development of water use plans on the basis of hydrological catchment areas. Procedures for systematic assessment and monitoring of water resources development will need to be developed and basic systems (e.g. databases) established for collecting, storing and processing accurate and timely information on surface and groundwater resources with regard to quantity, quality, location, demand and patterns of use and making the same accessible to those tasked with planning and implementing projects.”

The Ministry of Water Resources and Irrigation (MWRI), which is the sole custodian of water resources in Southern Sudan, acknowledges that the establishment of an adequate water information system (WIS) is a prerequisite for any successful assessment, planning, design, operation and rational management of water resources. A central pillar of WIS is a hydrological Information System (HIS). Other components of WIS cover all water related data including not only the characteristics and availability of water resources, but also the relevant data on existing and anticipated water demands for all sectors, data on capacity development, knowledge base information, socioeconomic and environmental information as well as supporting data from satellite imageries, aerial photographs, topographic maps and ground and bathymetric surveys. Such a water information system should also be equipped with various models, analysis tools; design aids and interface with a Decision Support System (DSS) that enable the decision makers take rational and optimum decisions on water resources management in Southern Sudan.

A.2 Water Supply and Sanitation Project: The US$30 million Water Supply and Sanitation Project supported by the Multi-donor Trust Fund is under implementation in Southern Sudan during 2009 - 2011. The development objectives of the project are, (i) increase access to safe water supply and sanitation in all states of Southern Sudan by building a sustainable management system (ii) develop the knowledge on water resources. The project focuses on the following: (i) development and rehabilitation of water supply facilities in rural areas and villages and trading centres across all States of Southern Sudan, and assessments, feasibility studies and design of water supply and sanitation systems for 7 state capitals (ii) construction of institutional latrines at health centres, schools and other relevant public buildings, promotion of household hygiene, (iii) building the capacities of the PMTs at the National level and in the States, through human resources development based on institutional capacity needs and provision of adequate infrastructure (such as office facilities, office equipment, transport); (iv) water resources management support through knowledge-based activities, and (v) continuation of development and improvement of an adequate Management Information System and provision of technical assistance to enhance overall execution and management of the Project.

The project will have the following major components, each supporting a range of activities. The components are water supply, sanitation and hygiene promotion, water resources technical support,
capacity building, and strengthening the data base and Project Management support. The detailed description of the components is as follows:-

Component 1 - Water Supply: This component will finance an additional 90 new boreholes; rehabilitation of 1050 existing boreholes; and a variety of other schemes (including 20 hand-dug wells, 20 new and 13 rehabilitation of small water supply distribution systems, 2 hafirs (surface open water reservoirs), 1 Water Distribution System with Treatment and 6 spring protection systems. In addition, this component will also finance the assessments, feasibility studies and design of water supply and sanitation systems for 7 state capitals (Bor, Rumbek, Yambio, Torit, Kuacjok, Aweil, and Bentiu). The focus will be on previously neglected areas identified from the MWRI database and in response to requests received from County and State authorities.

Component 2 - Sanitation and Hygiene Promotion: - Under Phase I, sanitation achievements were very modest as not enough emphasis was put on sanitation. In The WSSP more emphasis will be made on the sanitation component in both the rural and urban areas and the concept of Community Lead Total Sanitation will be promoted. The focus will continue to be on household, environmental and institutional sanitation, both in the rural and urban areas, such as in a number of public places, including schools, health facilities, markets and bus parks, and provision of equipment for sewage removal and disposal, with emphasis on effective delivery of key hygiene messages to effect behavioral change. MWRI will work more closely with MoH and MoEST before contracting institutional latrines at health centers and schools to ensure facilities are built where they are really needed and to avoid duplication. VIP type latrines will be promoted for those who can afford to build them. Unsustainable subsidies will be discouraged.

Component 3 - Water Resources Technical Support: - Given the prevailing conspicuous lack of accessible data on the water resources of Southern Sudan, a knowledge based activities of WRM as a component in the WSSP have been included. This is to provide technical assistance for designing a water information system for the water resources (surface and ground water) assessment in southern Sudan to enable collection of much-needed information on the water resources of Southern Sudan and development of guidelines on future activities. Establishment and equipping of water quality laboratories in state capitals including training of staff will be one of the main activities under this component.

Component 4 - Capacity Building: - The Capacity Building unit under RWSSP Phase 1 undertook a needs assessment of both institutional and human resource development needs across the 10 States. The results of the unit’s work are encapsulated in the RWSSP Capacity Assessment Report, which forms the basis for capacity building under this project. This component aims to build on the process of building capacity of staff, giving emphasis to gender balanced selection of staff, at the central and state levels in the management, monitoring, operation and maintenance of rural and urban water and sanitation utilities. The component will also provide for improvement of office space, provision of vehicles, office equipment, and furniture, acquisition of billing and collection systems for the water operations and the rehabilitation of Amadi National Training Centre. The capacity building will also include training by consultants during the feasibility study, design and construction phases.

Component 5 - Project Management Support and Strengthening MIS/Data Base: - This component includes the technical support to be provided to the Project Management Team (PMT), the operating expenses of the project and a continuation of the establishment and strengthening of database for water supply that was started under Phase I. The PMT will be supported by a technical assistance support team (TAST) whose composition and scope will be defined later. Under Phase I, a prototype Management Information System (MIS) and Water supply database has been developed and staff have
been trained on its structure, how to input data. Follow up on this and providing technical support for further effective use of the system and setting up a network to connect all the departments in MWRI including the 10 state directorates are important activities under this component.

The proposed technical assistance under “Component 3- Water Resources Technical Support” is aimed to take the first step in designing and operationalising the water information system. It is envisaged to design a comprehensive water information system under this component of the WSSP.

A.3 Water Information System: The establishment of an adequate water information system is a pre-requisite for any successful assessment, planning, design, operation and management of water resources systems. A substantial effort has been made by the Ministry of Water Resources an Irrigation (MWRI), GoSS in this direction and a new water information system called the Southern Sudan Water Information Clearing House (SSWICH) has been established. The key tasks of SSWICH are to collect and process data, undertake surveys, store, and disseminate all information related to water resources. In particular, their stated goals are:

- Build water information system infrastructure, e.g. hardware, network (LAN and internet) and software tools for data manipulation and retrieval.
- Measure sufficiency and functionality of the information center such as collection, processing, dissemination and geo-coding
- Build human capacity and support to run the information system
- Meet Ministry’s expectation of the center with respect to data handling.

Although SSWICH operates under the directorate of Rural Water Supply and Sanitation of the MWRI, it contemplates in each state government provision of a data base officer(s). In effect, some states already have their database officers. Component 3 of the Southern Sudan Water Supply and Sanitation Project (SSWSSP) entitled “Water Resources Technical Support” plans to enhance SSWICH in a phase wise approach.

Data Available in SSWICH: The total water points and drilled logs entered in SSWICH database are 9,000, of this number only 44% is confirmed operational water points, the rest are comprised of unsuccessful, dry, low yield, cases of collapsed, and a good number is recorded as unknown or “no information”. Types of water points include: Boreholes - BH, Water yards - WY, springs - SPR, Hand Dug Wells - HDW, Hafirs, and Rain Water Harvesting points. There are about nine or more water yards. Longitude, latitude, State, County, Payam, Boma, Village and sites designate location. However, points with long & latitude coordinates are about approximately 20% of the stored points. The use of GPS is recently introduced in CPA era. Water levels within boreholes range from 7m to 60m in the records according to the details of drill logs reports from the field. These levels are recorded to only 16% of the existing data records. Facilities equipped with hand pumps are approximately 70%, though most of the equipped facilities are not functional for a reason or the other. No data on stream discharges is recorded yet in SSWICH database. But there are about ten stream gauging Stations. Some of the difficulties facing SSWICH in data collection are, (a) finance for field survey operations, (b) currently not enough personnel to undertake all require operations; (c) security is a major concern during field surveys. However, remote telemetry was not investigated; and (d) space, monitoring facilities, staff and equipment. In spite of these deficits, SSWICH represent a good start for a water information system. However, rational water resources management calls for a more comprehensive water information system (WIS) covering all water related data including not only the characteristics and availability of water resources but also data on existing and anticipated demands in all sectors as well as supporting data from satellite imageries, aerial photography, topographical maps, ground surveys, and data on capacity development, knowledge base and socioeconomic information.

Assessment of the Existing System: Despite the launching of the SSWICH project; currently the water resources sector in the Southern Sudan lacks the procedures for systematic assessment and
monitoring of water resources development and basic systems (e.g. databases) established for collecting, storing and processing accurate and timely information of surface and groundwater resources with regard to quantity, quality, location, demand and patterns of use and making the same accessible to those tasked with planning and implementing projects.

GoSS water related institutions, monitoring networks, databases, and facilities to process and analyze water resources-related information are not well developed or functioning effectively. The data that do exist is mainly information related to groundwater and domestic water in the form of data points, boreholes and hand pumps. Most of the other data and information are often scattered across several government institutions and departments, NGOs and INGOs and are difficult to access. Differences in data collection, processing, and record-keeping procedures within the different institutions across Southern Sudan (and even the Federal Government), mean that data are often inconsistent. This creates problems in providing adequate assessments. As coordination among water related institutions grows across the South, accurate information will be critical for informed decision-making and priority setting at GoSS and State levels. Integrated water resources management at all levels will depend upon access to reliable information, as well as adequate modeling and decision support tools to analyze the information as per the proposed WIS in the introduction to this chapter.

Various different water technologies have been used in Southern Sudan with some proving unsustainable in the long run. Furthermore, integrated water resources management is a complex process, which takes into account environmental, ecological, and socio-economic concerns in the planning and management of the resource aimed at solving the problems of supply, demand and control. This scenario calls for research and technological innovations for the purposes of allocating the available water resources to the needs of society in an efficient and cost effective manner.

There is a need to strengthen information and reporting systems in order to ensure effective monitoring and evaluation of service levels and quality and to provide adequate, affordable and sustainable safe water supply services to the rural and urban population on an equitable basis.

The features of the Water Information System (WIS) proposed are shown in Fig 3 and Fig 4.5. The proposed system has been previously discussed with the undersecretary of the MWRI GoSS and his staff during the visit of the consultant to Juba in February 2010.

One of the main components of the WIS will be an upgraded hydrological Information system (HIS). HIS which will include the collection of meteorological, surface and groundwater field data at the required intensity and frequency from an upgraded and adequate network, time-effective transmission; data checking, collation, processing and analysis. A Spatial Data System (SDS) is proposed to be linked to HIS, which includes GIS datasets, satellite imageries, and aerial surveys data from bathymetric and other surveys. Other components of WIS are Information Management System (IMS), Knowledge Management System (KMS), and the Data Storage and Dissemination System (DSDS). HIS data supplemented by other basin data, is transformed in IMS to higher-level standard information products for ready use by water resources practitioners, and transformed in KMS to knowledge products through more complex but standard models and decision support systems (DSS).

Hydrological Information System (HIS): The primary role of the HIS is to provide reliable data sets for long-term planning and design and to frame rules for management of water resources and water use systems and for research activities in related aspects. It would also be desirable that the system functions in such a manner that it provides the information to users both timely and in an appropriate

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5 The section is based on Preliminary Water Information Assessment Study- Final report (June 2010), prepared by Prof. Abdin Salih for MoWRI, GoSS, funded by the World Bank.
format. The HIS includes both the physical infrastructure and human resources to collect, process, store and disseminate data on hydrological, geo-hydrological, hydro-meteorological and environmental variables including data on sediment transport. The physical infrastructure includes observation networks, laboratories, data communication systems and data storage and processing centres equipped with databases and tools for data entry, validation, analysis, retrieval and dissemination. The human resources refer to well trained staff with a variety of skills to observe, validate, process, analyze and disseminate the data. The HIS would be demand driven to cater for the expected application, use standard equipment and follow acknowledged and standardised procedures for data collection and processing, develop a computerised, comprehensive and easily accessible database, and appropriate infrastructure and institutional capability to ensure sustainability. HIS should be linked to WIS to the facilitate a holistic approach to Integrated Water Resources Management (IWRM).

Spatial Data System (SDS): SDS would integrate data from satellite imagery, thematic maps, DEM, remotely sensed hydrologic measurements, aerial surveys, ground surveys, topography, river section, bathymetric surveys etc.

Information Management System (IMS): Interfacing HIS with Knowledge base, water use data and Hydrological Design Aids (HDAs) would be necessary to produce information products for ready use in water resources planning and management. Development of hydrological design aids in Surface Water (SW), Groundwater (GW) and Water Quality (WQ) domains would use appropriate HIS data for the creation/development of standardized information products using well-established and internationally acceptable methodologies. This would usher in a uniform approach to the hydrological assessment of both gauged and un-gauged catchments including the automatic interpretation of groundwater data where possible. Some possible HDAs could be: Rainfall: Depth-Duration-Frequency (DDF) curves for short-duration rainfall (1, 6, 12, and 24 hrs) and Probable Maximum Precipitation (PMP) estimation using available Autographic Rain Gauge (ARG) data; Probable Maximum Flood (PMF); point rainfall to areal rainfall (Area Reduction Factor, ARF) on a regional basis; estimation of areal rainfall using Thiessen polygon or other methods. Evapotranspiration (PET)/Crop Water Requirements (CWR) and Irrigation Requirements (IR), monthly/seasonal/annual flows of different probabilities at a gauging site; flood magnitudes/frequencies (estimation of mean annual and return period floods); and hydrological assessment of un-gauged catchments.

Decision Support System (DSS): Based on the output of the IMS’s decision support system should be proposed which enables the decision maker to investigate various water management scenarios and the likely outcome under each of them to develop optimal plans.

Knowledge Management System (KMS): Models and DSS proposed by the consultant would need to be interfaced in the WIS to transform processed HIS and other basin data into knowledge products addressing WIS functions including basin planning and management.

Data Storage and Dissemination System (DSDS): Users would be able to access the raw and processed data, information products and knowledge products through various options e.g. physical or online through an email/letter request. The Consultant will be required to make proposals on how the protocols should be established based on an assessment of both needs and international practice.
Figure 3 Major Components of a Water Information System (WIS)
B. Objectives

The objective of the proposed consultancy is to design and pilot a comprehensive Water Information System (WIS) for Southern Sudan covering all water-related data (water resources and water use/demand, climate, ecology and environment, surface and groundwater, quantity and quality data), a
central pillar of which will be an upgraded hydrological information system (HIS) that will include the collection of field data at the required intensity and frequency, time-effective transmission; data processing and analysis, spatial GIS datasets; data if available from bathymetric and environmental surveys; data from special studies including use of weather radar; and institutional strengthening/capacity building.

C. Scope:
The consultancy service would cover two distinct parts.

**Part 1:** The first part will cover the design and testing of a Water Information System (WIS) with details of attendant operations and maintenance needs for Southern Sudan. The features of the proposed water information system are as described in Section A.3 above.

**Part 2:** The second part will deal with a comprehensive assessment of water resources through the implementation of the designed water information system in a pilot sub-basin (Kuron in Upper Pibor Catchment in Eastern Equatoria, PSB), as a testing platform for the functioning of HIS/WIS.

D. Key Tasks:
The key tasks under the different consultancy phases are arranged systematically. This will either involve a tasks being implemented after the successful completion of prerequisite tasks or it may call for certain tasks to run concurrently amidst the different consultancy phases. The phases would cover: a) Inception phase (up to 2 months from start), ii) Design phase (9 months from start), iii) Pilot Implementation and operationalization phase (15 months from start), and iv) Final reporting phase (18 months from start). This phased contract management will ensure successful completion of the assignment.

To achieve the above objectives more effectively, the consultant is advised to undertake the study in two interlinked parts. The proposed two parts are:

1. Design of an appropriate HIS/WIS for Southern Sudan;
2. Undertaking of a comprehensive Water Resources Assessment in the selected pilot sub-basins (Kuron, in Upper Pibor Catchment in Eastern Equatoria - PSB) and feed the collected information into the interlinked system of the newly designed and the existing information systems, to test proper functioning of HIS/WIS.

The various tasks to be carried out in each part are given below.

**Part 1:** Design of a Water Information System (WIS): The tasks related to WIS development should cover two inter-related activities: The first activity covers the development, implementation and operation of the HIS, and the second activity covers the development, implementation and operation of the overall WIS. The objective of the Hydrologic Information System is to a) review current status of water resources planning and management in Southern Sudan and take note of existing and planned information systems and databases as well as provide necessary linkages including data sharing mechanisms in the development of the HIS framework for the Southern Sudan, b) design detailed upgrading/strengthening of the HIS, c) provide support in procurement with preparation of specifications and tender documents for measuring and laboratory equipment, civil works at site and for data centres and laboratories for pilot area (Part 2). For the other components of WIS (SDS, IMS, DSS, KMS etc), the design would be based on the definition of business processes, data requirements, process specifications, output (reporting & decision making) and communication, and networking requirements. The WIS is visualized as an on-line, dynamic, distributed system in multiple locations, with functions,
data types, formats and quality standards, and the use including database management and decision support system. While in the background the WIS will function as a huge information system with process models, the front end will interface with Decision Support System (DSS) for water management action and response. Effective functioning of WIS will call for appropriate user interfaces and system interfaces, and updated data inputs. The dynamic nature of the system will call for plans to keep the database current and system upgradable. The selection of database management and GIS software will depend on functional needs, upgradability, sustainability and local skills. The WIS specifications consider possible integration of existing computer and communication assets to reduce fresh outlays and implementation period. The communication and networking requirements would need to be identified. The System Requirement Specifications (SRS) include functional requirements and specifications, input-process-outputs, interfaces, communication aspects, processing methodology, and the implementation plan. The implementation plan provides the broad activity schedule and their inter-dependency, and the cost estimate.

Phase I. Inception Phase (up to 2 months from start): The Inception Phase is critical to successful implementation and would cover 2 months. The Inception Report at the end of the two months is expected to show a clear and complete understanding of the objectives, and describe the current scenario, expected improvements, other key studies/reports relevant to WIS development, stakeholders and responsibilities, key tasks, proposed methodology, activity schedule, deployment of consultant staff, reporting and review procedures and schedule, and deliverables. The consultative process underlying the ‘Needs Analysis’ and the preliminary conclusions based on interaction with key stakeholders will be covered. The report shall demonstrate a clear understanding of the current status of WIS, and the upgrade path based on the needs to which the HIS/WIS will have to respond. The result of the consultation process will contribute to the needs analysis that will guide the design of the hydrometric network and the other sub-systems of the WIS. The needs analysis will also contribute to the final choice of Hydrologic Design Aids (including their capabilities and limitations) that are to be developed and put in place under this consultancy. A first-cut list of standard models that would be interfaced with WIS would also be reported. Any improvement to the design and development process described in the preliminary report will also be covered.

Phase II. Design Phase (3 to 9 months from start):

a. Develop Framework HIS/WIS for Southern Sudan
   - Review global experience on WIS for lessons learnt from design and implementation of WIS in other countries.
   - Review current status of HIS data collection network, data flow and storage and access at basin/regional/county level in federal agencies.
   - Suggest arrangements between the federal agencies and regional state agencies for HIS data collection and data sharing.
   - Review HIS data needs for water resources assessment and identify gaps.
   - Evaluate current status of data collection, storage and dissemination and data sharing/communication linkages in MWRI and other relevant sector agencies; evaluate historic data availability, type and format and quality.
   - Evaluate existing infrastructure in regard to computer and communication equipment and human resources in federal/regional/county level agencies; take note of planned improvements; identify scope for integration in WIS.
   - Study IT and communication and networking initiatives at federal/regional/county level agencies; take note of planned improvements; identify scope for integration in BIS.
   - Develop/design WIS/HIS framework for Southern Sudan.

b. Design of HIS for Southern Sudan
   - Develop guidelines to upgrade the existing HIS considering the needs of water resources planning and management.
• Review proposed functions of various water agencies at federal/regional/county levels and define meteorological, hydrometric (both surface and groundwater), water quality and ecological and environmental data needs.
• Review current data collection and data recording practices, flow through regional offices to federal office, quality control, storage and dissemination processes, and identify gaps
• Define the HIS stakeholders in data collection and data use, and inter-relationships
• Conduct stakeholder consultation to finalize data requirements and identified applications and uses of data, information and knowledge products
• Suggest appropriate measuring equipment taking note of current deficiencies in meteorological and stream flow data collection, particularly in remote locations, high sediment flow, unstable river sections etc, and define measurement variables, frequency and period\textsuperscript{6} of data collection and transmission, periodic calibration requirements, etc
• Collect available meteorological records from all possible sources, during their respective periods of operation. Appropriate modelling techniques and satellite observations should be assessed for the prediction of un-gauged basins (such as PUB)
• Review need for strengthening stream flow measurements, and propose an action plan to strengthen stream flow network that takes into account technical, operational and logistical constraints.
• Review previous studies for preliminary mapping of aquifer extent and ground water flow; review available geological and hydrogeologic data; prepare hydrogeologic maps using satellite imagery and sample ground survey
• Develop plan for groundwater data collection (level, water quality) through existing water points and propose piezometer clusters and deep wells for ground water resource estimation.
• Review water quality data requirements, current status of sites, instruments, sampling procedures, laboratory capacity, and recommend strengthening/ upgrading for the entire chain of data collection-analysis-storage activities, including setting up water quality laboratories if necessary.
• In consultation with stakeholders and other relevant institutions, plan the strengthening of collection, processing and analysis of ecological information and water-related ecological/environmental data. These could include checking of stated in-stream flow requirements, compensation flows from reservoirs, ecological status of wetlands, fisheries biodiversity, etc.
• Design the overall network taking into account which variables are to be measured to capture the spatial and temporal variability in rainfall and river flow.
• Review historic data in regard to data quality, and suggest road map for processing and validation for integration in proposed HIS
• Conduct an assessment of existing water use, take into account how potential proposals for irrigated agriculture, hydropower, river transport, fishery development, recreation and tourism can be adequately assessed and planned using tools developed within the Water Information System
• Establish data flow between meteorologic agency, MWRI and regional units conducting the ecological/ environmental monitoring
• Review current data processing software for data validation and recommend improved maintenance or commercial software with assured upgrade path for data processing in the surface water, ground water, water quality and ecological/environmental domains. The data processing software should enable filling missing data and validating measured historical and current data. Develop and integrate database applications for data ingest, selective retrieval, database editing and updating, and exchanging data with external applications.
• Develop standards and design HIS database in consultation within the context of the overall spatial framework for Southern Sudan, to enable future seamless integration of sub-basin systems.

\textsuperscript{6} Some data could be collected only during the rainfall period; others may be collected round-the-year
• Describe data flow from observation site and laboratories through intermediate data processing centre\(^7\) to regional/federal data processing and Storage centre; define the institutional arrangements including staffing pattern and qualification requirements at each level.
• Develop design, operational, field and laboratory manuals in data collection, entry, processing, storage and dissemination of HIS data
• Develop HIS data dissemination strategy including user profiles and data requirements, data pricing policy, data dissemination policy, and mode of dissemination
• Review current and proposed staff structure of MWRI, its Branch offices and the Field Offices and propose staff requirement (including position, number, profile, and location) covering all HIS activities from data acquisition to dissemination.
• Recommend training requirements, plan and sources
• Develop HIS design, including data collection network\(^8\), data flow process, data storage and dissemination; manpower requirements\(^9\) and skill profile, cost of implementation and operational costs, training requirements and plan
• Develop plan for network implementation in phases, keeping in mind the procurement and ground preparedness aspects. The first phase shall include all key stations so that any implementation delay does not jeopardize the project objectives.
• Develop procurement plan
• Develop operation and maintenance manuals.
• Develop WIS as a distributed data archive, information, decision support and management information system – address information and decision process flow and timelines, functional requirements, data input, processing modules and outputs; and delivery systems taking note of technological developments; integration with existing and proposed IT initiatives and key studies and current infrastructure and data bases, system requirements (computer hardware, software, communication and networking, public alert/ warning systems, skill sets), organizational linkages, system specifications, implementation plan, and management plan including updating and upgrading and security aspects.
• Develop conceptual design and SRS including WIS hardware, software and communication network, as per internationally accepted standards. This would include user requirements and system functionality, user nodes, flowchart of data and decision flow and organizational linkages, system requirement specifications at multiple functional levels; Conceptual design of integrated modules of BIS, including interface between user agencies, systems and modules, taking into account existing and planned infrastructure; Functional specifications for computer hardware, software, and data bases, and communication and networking; Operational policies on system administration, including operation, maintenance, and upgrading, security, accountability and responsibility of system personnel and users, and skill upgrading.
• Design IS and sub-systems, including the basic architecture and generic structure, institutional arrangements and responsibilities, ICT requirements, meta database, etc.
• Recommend free or commercial relational database and GIS platform at user nodes such as Hydrology Department of MoWRI, and Data Centres at Basin and sub-basin level, taking note of functional needs at different nodes, upgradability, sustainability, and local skill level.
• Develop interfaces with existing and proposed databases and information systems
• Develop the implementation plan providing the broad activity schedule and their inter-dependency, staff/skill requirements, training plan and schedule, and modules, and the cost estimate. Define additional staff requirements.

c. Develop Spatial Data System (SDS) layers
• Design the SDS, including inputs, outputs and interfaces.
• Identify sources (and nature of spatial data sets) including other consultancy services planned in TBIWRDP which would provide spatial data

\(^7\) The need for additional data centre at intermediate level needs to be evaluated.
\(^8\) Network may consist of different type of sites where one or more-than-one variables may be measured, like gauge sites, gauge-discharge sites, gauge-discharge-sediment sites, etc.
Define the spatial data layers and map scale, projection and coordinate standards; define data sources, mapping methodology and map/digitizing standards, review GIS datasets as available.

- Develop spatial maps and attribute data, and integrate spatial GIS datasets in SDS
- Review Global hydrologic data (rainfall estimate and prediction, flood potential, lake water level, etc) and GIS datasets and integrate relevant data sets

d) Develop standard tools and applications including Hydrological design aids and develop interfaces
- Review user needs for information products and analysis support, and conduct stakeholder consultation to inform an analysis of development needs
- Develop standard tools and applications including Hydrological design aids for use of HIS and other data for generating information products for basin planning and management, watershed planning and management and M&E.
- Develop interfaces with DSS to be developed under a different consultancy, and identify data requirements and information and knowledge products.
- Develop interfaces to tools for monitoring ecological/environmental changes including goods and services accruing from the management of the system
- Develop loosely-coupled interfaces with standard models.
- Develop tools for archiving results of analysis
- Review institutional structure in MWRI and relevant agencies, and suggest capacity building, including additional staff, training, hardware/software, and other support
- Suggest partnership arrangements for data collection, product generation and use

e) Data access and dissemination
- Develop data access and dissemination protocols and mechanisms. The development of such protocols should be guided by international experience, best practices and discussion with the Client and stakeholders
- Design and develop the 'Water Portal' for on-line access and dissemination of raw and processed HIS data, information and knowledge products
- Develop other systems of data access and dissemination like email requests and physical delivery, periodic newsletters and bulletins, etc.

f). Procurement support
- Develop specifications for hardware, software and communications networking, design and specifications for data centres and water quality labs, global hydrologic data sets and GIS data sets, and standard hydrologic and hydraulic models

Part 2: Implementation and WIS for the pilot sub-basin (9-15 months):
For the suggested pilot sub-basin (Kuron sub-basin in Upper Pibor catchment in Eastern Equatoria), the efficacy of the design will be tested through implementation of the designed WIS. The implementation should be done factoring the existing system as developed for SSWICH but not be limited by it. The client will procure any additional hardware/software/other requirements based on the finalized design. The tasks will include:

a. Implementation and operational support
- Provide support in acceptance of equipment (measuring and laboratory equipment, HIS hardware and software) and during installation and integration, through Acceptance protocols, and assisting in acceptance.
- Provide support in site selection, site preparation, installation, and validation and signing-off, and formal and on-the-job training of staff in operation and maintenance, and data processing and storage procedures, etc. This requires that the Consultant will actively participate and initially take the lead during the installation and testing of new equipment.

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10 Improve the current DEM with SRTM data at 30 m grid is available under the Nile DSS
- Make recommendations on how sensor calibration of current meters and other measuring equipment (pressure transducers, water quality sensors etc) could be carried out within the country in a sustainable manner.
- Assist in the installation and use of the software for data entry (both current and historical), data processing, data storage, and dissemination and ensure that such software is fully operational
- Assist in establishment of data centres including communication facilities and their inter linkages etc., WQ labs, installation of equipment etc.;
- Assist in design and provision of training in relevant domain and software;
- Assist implementation of uniform guidelines, standard methodology and compliance of protocol for HIS data observations, entry and processing for rainfall and river data, ground water data & sediment data, and ecological/environmental data
- Provide timely technical support and trouble-shooting with regard to HIS establishment and operation
- Plan and develop ‘Help Desks’ for HIS maintenance and use and ensure that such Help-Desks are operational. The Help Desk will be an effective tool, especially in the post-project period, supporting online queries through FAQs on system maintenance and use, and customised responses to more complex queries.
- Assist in identifying and providing technical inputs for generating forms and formats for demand driven HIS data
- Provide support in collection, processing and storage of HIS data during one year of operation.

b. Implementation and Operational support

- Provide need-based support during hardware/software acceptance and integration,
- Assist in implementation of Data Centres and water quality labs and installation of equipment and ensure that they are operational
- Assist in procurement and integration of global GIS datasets and hydrologic and hydraulic models. Assist in implementing uniform guidelines and protocols for data dissemination and exchange with water agencies and other non-institutional users
- Provide support to operational validation of WIS

Human resources development

- Human resources training and development should be a main component of the project as this system is new. Detailed training plans including training resources would be developed for in-project and post-project periods. Training during project duration would be provided.

Phase IV. Final Reporting Phase (15-18 months): Prepare draft final report ad final report along with all manuals, annexure, etc.

E. Schedule of Completion of Tasks (Parts 1 and Part 2 of consultancy to run concurrently)

Part 1: WIS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Activity Completion/Report submission</th>
<th>Completion period after start (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Inception report</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Design of WIS, including design, operation, laboratory, sampling, reference, data sharing and dissemination manuals covering all WIS processes from data collection, entry, processing, storage and dissemination.</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Report on implementation and operationalization for pilot sub-basin</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Final report</td>
<td>18</td>
</tr>
</tbody>
</table>
F. Data, Services and Facilities to be provided by client

- Access to earlier and on-going consultancy studies and reports
- Provide information on basin and sub-basin organizational structure and implementation plans
- Facilitate interaction within MoWRI agencies and external agencies at federal and regional levels on data holdings, data collection mechanisms, proposed plans, and institutional structure
- Release of funds and review of reports as per agreed schedule
- Facilitate travel to selected locations for field inspection and necessary surveys, and during implementation and operationalisation of WIS.
- Constitution of a Technical Advisory Committee to support the client in interaction with the consultant on technical issues through the contract period.

G. Deliverables

<table>
<thead>
<tr>
<th>Item</th>
<th>Report</th>
<th>Contents</th>
<th>Time of Submission (Cumulative Months from start of Project)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inception Report</td>
<td>User need analysis, evaluation of current status, scope of HIS/BIS, and development plan</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Framework Design Report</td>
<td>The framework design including design, operation, laboratory, sampling, reference, data sharing and dissemination manuals covering all HIS processes from data collection, entry, processing, storage and dissemination.</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>WIS Sub-systems Design Report</td>
<td>The WIS sub-systems, including external and internal interfaces, system and user manuals, maintenance and operation manuals, etc.</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Procurement Report</td>
<td>Specifications and tender documents for all equipment (measuring, laboratory and data centre hardware/software), communication network, civil works at site and data centres</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Implementation Plan</td>
<td>Implementation and operationalisation plan</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Progress Report</td>
<td>To report on implementation and operationalisation experiences in the pilot sub-basin</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Report on Training</td>
<td>Provision of a comprehensive Training plan. Report on the training of HIS staff at all levels as well as training of identified staff in the federal and basin entities, and non-institutional users through awareness workshops.</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Manuals</td>
<td>All manuals; including design, Operation, maintenance, field and laboratory and training manuals.</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Report on Institutional Planning</td>
<td>Report on the institutional structure including staff structure and profile, equipment, etc.</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Final reporting</td>
<td>A fully functional and validated WIS and submission of the Final Report</td>
<td>18</td>
</tr>
</tbody>
</table>
Review Mechanism
The client (MWRI) has set up a Technical Advisory Committee for this project comprising a number of experts in the field. They will support the Project Coordinator through provision of guidance and carrying out of technical reviews of the consultant’s outputs. In addition, key deliverables will be presented by the Consultant at workshops to a larger group of stakeholders (in Juba) or elsewhere in the Southern Sudan in order to get their feedback, suggestions, and comments. The client with the support of the Technical Advisory Committee will approve revised reports following such workshops.

Key Specialists in Consultant Team
All proposed experts must be fluent in both spoken and written English. Local language skills would be desirable. Tenderers are permitted to add, delete and/or combine positions in order to put forward the team best qualified to carry out the assignment, but such modifications must be adequately motivated. It is strongly recommended that an appropriate blend of international and national consultants should be involved to ensure both maximisation of international experience combined with knowledge of local conditions and the building of local capacity. It is expected that the majority of each of the allocated inputs are spent in Southern Sudan. The expected man months for key staff are around 60.

<table>
<thead>
<tr>
<th>Item</th>
<th>Position</th>
<th>Required Experience &amp; Academic Qualifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HIS/WIS Team leader/Hydroinformatics Specialist</td>
<td>15 years of international experience in designing and implementing water information systems, experience in hydrology and meteorology, experience in information technology and data bases, including 5 years experience in developing countries; relevant postgraduate engineering degrees</td>
</tr>
<tr>
<td>2</td>
<td>HIS Specialist (Deputy Team Leader)</td>
<td>15 years international experience in designing and implementing HIS, all aspects of hydrometry, Meteorology, including 5 years experience in developing countries; relevant post-graduate degree and knowledge of local conditions an advantage</td>
</tr>
<tr>
<td>3</td>
<td>Specialist in Surface water Hydrology</td>
<td>10 years international experience in field hydrology, RS/GIS applications, Monitoring Network design and operation; surface water modeling, relevant postgraduate degree</td>
</tr>
<tr>
<td>4</td>
<td>Surface water Hydrology (Modeling Specialist)</td>
<td>10 years international experience in hydrology and hydrologic modeling; relevant postgraduate engineering degree</td>
</tr>
<tr>
<td>5</td>
<td>Groundwater Specialist</td>
<td>15 years experience in groundwater monitoring networks, groundwater development, groundwater modeling and management; postgraduate degree in the relevant fields.</td>
</tr>
<tr>
<td>6</td>
<td>Hydrometeorologist</td>
<td>10 years experience in meteorological data measurements, equipment, network design, database development, data processing; postgraduate degree in meteorology.</td>
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<tr>
<td>7</td>
<td>Water Quality Specialist (to be provided by the client)</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Role Description</td>
<td>Experience and Qualification</td>
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</tr>
<tr>
<td>8</td>
<td>Hydrometry/Instrumentation Specialist</td>
<td>15 years experience in surface water measurements and measuring equipment; relevant graduate degree</td>
</tr>
<tr>
<td>9</td>
<td>Consultant in River Morphology &amp; Sediment Transport</td>
<td>10 years experience in sediment transport and watershed management, relevant postgraduate degree.</td>
</tr>
<tr>
<td>10</td>
<td>RS/GIS specialist</td>
<td>10 years experience in RS/GIS applications for resource mapping, preparation and integration of GIS datasets, experience in integrating global satellite derived data; post graduate degree in relevant discipline an advantage</td>
</tr>
<tr>
<td>11</td>
<td>Training Specialist</td>
<td>10 years experience in planning training in water resources planning and management, particularly in HIS; developing training modules; evaluating feedback on training effectiveness; post-graduate degree in relevant discipline.</td>
</tr>
<tr>
<td>12</td>
<td>IT specialist</td>
<td>Minimum 10 years experience in IT, design and development of database, and communication networks; post-graduate degree in IT</td>
</tr>
<tr>
<td>13</td>
<td>Institutional Specialist</td>
<td>10 years experience in developing institutional structure and strengthening; institutional linkages for data sharing; post-graduate degree in relevant discipline.</td>
</tr>
</tbody>
</table>

**J. Duration of Consultancy:** 18 calendar months