Water Research Center (WRC), University of Khartoum (UofK)

NEPAD CEANWATCE PROJECT

WAter and COoperation within the NIle River Basin (WACONI)

Blue Nile Basin Downstream the Grand Ethiopian Renaissance Dam

Database Report

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List of acronyms

ACEWATER2: African networks of Centers of Excellence in Water2

AU: African Union

CEANWATCE: Central/Eastern Africa Network of Water Centers of Excellence

GERD: Grand Ethiopian Renaissance Dam

HEC-GeoHMS: Hydrologic Engineering Center Geospatial Hydrologic Modeling Extension

MOD16: Moderate Resolution Imaging Spectroradiometer Global Evapotranspiration Project

NASA: National Aeronautics and Space Administration of the United States of America

NEPAD: New Partnership for Africa's Development

PDF: Portable Document Format

SRTM: Shuttle Radar Topography Mission

USGS: United States Geological Survey

WEF: Water-Energy-Food nexus

WGS84: World Geodetic System 1984

WMO: World Meteorological Organization

WRC: Water Research center

1. Introduction

This report describes a database on water availability, consumption, and infrastructures in the Blue Nile downstream the GERD. The report is part of a study conducted by the Water Research Center (WRC) of the University of Khartoum, the secretariate of the Central/Eastern Africa Network of Water Centers of Excellence (CEANWATCE), for AU/NEPAD ACEWATER2 project. Figure 1 shows the location of the study domain of WRC.

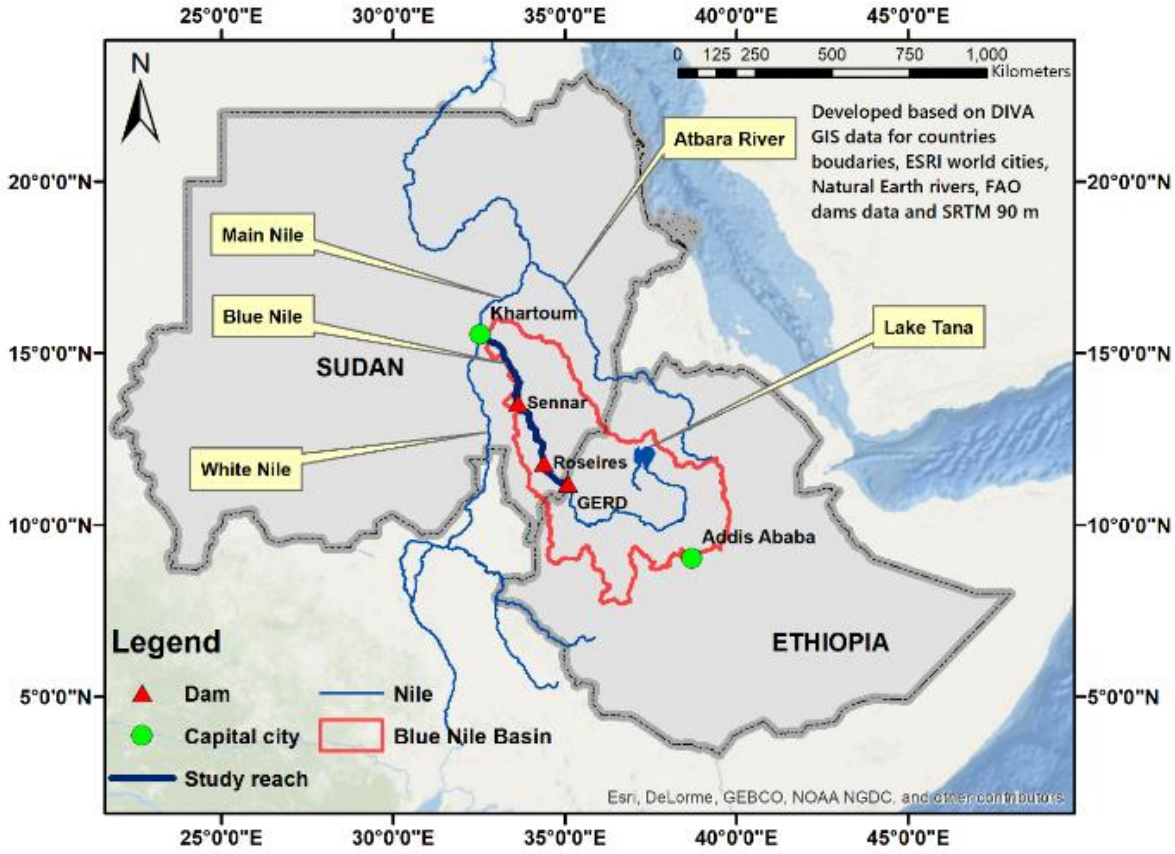

Figure 1 Study region of the Water Research Center

The architecture of the database is designed as indicated in Figure 2 below. Due to the large size of some of the data and to ease data sharing and distribution between the project partners, the data have been categorised and uploaded to a Dropbox Folder. Then a Portable Document Format (PDF) file has been created to act as an entry point to the database. The PDF file is provided with this report but separately. The PDF file includes the flow chart illustrated in Figure 2. Through the PDF file, the user can view or download the data. The database contains several data formats such as Excel files, shapefiles, and

raster files. Clicking on any of the boxes in the PDF file opens the respective data folder on Dropbox. The database includes four main data categories: (1) spatially distributed data, (2) descriptive data, (3) geographic data, and (4) point data. Each of the four categories includes sub-categories. The following part of the report describes the data within each category and their sources.

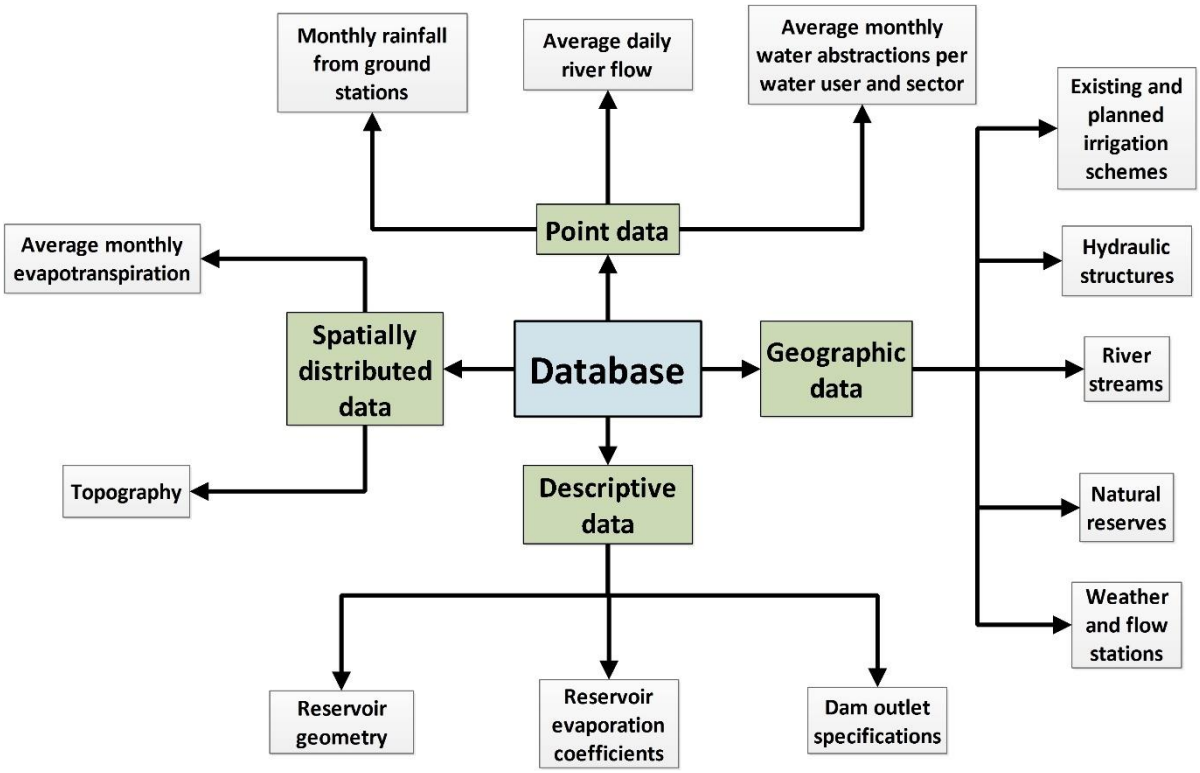

Figure 2 Architecture of the baseline database

2. Spatially distributed data

The database includes two types of spatially distributed data which are average monthly evapotranspiration and topography.

2.1. Average monthly evapotranspiration

Average monthly evapotranspiration was calculated for the Blue Nile Basin based on the Moderate Resolution Imaging Spectroradiometer Global Evapotranspiration Project (MOD16; Mu et al. (2011)). MOD16 is a satellite-based evapotranspiration product that

covers the globe with monthly data for the period 2000 to 2014. The product has a 1 km × 1 km spatial resolution. The University of Montana developed MOD16 as part of NASA/EOS Project. The evapotranspiration data provided by MOD16 includes direct evaporation from wet and moist soil plus transpiration from vegetation during daytime and nighttime. Herein, the data are added to the database in a Raster (GeoTiff) format and has a unit of 0.1mm/month. Moreover, the data are provided in the World Geodetic System 1984 (WGS84) geographic coordinate system.

2.2. Topography

Topographic data for the Blue Nile Basin have been acquired from the hole-filled Shuttle Radar Topography Mission (SRTM; Jarvis et al. (2008)). SRTM provides digital elevation data for approximately 80% of the globe with a spatial resolution of 3 arc second (around 90 m × 90 m). SRTM was initially developed by The National Aeronautics and Space Administration (NASA) of the United States of America (USA). Then the product was further processed by a group of scientists to fill in the data gaps (Jarvis et al., 2008). SRTM data are available from 60 degrees north to 60 degrees south as 5-degree x 5-degree tiles in the WGS84 geographic coordinate system. The topographic data are added to the Blue Nile Basin database in a Raster (GeoTiff) format and has a unit of meters above sea level. The topographic data in the database have the same coordinate system as the parent data.

3. Descriptive data

This data category includes reservoir geometry, reservoir evaporation coefficients, and dam outlet specifications for the Grand Ethiopian Renaissance Dam (GERD), Roseires Dam, and Sennar Dam. It is worth noting that the GERD is currently under construction while Roseires and Sennar dams where constructed in 1966 and 1925, respectively.

3.1. Reservoir geometry

This sub-category of the database includes the geometry of the reservoirs of the GERD Roseires Dam and Sennar Dam. The geometry data consists of the elevation-volume table and the elevation-area table for each of the three reservoirs. The elevation-volume table is a relationship between the reservoir water elevation and the reservoir storage volume

whereas the elevation-area table is a relationship between the reservoir water elevation and the area of the reservoir water surface. Both sets of data are essential for the operation of the three dams. For the GERD, the reservoir geometry data were acquired from the Eastern Nile Technical Regional Office of the Nile Basin Initiative. For Roseires and Sennar dams, the geometry data were obtained from the Ministry of Water Resources, Irrigation, and Electricity of Sudan. The geometry data of the GERD are based on a bathymetric survey for the reservoir area that has been conducted in 2011. Furthermore, the data for Roseires and Sennar are based on surveys for the two reservoirs in 2012 and 1985, respectively. The reservoir geometry data in the database are in Microsoft Excel format (.xlsx). The elevation is added in meters above sea level, the volume in million cubic meters, and the area in kilometres squared. The data for each reservoir is included in a separate Excel file, and the elevation-volume and the elevation-area tables are added to separate sheets.

3.2. Reservoir evaporation coefficients

Average monthly evaporation coefficients for each of the GERD, Roseires, and Sennar reservoirs are included in this sub-category of the Blue Nile database. For the GERD, the data have been acquired from Wheeler et al. (2016). The evaporation coefficients of Roseries and Sennar reservoirs were obtained from the Ministry of Water Resources, Irrigation, and Electricity of Sudan. GERD evaporation coefficients were derived in 2011 whereas as the evaporation coefficients of Roseries and Sennar reservoirs date back to 2012 and 1985, respectively. The data in the database are in Microsoft Excel format (.xlsx). The data for each reservoir are included in a separate file. As regards the unit, the data are provided in centimeters per month.

3.3. Dam outlet specifications

This sub-category of the database includes the relationship between reservoir water level and physical water release capacity for each of the GERD, Roseires Dam, and Sennar Dam. The physical release capacity is the total amount of water that can be released through bottom outlets, turbines outlets, and spillways. This capacity is dependent on the available water head at any given time. The data for the three dams were collected from

the Ministry of Water Resources, Irrigation, and Electricity of Sudan. The data for each of the three dams are included in the database in separate Excel files. The Excel files have a ".xlsx" format.

4. Geographic data

4.1. Existing and planned irrigation schemes

The Blue Nile Basin downstream the GERD includes several existing and planned irrigation schemes (see Figure 3). The existing schemes include Gezira and Managil, Rahad 1, Suki, North West Sennar, and Gunied. On the other hands, the planned schemes are Kenana 1, Kenana 2, Kenana 3, Kenana 4, Roseires, Dinder South, Dinder North, Rahad 2 South, and Rahad 2 North. This section of the database includes the locations and extent of each of the existing and planned schemes in the study area. The polygons of the schemes are included in a single shapefile. The names of the schemes and their status (i.e. existing or planned) are included in the attribute table of the shapefile. The shapefile was zipped in ".7z" format before it was uploaded to the database. The shapefile is in the WGS84 geographic coordinate system. The source of the data is the Ministry of Water Resources, Irrigation, and Electricity of Sudan.

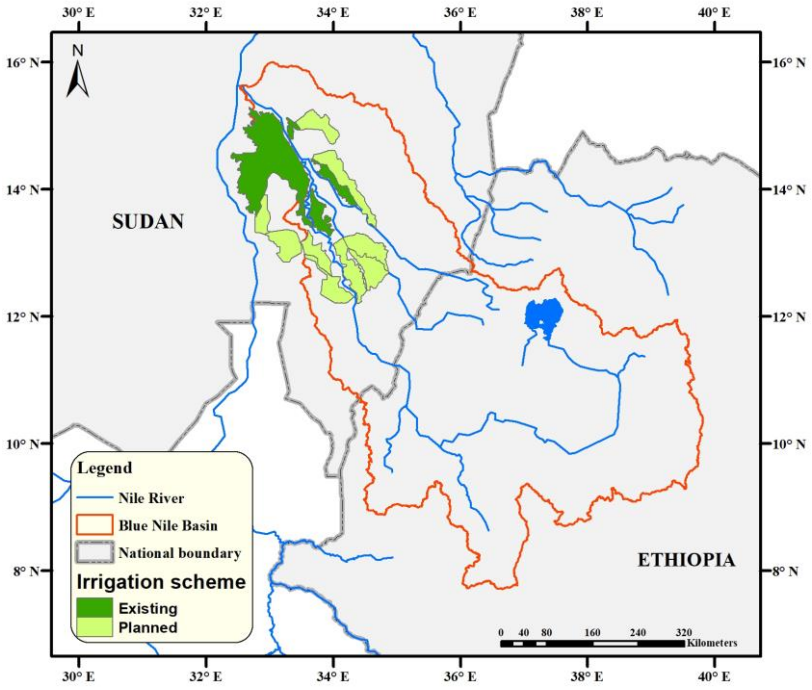

Figure 3 Irrigation schemes in the study area

4.2. Hydraulic structures

The study area encompasses three dams: The GERD which is under construction since 2011; Roseires dam which was built in 1966; Sennar Dam which was constructed in 1925. Figure 1 shows the three dams. The locations of the three dams are included in a shapefile which has been added to the database. The locations of the three dams were manually digitized utilizing Landsat satellite images from the United States Geological Survey (USGS) which is a scientific agency of the United States government. The attribute table of the shapefile includes the names of the three dams. The shapefile was zipped in ".7z" format before it was uploaded to the database. The shapefile is in the WGS84 geographic coordinate system.

4.3. River streams

Major river streams in the Blue Nile Basin (see figure 1) were delineated based on the hole-filled Shuttle Radar Topography Mission (SRTM; see Section 2.2). HEC-GeoHMS, a tool developed by the Hydrologic Engineering Center of the USA Army Corps of Engineers, was used to perform the delineation of river streams in the Blue Nile Basin. The streams' data were prepared in a shapefile format and then zipped in ".7z" format before being uploaded to the database. The attribute table of the shapefile includes the names of the river streams downstream the GERD. The shapefile is in the WGS84 geographic coordinate system.

4.4. Natural reserves

The study area encompasses the Dinder National Park (Figure 4), a biosphere reserve located in Sudan. A shapefile of the extent and location of the park has been included in the database. The shapefile was zipped in ".7z" format before it was uploaded to the database. The shapefile was acquired from Sulieman and Mohammed (2014) and is in the WGS84 geographic coordinate system.

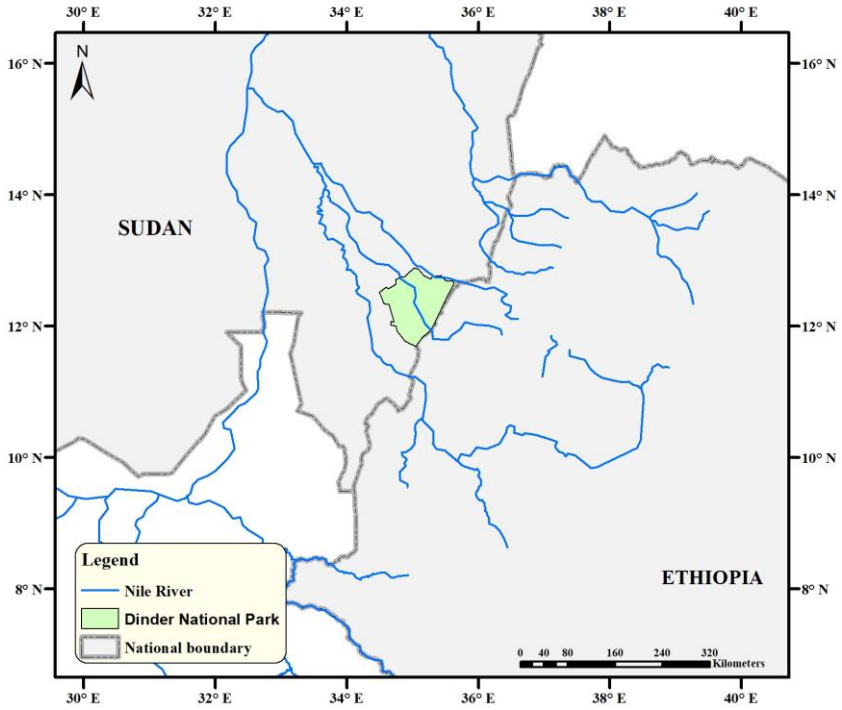

Figure 4 Natural reserves in the study area

4.5. Weather and flow stations

The study area encompasses four stage-discharge stations, four stage stations, and six weather stations that are currently in operation (see Figure 5). The stage-discharge stations report the Blue Nile discharge and water levels whereas the stage stations report water levels only. The weather stations report several climatic parameters such as rainfall, wind speed, sunshine hours, etc. The four stage-discharge stations are Eldiem, Khartoum, El-Guisi, and El-Hawata whereas the four stage stations include Wad-Elhadad, Hag Abdulla, Wad Medani, and El-Kamleen. Furthermore, the six weather stations are Damazine, Abu Na'ama, Sennar, El-Gedarif, Wad Medani, and Khartoum. The locations of the stations were added to a shapefile, zipped in ".7z" format, and then uploaded to the database. The attribute table of the shapefile includes the names and the types of the stations. The locations of the stage-discharge and stage stations were acquired from the Ministry of Water Resources, Irrigation, and Electricity of Sudan. The locations of the weather stations were obtained from WMO (2016). The shapefile is in the WGS84 geographic coordinate system.

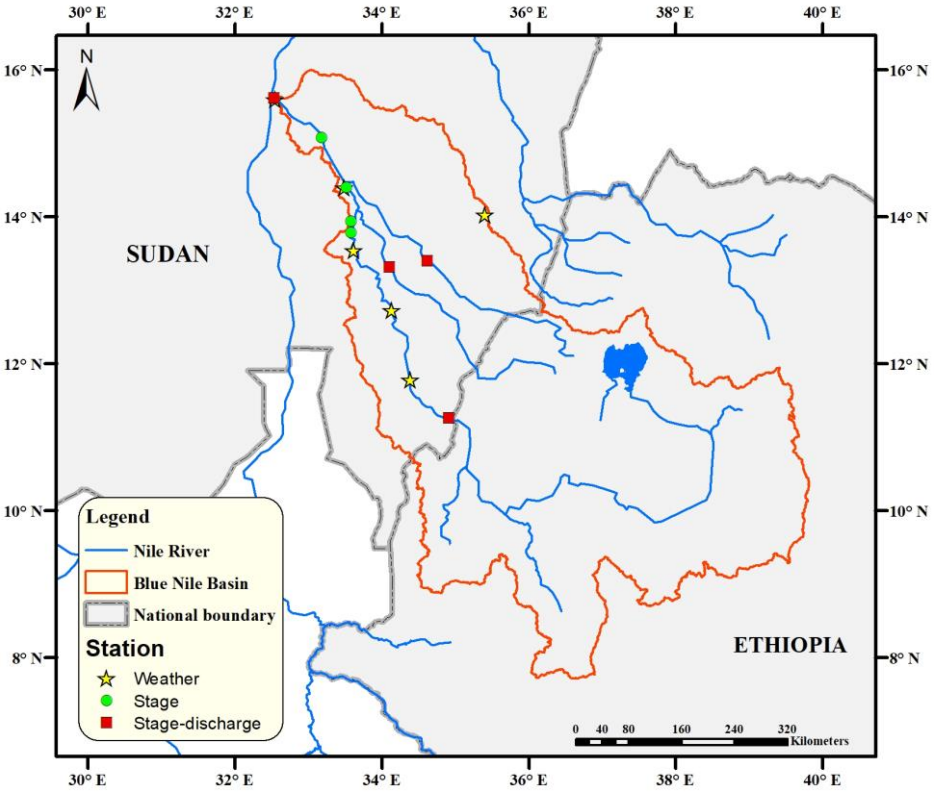

Figure 5 Weather and flow stations in the study area

5. Point data

5.1. Monthly rainfall

This sub-category includes monthly rainfall data for five ground weather stations, namely Damazine, Sennar, Wad Medani, Sennar, and El-Gedarif. The data covers the period from 1999 to 2009. Raw daily rainfall time series of the five stations were purchased from Sudan Meteorological Authority and then aggregated into monthly data. Due to the data use policy of Sudan Meteorological Authority, we are unable to include the raw daily rainfall records in the database. However, we used the raw data as a comparison benchmark to evaluate the performance of long-term daily satellite-based rainfall products and to spot the best performing one in the study area. The procedure and results of the performance evaluation of satellite-based rainfall products will be presented as part of the next report (i.e. assessment of WEF nexus in the study area). The monthly rainfall data are presented in the database in Microsoft Excel format ".xlsx" in a single workbook and a single sheet. The data unit is millimeters per month.

5.2. Average daily river flow

The database includes average daily river flow data for the four river discharge stations located in the study area. The stations are El-Diem, Khartoum, El-Guisi, and El-Hawata. Daily river flow time series for the four stations were obtained from the Ministry of Water Resources, Irrigation, and Electricity of Sudan for the period 1984 to 2016. For each of the four discharge stations, the time series were averaged to calculate the mean daily river flow data. Unfortunately, the raw daily time series cannot be included in the database due to the data use and distribution policy of the Ministry of Water Resources, Irrigation, and Electricity of Sudan. However, the raw data will be used in the upcoming modelling exercise. The average daily river flow data are presented in the database in Microsoft Excel format ".xlsx" in a single workbook and a single sheet. The data unit is million cubic meter month.

5.3. Average monthly water abstractions

This sub-category includes average monthly water abstractions by the major irrigation and domestic water users in the study area. Fiver primary irrigation water users are located in the study area, i.e. Gezira and Managil, Rahad 1, Suki, North West Sennar, and Gunied, whereas only one weighty domestic water user is in the study area which is the City of Khartoum. Average monthly abstractions for the water users mentioned above were obtained from the Ministry of Water Resources, Irrigation, and Electricity of Sudan and added to the database. The average data are presented in the database in Microsoft Excel format ".xlsx" in a single workbook and a single sheet. The data unit is million cubic meter month.

6. References

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