Regional Climate Resilience Program (RCRP)

for

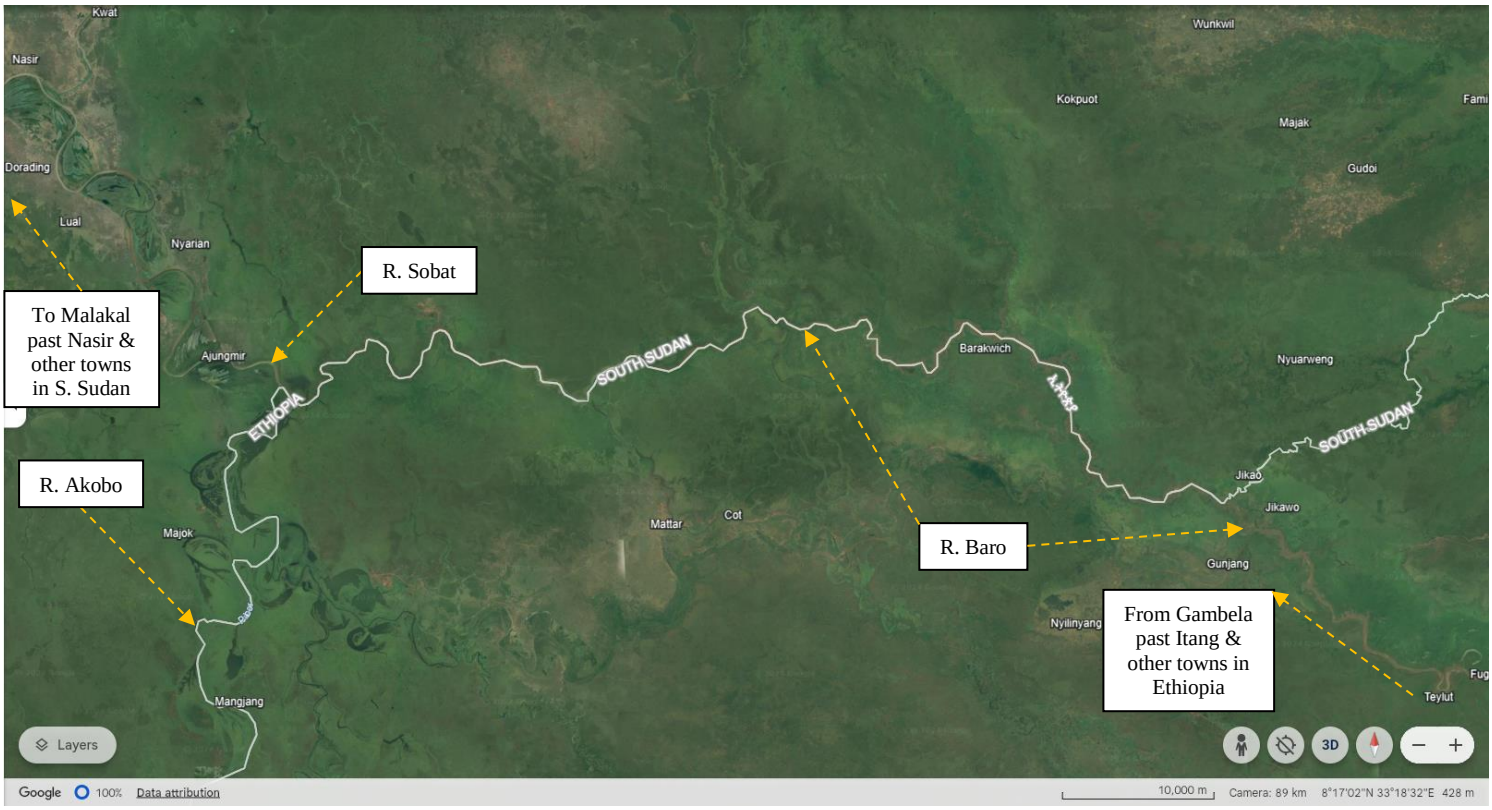
Eastern and Southern Africa (ESA)

Component 1: Risk Management and Climate Financing

Sub-component 1.1: Climate and Disaster Risk Management

Terms of Reference (TOR) for a Consulting Firm

"Develop Flood Risk Mapping for select areas in Baro-Akobo-Sobat (BAS) Sub-Basin"



1st August 2024

CONTENTS

1 INTRODUCTION

1.1 The Nile Basin and NBI

The Nile Basin Initiative (NBI) is an intergovernmental partnership of ten Nile River riparian Countries of Burundi, D.R. Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, and Uganda established, to develop the Nile River cooperatively. NBI now provides an all-inclusive regional platform for multi stakeholder dialogue, information sharing as well as joint management and development of water and related resources in the Nile Basin. The member countries launched two Subsidiary Action Programs (SAPs), namely: (1) the Eastern Nile Subsidiary Action Program (ENSAP) and (2) the Nile Equatorial Lakes Subsidiary Action Program (NELSAP). These subsidiary action programs initiate concrete joint investments and action on the ground at sub-basins level.

- The Eastern Nile Technical Regional Office (ENTRO), based in Addis Ababa, Ethiopia is the executive arm of ENSAP.
- The executive arm of NELSAP is NELSAP Coordination Unit (NELSAP-CU) based in Kigali, Rwanda.

1.2 Flood Risk in the EN

The Eastern Nile (EN) region is extremely vulnerable to floods. Estimated average annual flood damages on the Blue Nile and Main Nile in Sudan and in the floodplains adjoining Lake Tana in Ethiopia exceed 30 million US$. The 2006 flood in Ethiopia resulted in a loss of 700 peoples' lives and a displacement of 242,000 people in the Tana and Baro-Akobo-Sobat sub-basins. The extent of the 2005 flood damages to the agricultural sector in Sudan impacted 115,000 ha of agricultural crops. The 1998 flood in Sudan caused a direct flood damage of 24.3 million US$. The year 2020 flood in the EN was described as one of the worst flooding in 30 years that killed 100 people; destroyed more than 166,000 household and critically affected around 830,000 people. In *South Sudan,* the three years (2019-2022) *floods* impacted the lives of over 900,000 people across 9 states and in the southern part of the Abyei Administrative Area. In *Gambela*, *Ethiopia,* in 2022, heavy rains from early August to October caused flooding across 12 woredas and in the Gambela city with about185,200 people were displaced. Moreover, significant areas of cropland were damaged (mostly the staple maize) and, on average, 8% of livestock have reportedly died, mostly poultry. Destruction of properties and of social infrastructure was also rampant.

Addressing hydrometeorological hazards and planning for flood mitigation has been one of the key action areas of the NBI since its establishment in 1999. The Integrated Development of the Eastern Nile (IDEN) is an ENSAP project agreed by the member countries in 2002. IDEN consists of several subprojects, one of which focuses on flood preparedness and early warning - the Eastern Nile (EN) Flood Preparedness and Early Warning Project (FPEW) – as floods in the Eastern Nile sub-basins have significant impacts on livelihoods and economies in the region. The Flood Preparedness and Early Warning System (FPEW) project focused on enhancing regional collaboration and national capacity in flood risk management, including flood mitigation, flood forecasting and early warning, as well as flood emergency preparedness and response. The project had been planned to be implemented in two phases (FPEW I and FPEW II).

FPEW I, focused on building the institutional capacity and developing critical baseline information to enhance the readiness of EN countries to implement subsequent FPEW phases. It delivered a platform for institutional settings and data/information collection/sharing at community/local and national levels, together with enhancing regional coordination and cooperation with the recommendation for subsequent phases. FPEW I was concluded in 2010.

Based on the FPEW I, ENTRO created a regional Flood Forecast and Early Warning System (FFEWS) under the Eastern Nile Planning Model (ENPM) project. The FFEW activity continued under the Nile Cooperation for Results (NCORE) project. The FFEW system has continuously been

implemented since 2010 for every flood season (June/July–September/October). The FFEW system has helped the EN countries in reducing the loss of life and money by preparing flood forecast bulletins for the flood-prone areas in i) Lake Tana - Abbay / Blue Nile (Ethiopia), ii) Blue Nile - Main Nile (Sudan), and iii) Baro-Akobo-Sobat (Ethiopia and South Sudan) sub-basins.

Over the last 10 years (2010-2020) of implementation, the FFEW system has been enhanced in the following areas:

- expansion of the coverage area of FFEW to few parts of BAS sub-basin in South Sudan and Tekeze-Setit-Atbara (TSA) sub-basin in Ethiopia.
- integration of flood models that depended on different tools for different sub-basins, into a uniform platform of MIKE suites.
- update of stakeholder list of respective countries to reduce inefficient issuance of early warnings:
    - During the 2020 flood, for example, the river flow forecast bulletin released through the FFEW system has been utilized by the Government of Sudan to issue evacuation advisory to people and livestock across the country.

The FFEW system has the potential to improve forecast accuracy by incorporating more ground observed data collected through the NBI regional hydromet stations network, operation rules of dams along the main channels and major tributaries, and river cross section and flood plain survey data to predict flood-inundated areas more accurately.

1.3 Flood risk mitigation efforts in BAS

Nearly 174 000 km^2 (50% the BAS catchment area) is in a floodplain (Annex I / Figure 1A). In the rainy season (~May-Oct) the rivers Baro, Gilo, Akobo and Pibor, when they enter in the low-lying plains, overflow their channels into floodplains and wetlands and often cross into adjacent rivers during high flow events inundating significant areas (ENTRO, 2017). Annex I / Figure 1B shows about 10,000 km^2 areas of wetlands and regularly flooded areas at six locations in the BAS basin affecting 100 thousand livelihoods.

The World Bank through the Regional Climate Resilience Program (RCRP) is supporting ENTRO and NELSAP-CU to strengthen the resilience to water-related climate impacts in Eastern and Southern African countries, with an emphasis on South Sudan. To achieve this objective, the RCRP aims to implement investments for improving the enabling environment, capacity building, and infrastructure.

2 PROJECT OBJECTIVE

Component 1 of the RCRP project focuses on disaster risk management and early warning systems. It aims to improve understanding of flood hazards and early warning systems in select areas of the BAS basin located in Ethiopia and South Sudan. This component builds upon ongoing activities financed by another World Bank supported project, called the Nile Cooperation for Climate Resilience (NCCR) project. The NCCR project focuses on information services for riverine flooding FFEW in the BAS at Gambela city, Itang town, Nasir town, Malakal City, Akobo town, and Pibor town that are situated on main riverbanks. However, the NCCR project does not cover the wetlands and larger floodplains along the tributaries and within the spills of the main rivers in the BAS area (South Sudan and Ethiopia), although considerable number of people live in these flood-prone areas. Because their livelihoods depend on farming and rearing of livestock in/around these floodplains and wetlands; on fishing from rivers and wetlands; and live in the numerous settlements among which several towns furnished with administrative, social and market infrastructure have emerged to serve the populations within these floodplains and wetlands. Component 1 of the RCRP, and this ToR in particular, addresses this gap.

3 RATIONALE FOR THIS CONSULTANCY

3.1 The Need for extended flood risk mitigation in BAS

The current riverine (fluvial) FFEWS and Flood Risk Mapping only cover urban areas in the BAS river sub-basin. However, pluvial floods due to spill/overflow from stream channels, localized heavy rainstorms and inadequate drainage capacities over vast land (> 10,000 km^2) affect floodplain and wetland areas in Gambela and Itang (Ethiopia); and Pibor, Akobo and Nasir (South Sudan), amongst others.

The floodplains and wetlands of the BAS play a crucial role in sustaining the livelihoods of around one million people engaged in agriculture, livestock, and fisheries. However, floods have considerable adverse effects, including the loss of lives through drowning; the destruction/submersion of homes and assets; damage to infrastructure, harm to crops and livestock; and displacement. These impacts are expected to escalate with the intensifying climate change variabilities. Consequently, there is a pressing need for expanded flood-related information services in the BAS sub-basin, including Flood Forecasting and Early Warning (FFEW), as well as strategic flood inundation hazard, exposure and vulnerability mapping, to facilitate the effective implementation of flood risk management.

Strategic Flood Inundation Mapping (SFIM), derived from a flood risk map, proves invaluable for assessing flood-prone areas within BAS. It is essential for evaluating the impact of flooding on crucial assets such as for social sectors (housing, health, education, etc.) and associated services, e.g., safe drinking water and sanitation facilities; agricultural sub-sectors (crops, fisheries, livestock, etc.); transport and communication infrastructure (roads, etc.); and the lives and socioeconomic aspects of affected communities. The SFIM will provide the depth and spatial extent of flooded zones (with various risks), required by the administrators to inform the citizens about the major flood prone areas and adopt appropriate flood management strategies including flood preparedness planning, land use zoning and construction typology. The SFIM map, which is a flood risk map that is the function of flood hazard, exposure, and vulnerability will be produced, with close interaction with all BAS stakeholders at all levels.

3.2 Objective of this Consultancy

The overall objective of this consultancy is to enhance preparedness/resilience against BAS sub-basin flood disasters in the select areas of Ethiopia and South Sudan through flood risk mitigation, aiming at the following:

- Survey and develop detailed strategic flood inundation mapping that shows the flood hazard, exposure, vulnerability to guide the development of flood risk maps to be used for flood risk management in the target hotspot areas.
- To strengthen and expand the BAS FFEWS and Flood Risk Mapping for both riverine and pluvial floods.
- To enhance flood preparedness in the EN region, with a focus on the BAS sub-basin, by increasing community awareness and fostering cooperation among local stakeholders.

4 SCOPE OF WORK

No detailed strategic flood inundation mapping exists for the most areas affected by pluvial flooding in the BAS. Strategic inundation mapping should show the flood hazard, exposure, and vulnerability to guide the development of flood risk maps to be used for flood risk management. Detailed strategic flood inundation mapping in the BAS exists only for the Gambela City, Itang town, Nasir town, Malakal City, Akobo town, and Pibor town. Now, the flood risk study areas, generally include the following river segments:

- **Ethiopia:** BAS-ETH Flood Risk study area is a total area in km^2, between Gambela City and Itang town; and from Itang town to the border with South Sudan (to Mattar in Ethiopia and Jikou in South Sudan), bounded by the Roads 1 and 2 adjacent to the Baro River (covering village centres, tukules, farmlands, social services infrastructure, lives, and the roads), which must be protected.
- **South Sudan:** BAS-SSD Flood Risk study area is a total area in km^2 (with 10 km band that is 5-km from Sobat river centerline) between Nasir town and the border with Ethiopia at Jikmir; from Nasir town to Sobat river Junction with White Nile river past the small administrative, community, and village centres in South Sudan (covering Yomding, Ulang, Baliet, Anakdiar, and Khorfulus, among others); and the right bank road that goes from Nasir to Doleib-Hill. Within this bound (villages, tukules, farmlands, social services infrastructure, lives and the road) must be protected).

Location maps of these study areas are given in Annex II (Figures 2A and 2B).

The specific scope of work under this BAS Flood Risk Assessment and Mapping for the identified areas include:

- Task 1: Survey, Data Collection, and Flood Frequency Study (FFS).
- Task 2: Flood Hazard Assessment.
- Task 3: Flood Exposure Mapping Across Vertical and Horizontal Scale.
- Task 4: Flood Vulnerability Assessment and Mapping.
- Task 5: Flood Risk Assessment and Mapping.
- Task 6: Develop Strategic Flood Management Plan and Mapping.
    - 6.1: Strategic Flood Inundation Mapping.
    - 6.2: Structural and Non-Structural Measures (Development Plan).
- Task 7: Capacity Building in flood risk management at regional, national and local levels.

A parallel exercise being conducted under the NCCR project focuses on the forecasting elements and on enhancing the Early Warning systems (Annex III: Eastern Nile Flood Forecast and Early Warning (EN-FFEW) System). The consultants are expected to be coordinated with that team on this topic. ENTRO will facilitate the coordination.

The detailed tasks are explained below.

4.1 Task 1: Survey, Data Collection & Flood Frequency Study for Select Areas in BAS

- Task 1.1: Collect terrain, infrastructure, and assets datasets of flood prone select areas in the BAS at their specified locations in the scope of work herein, using publicly available EO data. If the public source(s) couldn't provide the required data, a high resolution DTM/DEM of 2-3 m horizontal resolution and 0.5-1 m vertical accuracy Earth Observation (EO)[1] data (to be budgeted and procured by the consultant under the approval of ENTRO) may be utilized in the hotspot areas. Task 1.2: Compile Historical Hydro-Meteorological Datasets relevant to this study and calibrate at least two satellite based daily rainfall time series data for use in the rainfall runoff model.
- Task 1.3: Flood Frequency Study.

[1] Producing VHR DEM 1-meter vertical accuracy with assets map/mapping from HR images at 3 meters of resolution for the selected hot spot areas. The exact locations of the above EO survey will be specified at the inception stage. Use ICESat-2 (spatial resolution of 70 cm, and vertical resolution of 15 cm) or better satellite altimeter to produce river and floodplain cross-sections together with 30 m DEM or less. For asset mapping use UN Satellite Center UNOSAT or better including OpenStreetMap and others EO products. Combine also existing ground observations from 1:50,000 scale maps where available, and use river cross-section data obtained during Q-measurement.

- Task 1.4: Identify location, design, and install manual staff gauges (at least five stations in each country) for use in flood forecasting and mitigation in the flood plains, and to be also used in the calibration for the future floods, beginning with 2025 (June/July-September/October) onwards. These will be budgeted and procured by the Consultant under the approval of ENTRO.
- Task 1.5: Determine key socio-economic characteristics of flood prone communities (see the guide in Annex IV).

A complementary exercise is being carried out under the same RCRP in South Sudan, on how to improve water resources monitoring, including with the installation of gauges. MWRI-RSS will be therefore consulted on the installation of the gauges on their side.

4.2 Task 2: Flood Hazard Assessment and Flood Extent Mapping

Flood hazard assessment will be carried out with the following key activities:

- The Consultant shall determine relevant flood events for the specific locations, including the return periods of floods specific intensities (2, 5, 10, 50, 100, 200, 500, 1000 years return period). The work includes statistical discharge frequency analysis and rainfall-runoff modeling by using and improving on the existing MIKE based ENTRO modeling systems and additional model (using HEC). It will include analyzing historical flood data to understand past flood events and their impacts and using this information to inform the assessment and the mapping process.
- **Hydrodynamic modelling and floodplain mapping for the target areas:** Based on adequate digital terrain models with appropriate spatial resolution (e.g., high-resolution DEM in conjunction with cross-section survey datasets of Task 1). The Consultant should model floods with 2D hydrodynamic modeling tools in the flood prone areas. The Consultant shall delineate flood extents for selected extreme floods and overlay results with diverse earth observation (EO) information with topographic and land use data. The Consultant should document the results and produce flood hazard maps.

4.3 Task 3: Flood Exposure Mapping Across Vertical and Horizontal Scale

The consultant shall map the locations and characteristics of the elements exposed to both fluvial and pluvial flooding. This might include population density; building types and materials (residential, school, hospital, religious sites, police stations, administration blocks, etc.); critical infrastructures (roads, telephone lines, water supply systems, sanitation facilities, …); agricultural assets (farms, irrigation facilities, etc.); industries; and environmental assets (sanctuaries, wetlands, and bio-diversity hotspots). The analysis considers the exposure of these elements to flooding and the potential consequences of flood damage such as economic/livelihood losses, social/services disruptions, and environmental impacts. The consultant shall propose an adequate methodology for conducting the flood exposure mapping combining open data, remote sensing, and field surveys in conjunction with DTM of Task 1.1 where appropriate.

4.4 Task 4: Flood Vulnerability Assessment and Mapping

Flood vulnerability assessment comprises identification of physical and non-physical flood vulnerability of land use, people, infrastructure, and economic/livelihood activities in the flood prone areas as identified in flood hazard and exposure maps of Task 2, and mainly utilizing the datasets of Task 1.

The Consultant shall conduct the following key activities:

- **Analyze physical vulnerability:** The impacts of floods on any land use entities (such as houses, infrastructure and other assets) will be represented by damage curves (also referred to as damage functions or vulnerability functions), e.g. describing the relationship between damage and flood

characteristics such as water depth or velocity. Where necessary and possible fragility curves (also referred to as fragility functions) will be used to reflect the effects of floods on flood mitigation infrastructure such as levees.

- **Analyze non-physical vulnerability:** In addition to the physical vulnerability of infrastructure and other land use entities, there are other important vulnerability classes. These encompass economic/livelihood losses, social/services vulnerability, and environmental impacts. The presence of institutions for managing flood impacts and issuing early warning systems shall be assessed. As far as possible, non-physical vulnerabilities will be assessed for each flood prone community. The consultant shall clearly lay out an approach to take into consideration differential vulnerability (e.g., vulnerability by gender and income or livelihood group).

With this, the Consultant shall establish for each flood prone community relationships between flood damages, flood extents, socioeconomic situations, and flood preparedness adaptation circumstances.

4.5 Task 5: Flood Risk Assessment and Mapping

Flood risks are evaluated by combining the outcomes of flood hazard assessments with those of vulnerability assessments which includes exposed assets through spatial overlay analysis. These risks establish connections between flood damages, flood return periods, and illustrate the anticipated annual damage. While flood risks are essential for assessing and comparing flood impacts among flood-prone areas and communities, they are not the sole means of evaluation. Non-economic effects of floods, such as short- and long-term impacts on livelihoods, must also be considered alongside economic flood risks.

The Consultant is tasked with providing flood risk assessment results for each flood-prone community as flood maps. These maps should depict flood extents with varying flood levels and return periods, as well as identifying vulnerable land use entities and critical local flood protection infrastructure, such as high beds, food silos, levees and dikes. The maps shall be provided in QGIS readable formats to be embedded in ENTRO's existing spatial mapping platforms.

In developing the risk mapping model, inclusive of hazard and vulnerability maps, the consultant shall incorporate characteristics that facilitate future updates of risk maps by modifying the MIKE models used in hazard mapping. This process should be thoroughly documented in an operational manual, specifically created for this purpose.

The flood risk maps associated with various flood return periods will be disseminated using various platforms including the Nile Basin IKP.

4.6 Task 6: Develop strategic flood management plan and mapping

4.6.1 Task 6.1: Strategic flood inundation mapping

The consultant shall develop strategic flood inundation mapping that will provide the depth and spatial extent of flooded zones (with various risks) in close consultation with the flood affected communities and their local authorities. When developing the strategic flood management plan and mapping, the consultant works closely with the community and local institutions. This information is crucial for administrators to inform citizens about major flood-prone areas and for land use planning/demarcation. Additionally, the consultant will propose suitable flood management strategies, encompassing both flood preparedness planning and land use zoning, to prevent settlement and other developments in highly exposed areas. The creation of strategic flood inundation mapping will involve close collaboration with all BAS stakeholders at all levels (regional, national and local).

4.6.2 Task 6.2: Structural & Non-Structural Measures (Flood Mgt. Devt. Plan Pre-FS)

The consultant will collate information key to designing and identifying effective mitigative/adaptive flood control and alternative livelihoods interventions/measures as appropriate from the results of all

the above tasks and use them to provide strategic flood management development plan, inclusive of both identified: 1) suitable structural / engineering solutions (e.g., drains, dikes, retaining walls, water supply / sanitation facilities' designs and access works); and 2) non-structural interventions (nature-based/socio-economic based solutions) as appropriate to enhance flood resilience in the flood prone areas. Other considerations include strategies for joint flood risk monitoring, operations, and maintenance to enhance flood preparedness, by fostering cooperation among local, national, and regional stakeholders in the target BAS areas prone to floods. This flood management development plan should be supported by at least a prefeasibility level investigation, inclusive of indicative cost estimates and implementation arrangements.

The consultant will then produce a draft strategic flood management development plan proposal report, which will be reviewed by the client and other stakeholders in a validation workshop, which will be facilitated by the Consultant for regional, national, and local participants from the two countries and ENTRO representing stakeholders, partners, and affected communities to review and update it, at an appropriate location relevant to the project area. It will be discussed, and comments collated by the consultant and address them in a draft final strategic flood management development plan.

4.7 Task 7: Capacity Building in Flood Risk Mgt. at Regional, National & Local Levels

The Consultant shall strengthen/establish as appropriate Flood Forecasting Center(s) and train the technical staff at National Flood Forecasting Centers of Ethiopia and South Sudan, and ENTRO to undertake essential tasks of flood risk assessment including flood extent mapping and mitigation measures. Ideally the designated trainees should accompany the work (hands-on training on-the-job) covering all the steps, starting with data collection, quality control and processing activities such as the geodatabase establishment, GIS mapping system, assessments related to floods, structural and non-structural flood intervention measures planning; and ending at results documentation on maps.

In collaboration with the client (ENTRO), the training activities will include conducting lecture-like sessions by the consultant to train the identified personnel of stakeholders, partners, and affected communities, at an appropriate location relevant to the project area (at regional, national, or local level), in relation to their assignment and deliverables produced for further implementation and ownership by the stakeholders. The capacity building program must incorporate related government officials as well as community needs and local organizations, inclusive of gender, youth, elderly, and disabled/handicaps issues. It shall include carrying out of awareness creation among participating communities and government officials at both national and local levels in both countries, to empower them on how to respond to climate risks and on how to jointly monitor floods in these select areas of BAS.

5 CONSULTANT′S DELIVERABLES

Deliverables include processed and quality assured datasets, enhanced and improved EN-FFEW system and associated manuals and documentation of data processing, and bi-monthly progress reports. All reports shall be delivered as soft copies (documents as Microsoft-Word-files and PDF-files – in addition tables as Microsoft-Excel-files). Furthermore, the Consultant shall submit at the end of the consultancy 5 high quality hard copies of the final report.

Note that the deliverables include all database (Datasets and Models) that includes models, collected data, assumptions made, user guide and manual in addition to the reports.

Tabulation of the Deliverables and their schedule

Task Ref.	ID	Deliverable	Type	Explanation and Remarks	Targeted Date (After Commencement)
0	**0.1**	Inception Report	Report	The inception report details the technical proposal with emphasis on methodology and approach after initially assessing the available data and reports. The Inception report will be presented in an Inception Workshop – see Deliverable No. 0.2	2 Month
0	**0.2**	Inception workshop	Workshop	Pre-planning and stakeholder review and consultation workshop.	2 Month
Task I: Survey, Data Collection and FFS for in these select areas of **BAS**					
1	**1.1**	Collected DTM/DEM of 2-3 m horizontal resolution, with 0.5-1 m vertical accuracy EO Terrain, Infrastructure and Assets Datasets of the hotspot areas in the Four Flood Prone River Segments along Baro and Sobat in the BAS	Data & Report	The Consultant will use the latest publicly available EO data to produce the data. When the publicly available EO data couldn't provide the required data, high resolution EO may be utilized. If need be, the high resolution EO data (Asset and DTM) will be budgeted and procured by the Consultant under the approval of ENTRO) may be utilized in the hotspot areas.	Draft 4 Month Final 5 Month
1	**1.2**	Compiled Historical Hydro-Meteorological Datasets for the select areas of BAS	Data & Report	Concise documentation of the rainfall, daily flow, water level, and major flood events data (satellite based).	Draft 4 Month Final 5 Month
1	**1.3**	Flood Frequency Study	Reports and model	At least two sources of precipitation, with EO datasets as inputs for the flood model, and flood specific return periods (2, 5, 10, 50, 100, 200, 500, 1000 years return periods)	Draft 5 Month Final 6 Month
1	**1.4**	Identified, designed and installed staff gauges for use in flood forecasting and mitigation in the critical locations of the flood plains.	Report and Installations	Simple staff gauge to be attached to critical permanent infrastructure (permanent school / hospital / administrative / market, etc. structure). The gauge be referenced to elevation above sea level.	Draft 6 Month Final 9 Month

Task Ref.	ID	Deliverable	Type	Explanation and Remarks	Targeted Date (After Commencement)
1	**1.5**	Report on key socio-economic Characteristics of Flood Prone Communities (the villages, camps and towns identified).	Report and survey data	From the four flood risk map areas in Ethiopia and South Sudan, the consultant will select sample villages, camps and towns for the study.	Draft 9 Month Final 11 Month
2	2.1	Flood Extent Models	Model	Hydrodynamic Models developed to delineate flood extents in the selected flood prone areas for selected flood scenarios	Draft 6 Month Final 7 Month
2	2.2	Flood Extent Geospatial Layers	Data	Model results (see Deliverable 2.1) as geospatial themes: (a) polygons (vector data) and/or (b) water depth raster (where possible and appropriate)	Draft 7 Month Final 8 Month
2	2.3	GIS Project Files with Flood Extent Layers	Data	Deliverable No. 2.2 incorporated in GIS project files (e.g. QGIS) for easy access and visualization	9 Month
3	3.1	Flood Exposure Models	Data/Model	GIS based model developed for a selected flood prone areas and scenarios (T).	Draft 7 Month Final 8 Month
3	3.2	Flood Exposure Geospatial Layers (vertical and horizontal)	Data	Model results (see deliverable 3.1) as geospatial themes: polygons (vector datasets).	Draft 9 Month Final 10 Month
3	3.3	GIS Project Files with Flood Exposure Layers	Data	Deliverable No. 3.2 incorporated in GIS project files (e.g., QGIS) for easy access and visualization.	11 Month
4	**4.1**	Flood Vulnerability Assessment and Mapping	Report	The report will be supplemented with geospatial layers that represent the vulnerabilities in the flood prone communities.	Draft 11 Month Final 12 Month
4	**4.2**	Flood Vulnerability of the Flood Prone Communities	Data	To be seen in conjunction with Deliverable No. 4.1	12 Month 13 Month

Task Ref.	ID	Deliverable	Type	Explanation and Remarks	Targeted Date (After Commencement)
5	**5.1**	Flood Risk Assessment and Mapping	Report	The report will be supplemented with geospatial layers that represent the flood risks in the flood prone communities.	Draft 13 Month Final 14 Month
5	**5.2**	Flood Risks of the Flood Prone Communities	Data	Report and detail maps.	Draft 14 Month Final 15 Month
6	**6.1**	Strategic Flood Inundation mapping.	Maps	Report with Geospatial layers	Draft 15 Month Final 16 Month
6	**6.2**	Strategic flood management development plan proposal (draft report).	Report and Schemas	Strategic flood management development plan at a prefeasibility study (Pre-FS) level, comprising of suitable structural / engineering solutions; non-structural interventions; and strategies for joint monitoring as appropriate (furnished with preliminary designs and costs' estimates of the proposed floods mitigation/adaptation infrastructure and associated livelihood works).	Draft 16 Month Final 17 Month
6	**6.3**	Validation workshop	Workshop	Stakeholder review and validation workshop	17 Month 18 Month
6	**6.4**	An updated strategic flood management development plan Pre-FS (final report).	Report and Schemas	An updated strategic flood management development plan at a Pre-FS level, comprising of suitable structural / engineering solutions; non-structural interventions; and strategies for joint monitoring as appropriate (furnished with preliminary designs and costs' estimates of the proposed floods mitigation/adaptation infrastructure and associated livelihood works).	18 Month 19 Month

Task Ref.	ID	Deliverable	Type	Explanation and Remarks	Targeted Date (After Commencement)
7	**7.1**	Concise reports of 1) stakeholders'/partners' personnel trained on-the-job during delivery of the consultancy assignment; 2) capacity building needs assessment; 3) capacity building program (inclusive of awareness creation materials/manuals developed); and 4) flood impact/risk assessment and mitigation measures training sessions conducted for the stakeholders'/partners' personnel.	Training	Launch of capacity building program (inclusive of awareness creation), facilitated in collaboration with the client (ENTRO by the Consultant, in relation to their assignment and deliverables produced to the identified regional, national, and local participants from the two countries and ENTRO, representing stakeholders, partners, and affected communities, at appropriate locations relevant to the project area(s) as follows: 1) Hands-on training on-the-job, covering all the assignment steps. 2) Three physical training sessions (max. of 2 days each) for the FFCs.	8 Month 20 Month
7	**7.2**	Flood Forecasting Center(s) strengthened/established for the select BAS areas where appropriate in the two countries.	Report	Flood Forecasting Centers strengthened/established for the select BAS areas at national/local level where appropriate in the two countries.	8 Month 20 Month

6 IMPLEMENTATION ARRANGEMENTS

6.1 Joint Coordination Meetings and Administrative Reporting

Besides the above, there shall be joint coordination meetings of the teams engaged in the work packages and the Client, Flood Project Coordinator. It is envisaged that such joint coordination meetings shall be carried out once every month. To the extent feasible, the joint coordination meetings shall be conducted back-to-back with workshops.

Furthermore, administrative reports are also required during the consultancy. These administrative reports shall be sent from the Consultant's Team Leader to the Client's Flood Project Coordinator. These reports shall consist of:

A E-mailed monthly reports that identify.

1. status and progress of work and progress anticipated during the subsequent reporting period,
2. identification of problems that impede or may impede work progress,
3. identification of opportunities to advance work progress more expeditiously, and
4. any other relevant information/issues.

B A final note that summarizes the Consultant's work on the consultancy, lessons learned, and recommendations about improving future similar undertakings, and strengthening Water Resources Planning and Management Program implementation at ENTRO.

6.2 Data, Personnel and Facilities Provided by the Client

The Consultant will be supported by ENTRO's team of experts, which mainly comprises of Flood Project Coordinator, Water Resource Planning Unit head, Water resource modeler, GIA and IT team.

In addition, the client will:

A RCRP project will leverage Flood Risk Map modeling system that ENTRO developed (DHI-Mike II based) for the specific BAS areas, For which the consultant will expand the flood risk mapping areas; recalibrate the hydrology model; calibrate the hydraulic model, etc.

B facilitate the availability and identification of stakeholders to be involved in training sessions and workshops,

C help in organizing training workshops (selection of participants, locations and infrastructure) and review meetings,

D provide access to licenses, computer /server rooms (remote and physical), and

E provide all relevant data at its disposal, to be used for this consultancy.

6.3 Staffing of Consultant's Team

6.3.1 General Requirements

The Consultant's team shall have demonstrated experience in the following:

- Hydromet data analysis and information management
- Flood plain socio-economic analysis
- Geo-spatial analysis (GIS / RS) and analysis of earth observation products
- Hydrologic and hydrodynamic modelling of flood plains
- Flood risk mapping

- Flood impact and risk analysis

6.3.2 *Expertise Required*

The Consultant shall be able to demonstrate a sufficiently experienced team. Specifically, the Consultant's team needs to include the following experts:

1. **Team Leader**: The team leader must have extensive experience working in a developing country environment with significant experience in flood impact and risk analysis. Demonstrated skills in project planning coupled with technical understanding gained through a career working in water resources modeling are essential. Experience in managing complex projects involving multidisciplinary teams is a requirement.

   Minimum qualifications: MSc. degree in engineering hydrology or similar; with a minimum of 15 years of professional experience including management of water resources modeling and software application projects, international experience including developing countries; experience in stakeholder consultations and participatory methods.

   Level of Efforts: The total expected level of effort for the Team Leader is four (4) person-months distributed over 20 months.

2. **Flood Risk Modelling Expert**: Minimum qualifications: MSc. degree in engineering hydrology, or similar; with a minimum of 10 years of professional experience in flood risk modelling, as well as training in the respective domain.

   The modelling expert shall mainly be responsible for hydrologic and hydrodynamic modeling, these comprising the model set-up, calibration, validation, and application of the models. In addition, the modelling expert shall be responsible for quality control and assurance of (1) input data, (2) data processing outcomes and (3) model results. Further, the modeler shall be responsible for flood mapping, including related modelling exercises and analyses, to develop hydrologic and hydraulic models to produce flood hazard, vulnerability and risk maps.

   Minimum qualifications: MSc. degree in engineering hydrology and hydraulic modeling or closely related fields. The modelling expert shall have a minimum of 10 years relevant experience in hydrological modeling, hydrodynamic modeling, flood extent mapping, data acquisition and processing, with strong GIS and programing capability as well as training in the respective domains.

   Level of Efforts: The total expected level of effort for him/her is four (2.5) person-months distributed over 20 months.

3. **GIS/Remote Sensing Specialist:** The minimum qualifications expected of him/her is possessing of a relevant MSc., master's degree or equivalent in GIS or Remote Sensing or related specializations coupled with a proven related basic qualification in Climatology, Geography, physical sciences or equivalent in related fields. S/he must have at least 5 years proven/demonstrated professional working experience in the use of remote sensing and GIS in water resources mapping/analysis, especially flood mapping mapping/assessments.

   Level of Efforts: The total expected level of effort for him/her is one and half (1.5) person-months distributed over 20 months.

4. **Sociologist with economics background:** The sociologist shall be responsible for (1) analyzing flood vulnerability assessments of the flood prone communities, and for (2) social impact assessment of floods for the flood prone communities.

   Minimum qualifications: Master's degree in sociology or closely related fields- agricultural economics; at least 15 years working experience in applied social impact assessment related to flood impact studies and risk analyses, as well as training in the respective domains; demonstrated experience in stakeholder consultations and participatory methods.

Level of Efforts: The total expected level of effort for him/her is two (2) person-months distributed over 20 months.

6.4 Organization and Administration of the Work

ENTRO Implementation Arrangements mean that ENTRO is responsible for the development and implementation of the EN-FFEW Project. The Consultant shall work under the overall supervision of the ENTRO's RCRP Project Coordinator, under the ENTRO Senior Regional Project Coordinator (SRPC); Water Resource Planning Unit will provide technical oversight of this consultancy.

To support the consultancy works, ENTRO will organize a regional working group and task teams respectively from each center of NBI, NBD and the South Sudan Ministry of Water Resources and Irrigation to review the Consultants' outputs and provide comments. ENTRO and the NBI task team will work with the national working group during the major milestones of the project and consultation and validation workshops.

6.5 Consultancy Coordination and Lines of Authority

The Consultant's contract is with ENTRO, which is in Addis Ababa, Ethiopia. All Consultant travel to and from (and within) the EN Basin for the purpose of this consultancy or liaison with the community of agencies, stakeholders, and others, must be documented in the work plan that the Consultant and ENTRO finalize at the beginning of the consultancy. Travel or schedule deviations from the work plan will likely arise, and these must be cleared through ENTRO. The Consultant must maintain an up-to-date work plan throughout consultancy as contingencies arise.

As in any Client-Consultant-relationship, ENTRO must ensure that the performance of the work is in line with the TOR and related norms, and the Consultant's team leader must ensure that the Consultant's team activities are consistent with the work plan, cultural and national sensitivities of the EN Basin countries, and have a high professional standard.

Although the supervision of the consultancy and approval of the work is the responsibility of ENTRO, the Consultant shall consider and incorporate comments from national and regional stakeholders. Effective working relationships with ENTRO and other national team members and stakeholders are an important element of this consultancy.

The consultant will supplement his work from the NCCR consultancy works to maximize the use of the existing data and share experience gained in the enhancement of FFEW system of BAS and flood risk mapping.

The Consultant is required to make appropriate efforts to ensure that there is equitable stakeholder access to trainings, workshops, consultations and/or other services of the consultancy such that there is neither direct nor indirect discrimination based on gender, age, disability, ethnicity or similar personal factor.

6.6 Level of Effort and Budget

The approximate budget for this Consultancy is about 10 person-months. The budget includes all the Consultant's costs, including professional fees, costs for travel for consultant team, communication, and reproduction of documents, stationery and other resources required for the consultancy. The Consultant will also be responsible for planning, in consultation with ENTRO, and conducting regional workshops and training described in the scope of work. However, travel expenses for participants of the meetings (excluding the Consultant's staff) and organization costs (including provision of meeting facilities and amenities) will be provided by ENTRO.

The cost of any data and/or specialized software required to be made available for the consultancy, including all license fees, shall be indicated separately in the Consultant's proposal. All data and software acquired accordingly shall become the Client's property.

Though the contract shall be a lump-sum contract, the Consultant's proposal shall indicate a detailed breakdown of costs by expenditure categories.

For this consultancy, a person-month consists of 22 working days, and this shall be used for all relevant calculations.

Any additional services outside the ones described in this TOR and further amendments during contract negotiations shall be subject to prior written approval by the Client, ENTRO.

6.7 Study Duration and Work Schedule

The total period of the study is **15 months** within the overall project tentative workplan.

Components	Activities	2023						2024												2025												2026											
Component 1: Risk Management & Climate	**Component 1: Risk Management and Climate**	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Sub-component 1.1: Climate and Disaster Risk Management																																								
1.1.1	**Activity 1**: Develop Flood Risk Mapping for select areas in BAS (areas to be selected in consultation in Ethiopia and SS). **Flood Hazard Assessment and Flood Extent Mapping for BAS (hotspot areas to be selected, sites not covred under NCCRP). Flood Vulnerability Assessment for BAS (hotspot areas to be selected). Flood Risk Assessment for BAS (hotspot areas to be selected)**																																								
1.1.1.1	Work and Payment for Consultancy services against an accepted Final Inception Report																																								
1.1.1.2	Work and Payment for Consultancy services against an accepted Interim Report I																																								
1.1.1.3	Work and Payment for Consultancy services against an accepted Interim Report II																																								
1.1.1.4	Work and Payment for Consultancy services against an accepted Final Report																																								
1.1.2	Preparation of Detailed ToRs for the Consultancy assignment (virtual and physical): Consultative meetings for joint review of draft ToRs (ENTRO, the Technical Officials from the Republics of South Sudan and Ethiopia / The RCRP Flood & Drought Technical Working Group members and the World Bank).																																								
1.1.3	**Stakeholder Engagements:** Field visits to BAS flood hot spot areas - Country Consultations between Ethiopia and South Sudan (Field reconnaissance and establishing contacts with key stakeholders on the ground; Engage Stakeholders during Inception phase of the Preliminary assessment of flood management in BAS areas)																																								
1.1.4	Validations Workshops (Inception, review of draft and Final study reports) – 2 Stakeholder review and Validation workshops for study outputs																																								
1.1.4.1	Inception Report Review and Validation Workshop (Juba South Sudan)																																								
1.1.4.2	Draft Final Report Review and Validation Workshop (Gambela - Ethiopia)																																								
1.1.5	Procurement of consultancy services: Preparations of Expressions of Interests, Evaluations of Expressions of interest, shortlisting of consultancy firms, Advertisements in Regional papers (for the EOI); and Evaluations of Technical and Financial Proposal and Contracting																																								
1.1.5.1	Advertisement of EOI in National, Regional and International Newspapers																																								
1.1.5.2	Evaluations of Expressions of interest, shortlisting of consultancy firms (Virtually)																																								
1.1.5.3	Evaluations of Technical Proposals (Physical)																																								
1.1.5.4	Evaluations of Financial Proposals (in-house)																																								

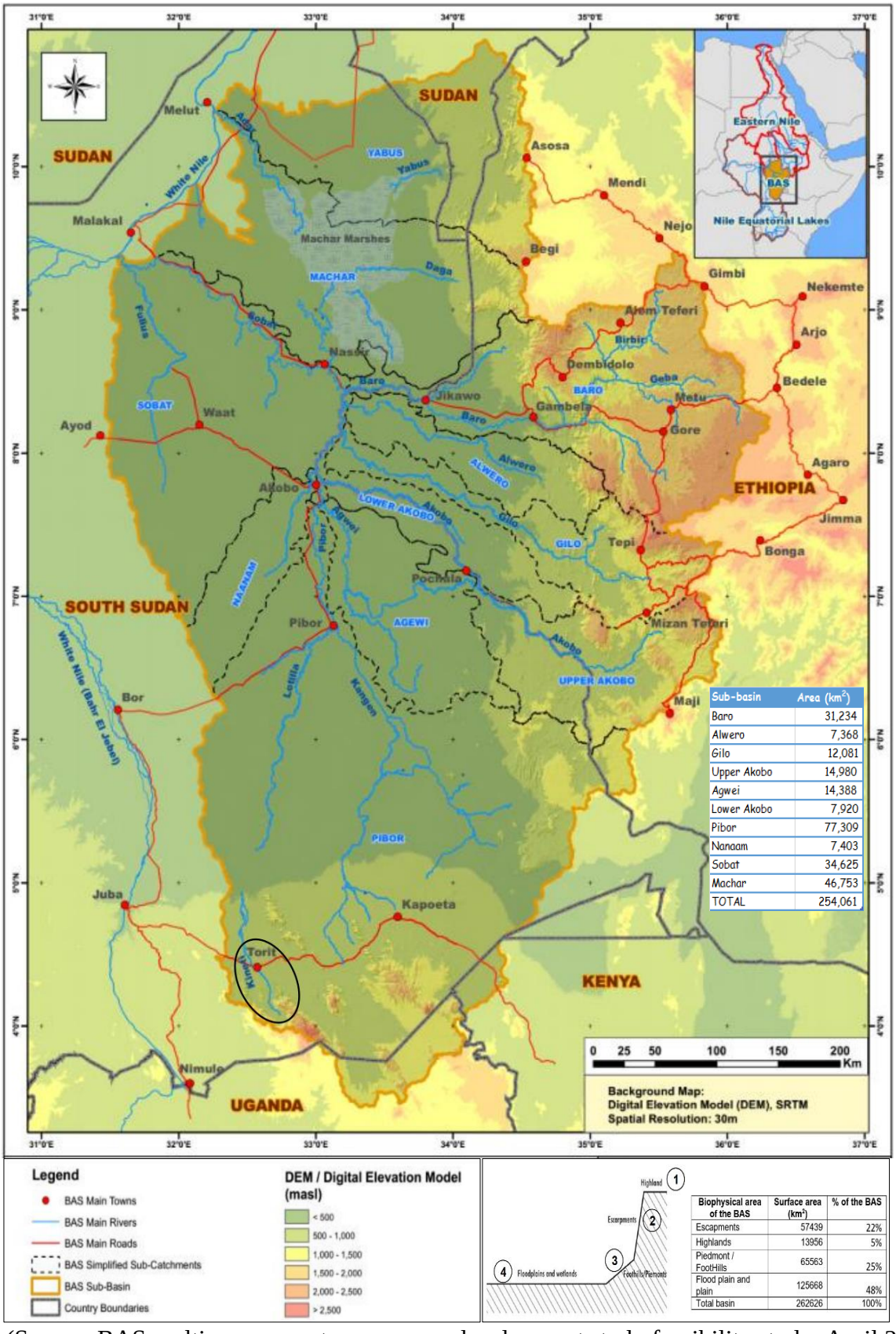
7 REFERENCES

1. Eastern Nile Technical Regional Office (2006). Project Preparation: Flood Preparedness and Early Warning, Technical Background Paper. Volume 1: Main Report. ENTRO
2. Eastern Nile Technical Regional Office (2006). Project Preparation: Flood Preparedness and Early Warning, Technical Background Paper. Volume 2: Appendices. ENTRO
3. Eastern Nile Technical Regional Office (2007). Project Preparation: Flood Preparedness and Early Warning, Project Implementation Plan. ENTRO
4. Eastern Nile Technical Regional Office (2018). 3rd Annual Eastern Nile Flood Forum. Enhancing Flood Forecast and Early Warning in Eastern Nile Basin. Proceedings. ENTRO
5. Eastern Nile Technical Regional Office (2020). Concept Note for Nile Cooperation for Climate Resilience (NCCR) project proposal. Flood Forecasting and Early Warning Enhancement Project. ENTRO
6. Eastern Nile Technical Regional Office (2020). EN-FFEW Enhancement Summary Report. Eastern Nile Technical Regional Office (ENTRO) Flood Forecasting and Early Warning Enhancement Project. ENTRO.
7. Eastern Nile Flood Risk Mitigation (EN-FRM) Project. "Work Package 2 -Enhancement of the Eastern Nile Flood Forecasting and Early Warning System (EN-FFEWS) and Flood Risk Mapping" – Undergoing.
8. Flood Situation Overview and Assessment Pertaining to Floods Episode (2019-2022), Ulang County, Upper Nile State, South Sudan (SS), FAOSS, September 2023.
9. The Khorfulus floods storyline by CCCM Cluster in South Sudan, November 2020.
10. Flood Vulnerability and Contingency Plan, Mapping and Assessment Report by REACH accompanied with Housing Design Report by ACTED, Warrap State, South Sudan, 2013.
11. Chapters 2, Annex 3 and associated data of the Republic of South Sudan (RSS) Irrigation Development Master Plan (IDMP), 2015.
12. Eastern Nile Groundwater Atlas and Hydrogeology Maps with an explanatory note, ENTRO, Addis Ababa, Ethiopia, 2019.
13. One-System Inventory Annex: Baro-Sobat-White Nile Sub-Basin, ENTRO, Addis Ababa, Ethiopia, 2009.
14. Eastern Nile Planning Model (ENPM) Project, Final Report, Water Balance Model for the Eastern Nile Basin, October 2012, submitted by Hydrologist Dr Ahmadul Hassan.
15. Machar Marshes Eco-Hydrology Assessment Project, Final technical report, HYDROC GmbH for ENTRO, November 2020.
16. BARO AKOBO SOBAT WETLANDS KNOWLEDGE BASE CONSULTANCY DRAFT REPORT, BUSULWA HENRY SSEBULIBA CONSULTANT, WETLANDS AND BIODIVERSITY, 12 June 2012.
17. Machar Marshes Wetland Economic Valuation of Biodiversity and Ecosystem Services for Green Infrastructure Planning and Development, Final Technical Report, prepared for NBI by Dawit Woubishet Mulatu (PhD) (Principal Consultant) Etsehiwot Semreab (Team Member), Tiruwork Arega (Team Member) Tinebeb Yohanes (GIS expert), April 2020.
18. Report No: PCBASIC0272713, International Development Association, Project Appraisal Document on, a Proposed Grant in the Amount of US$4 Million Equivalent to the Eastern Nile Technical Regional Office for a Regional Climate Resilience Program for Eastern and Southern Africa, the World Bank.

8 ANNEXES

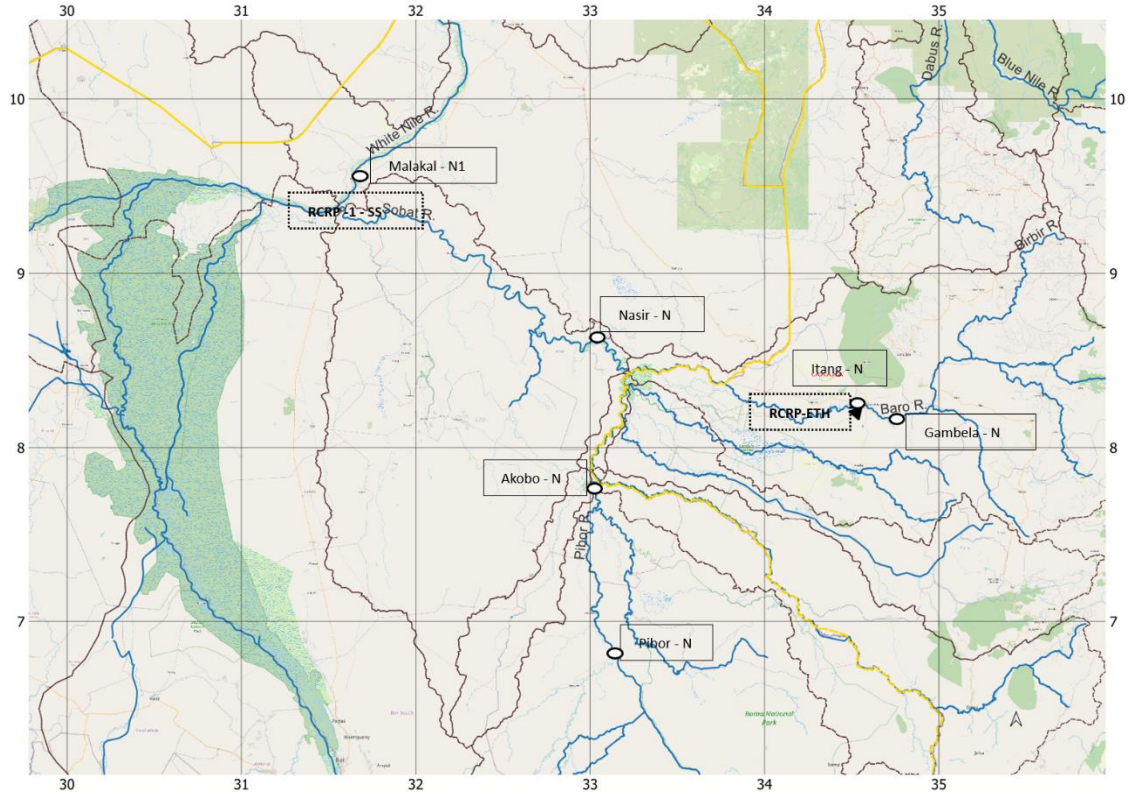
8.1 Annex I: Overview of the BAS Flood Risk Mitigation Studies

8.1.1 Figure 1A: BAS sub-basin location map, relief, biophysical area & river network



(Source: BAS multipurpose water resources development study feasibility study, April 2017)

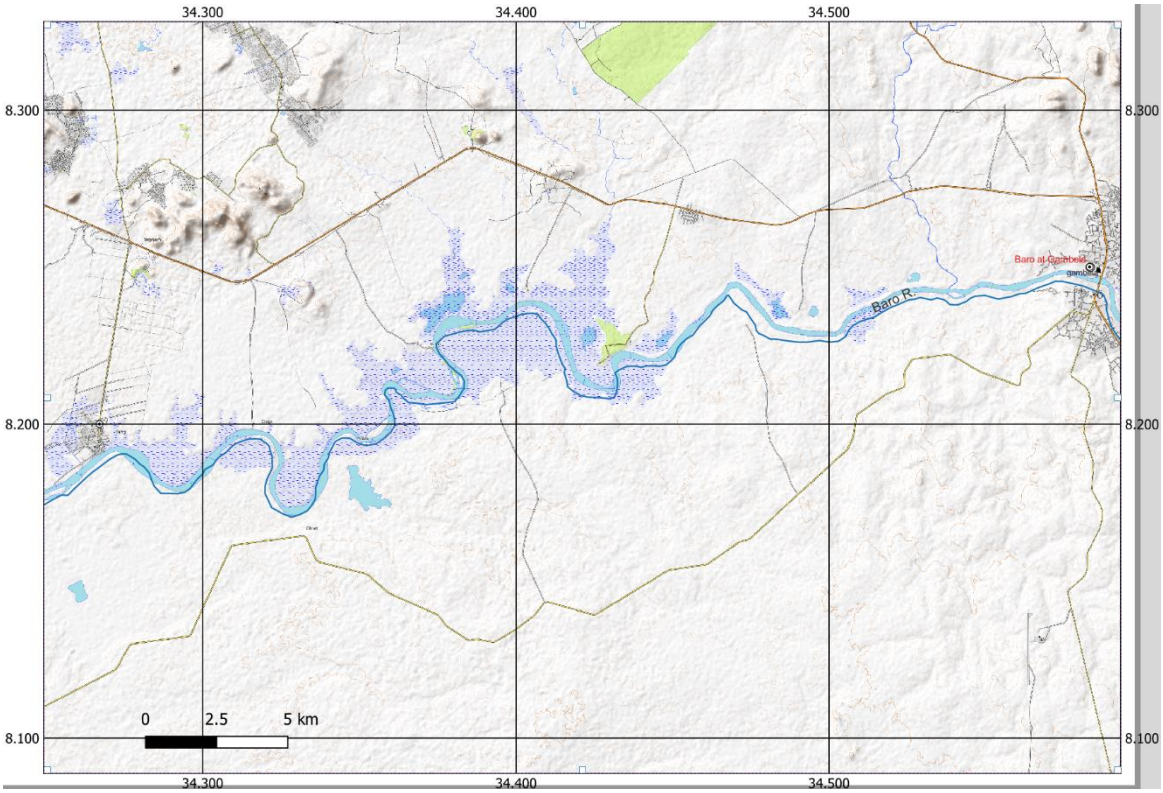
8.1.2 Figure 1B: Location of the NCCR (N) & RCRP flood risk mitigation study areas



(Source: Created with QGIS Platform at ENTRO)

8.2 Annex II: RCRP Flood Risk Mitigation Study Area

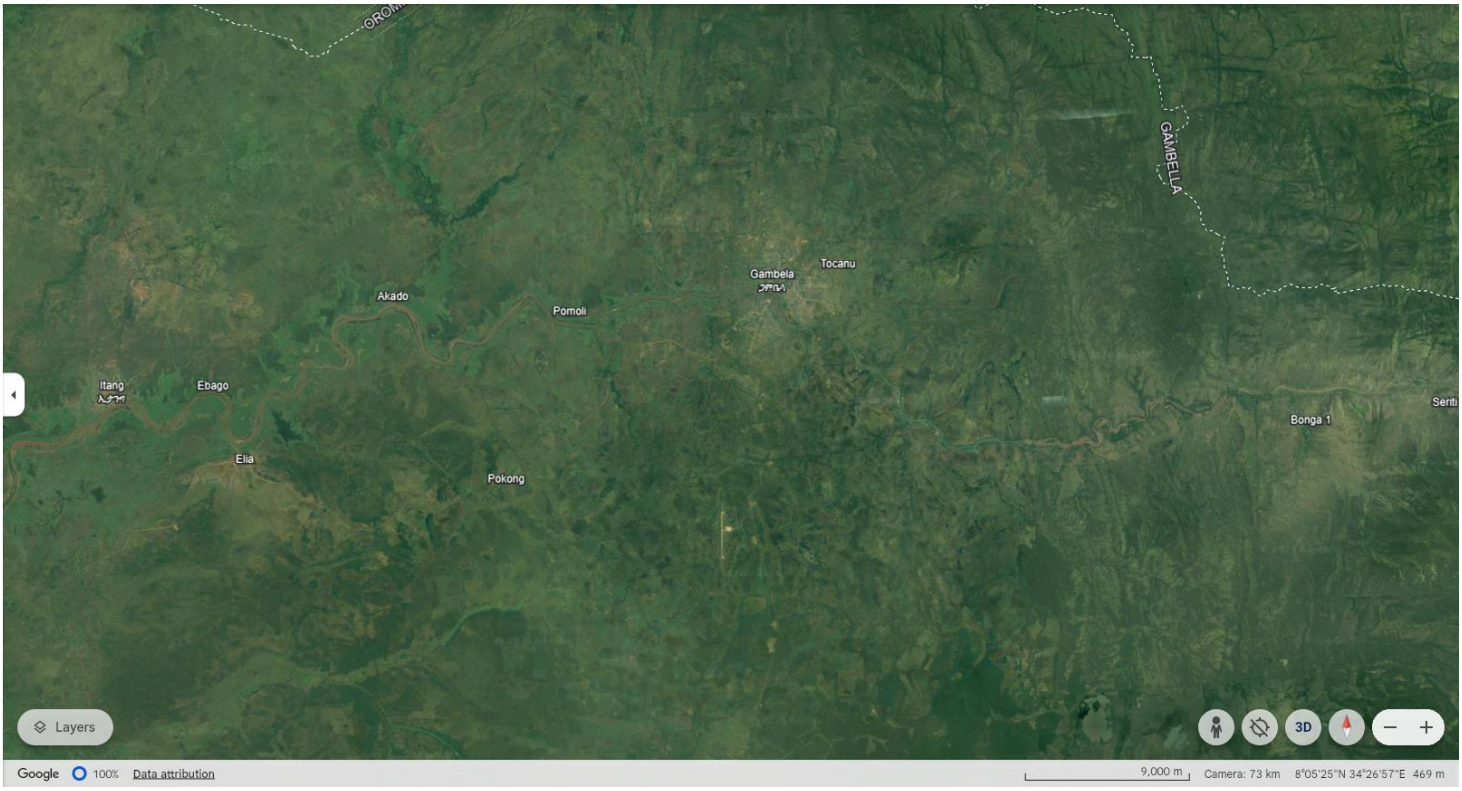
8.2.1 Figure 2A: Partial Locational Map of BAS-ETH Flood Risk Study Area

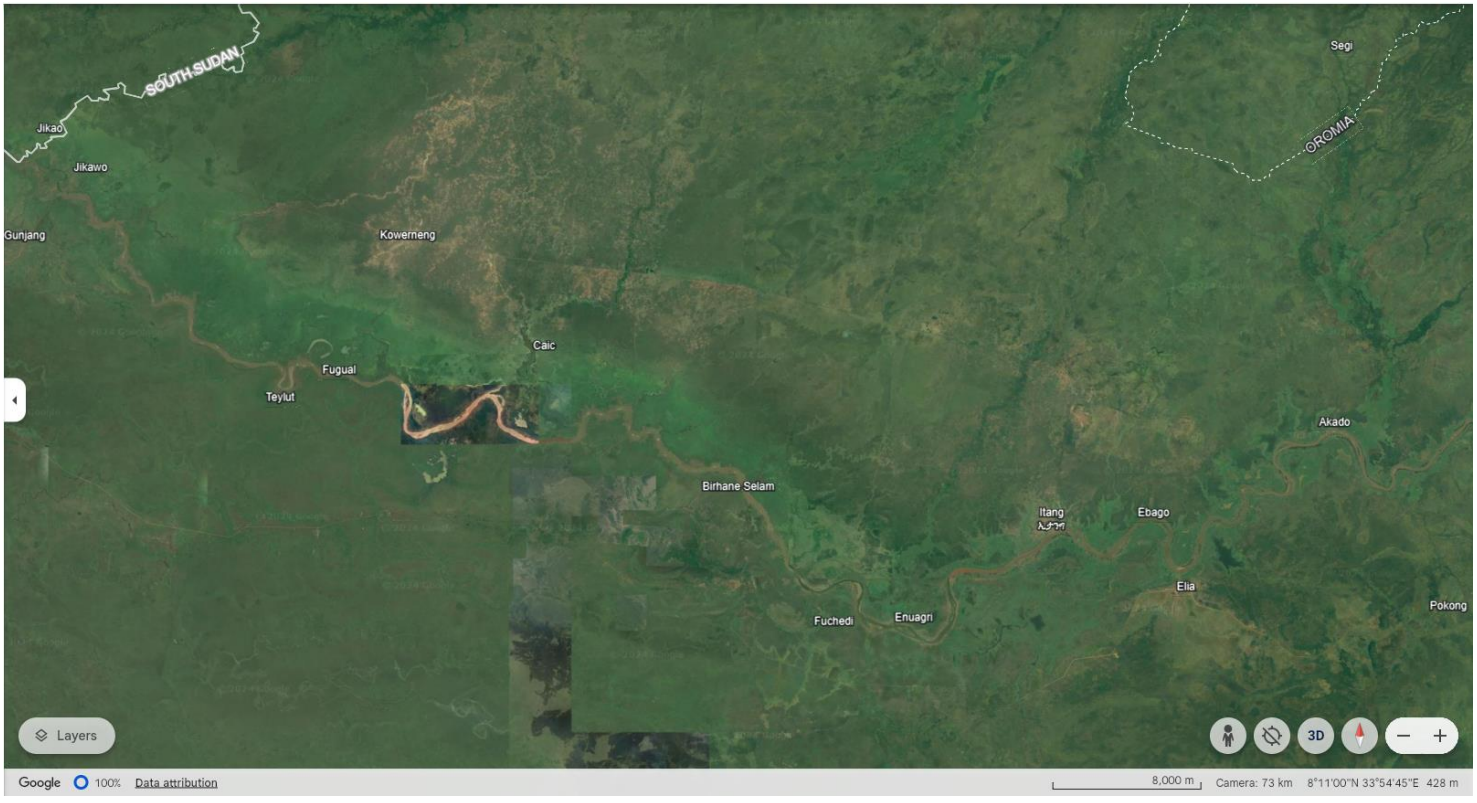


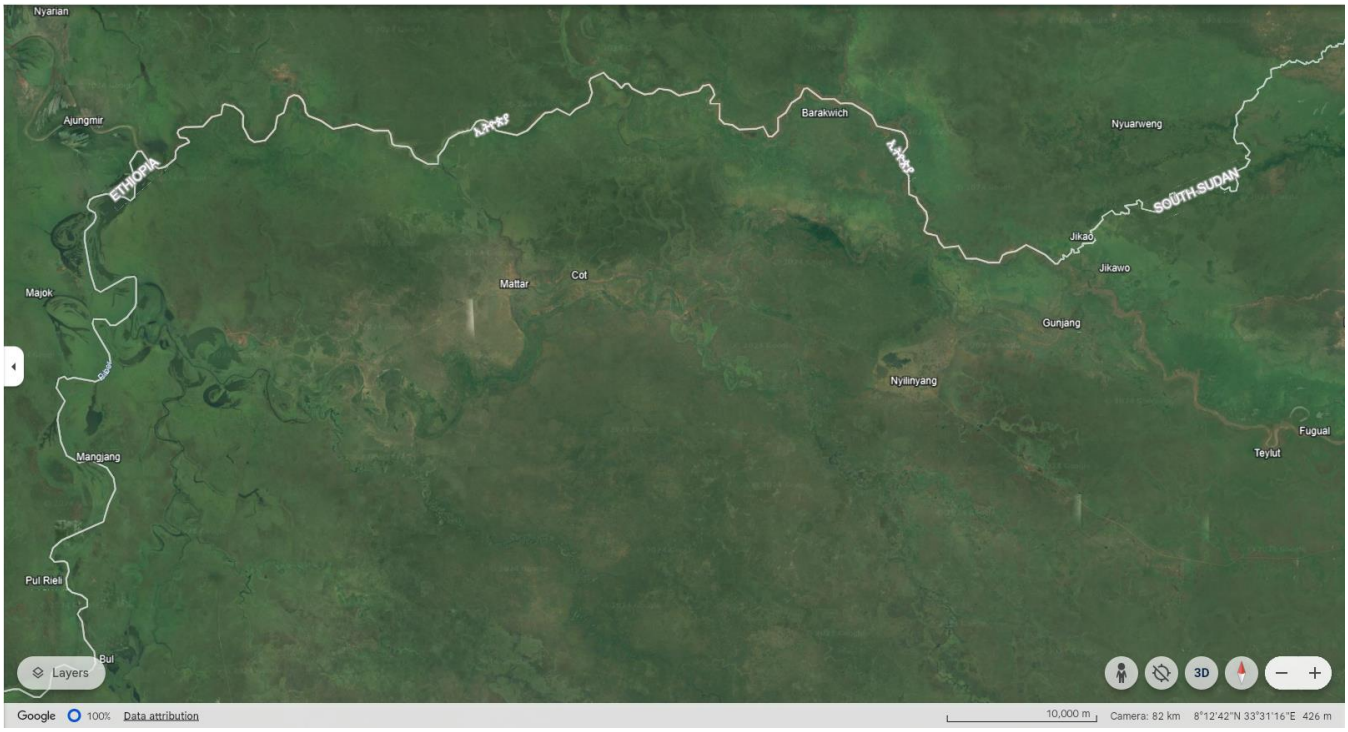
Characteristics of Flood Risk study area from Gambela City to Itang town and the border

(Source: Created with QGIS Platform at ENTRO)

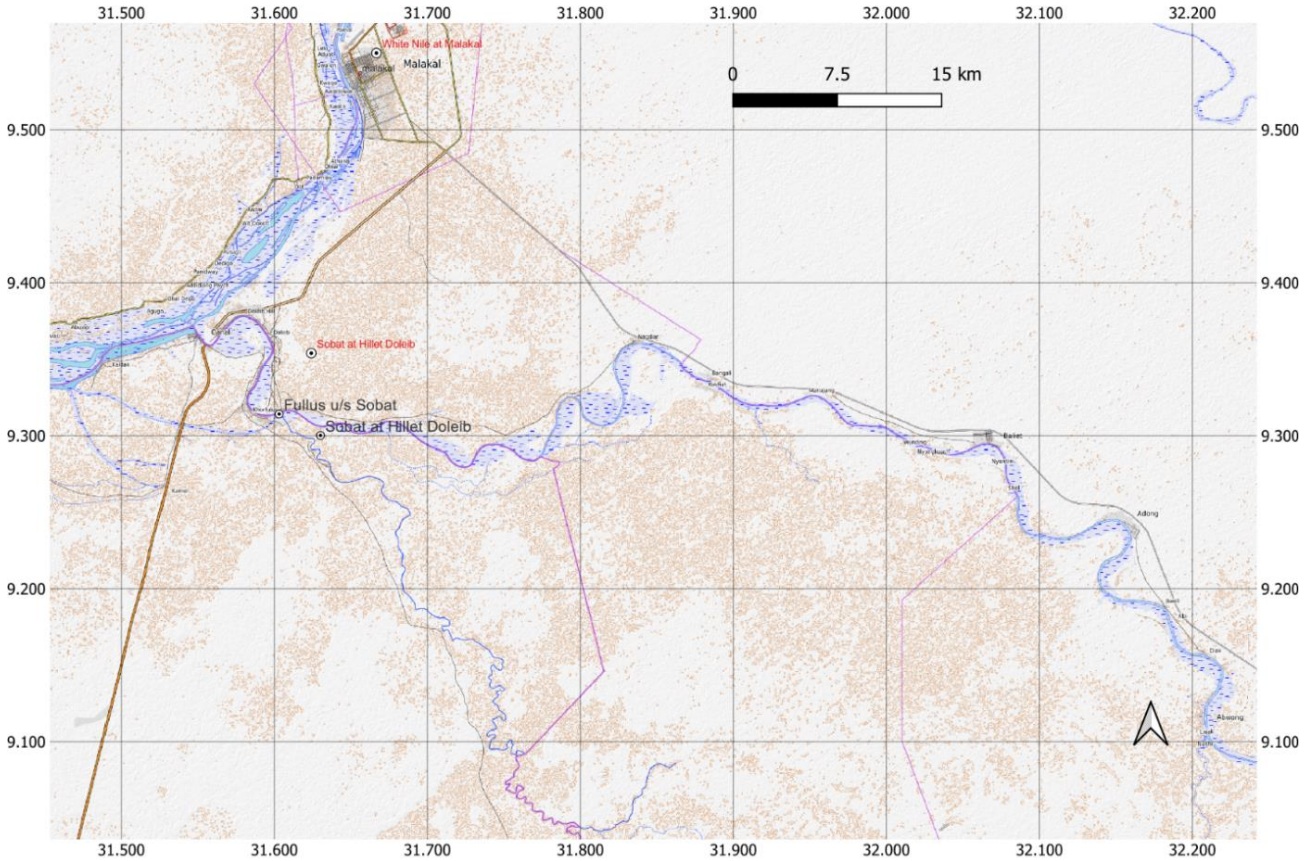
The study will include all the villages along the banks of Baro, from Gambela to Itang and the border with South Sudan (see series of Google images below).





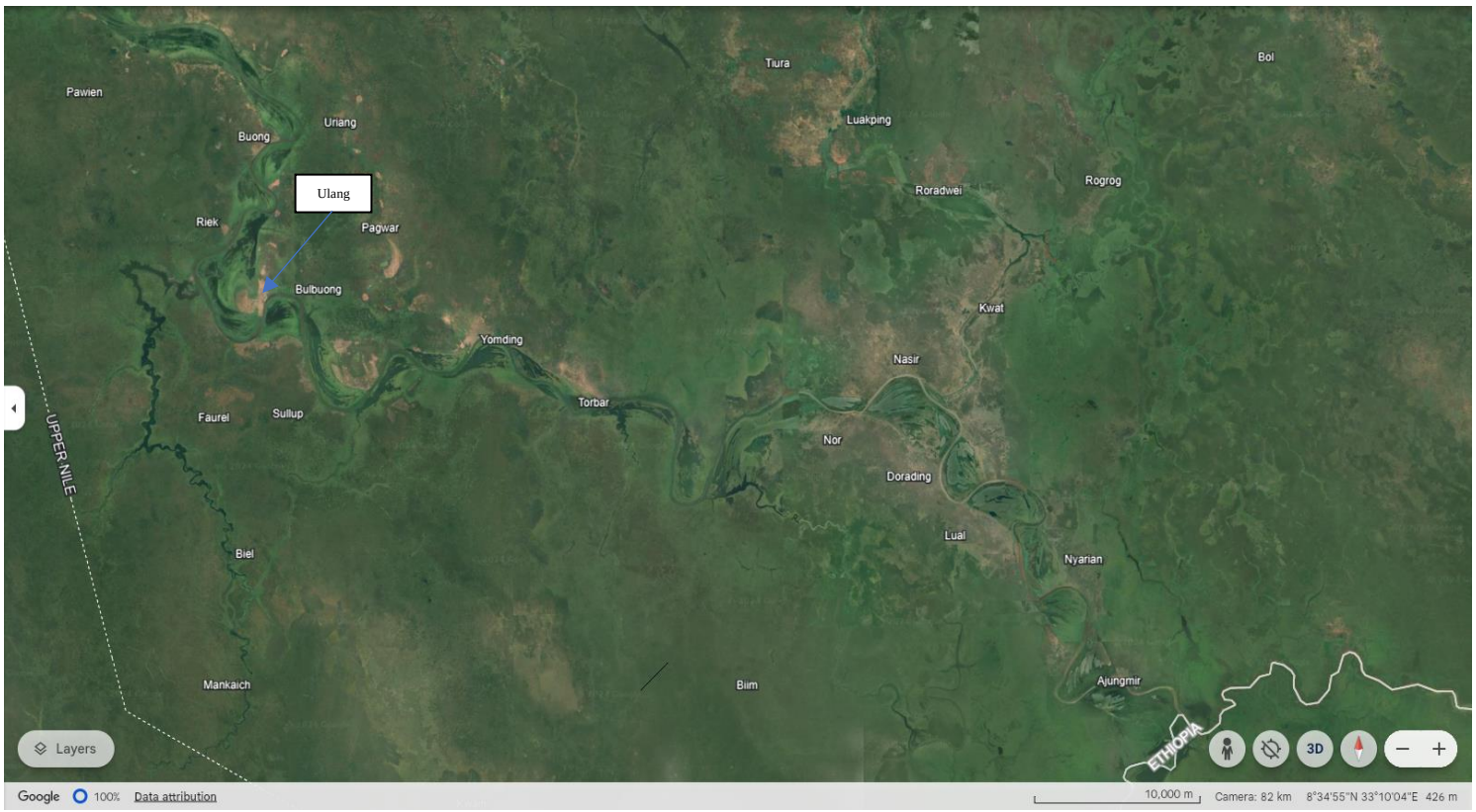


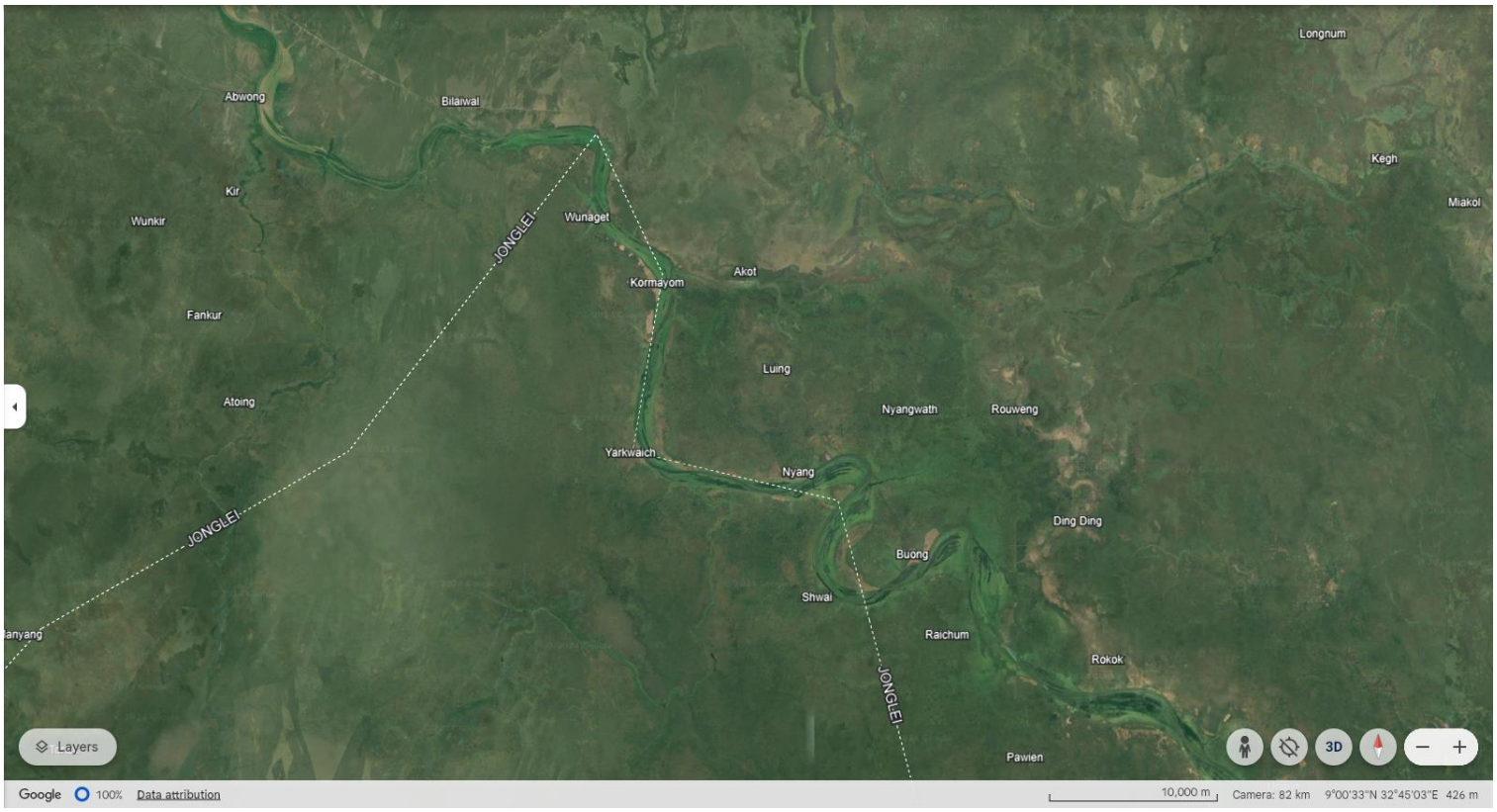
8.2.2 Figure 2B: Partial Locational Map of BAS-SSD Flood Risk study area

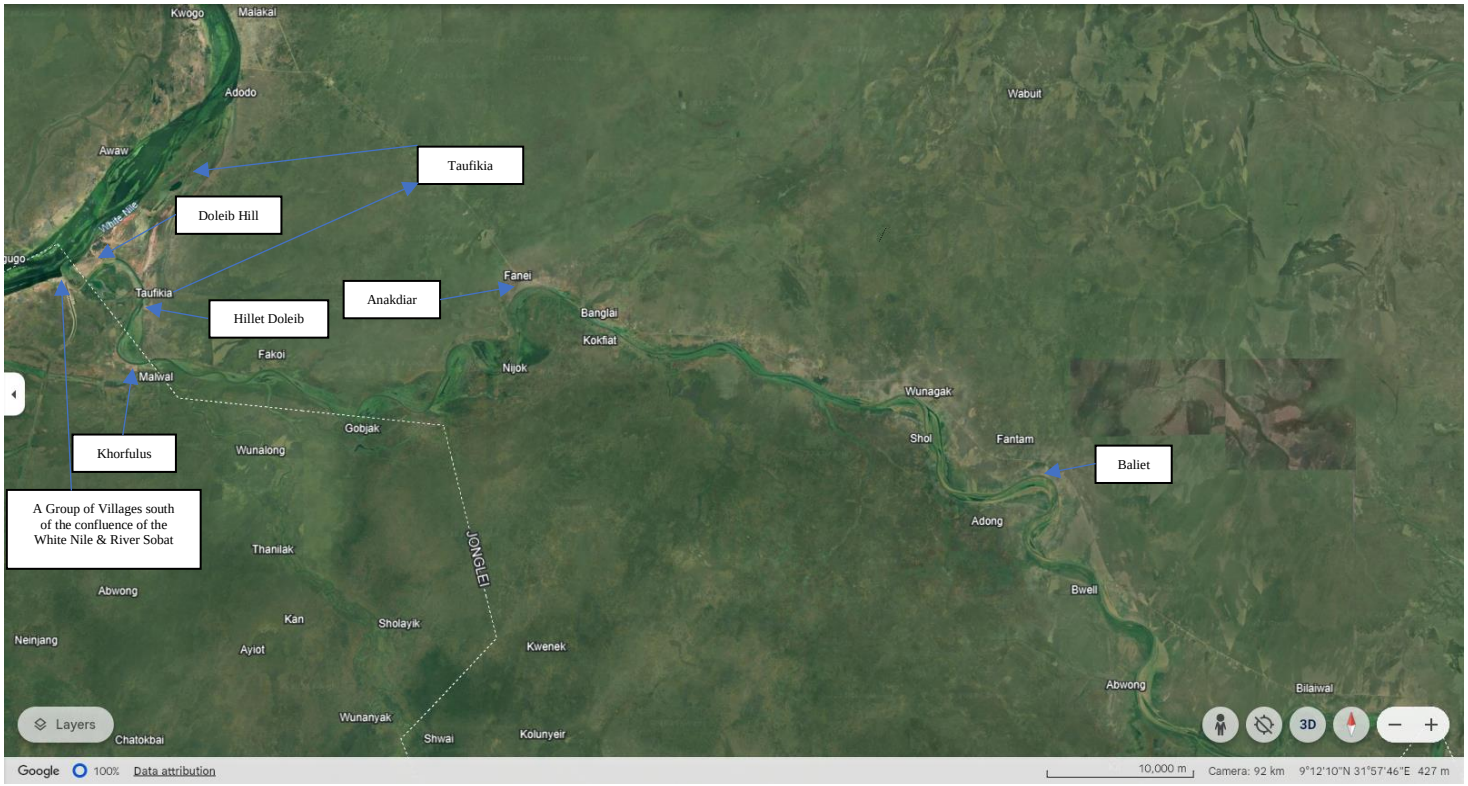


Characteristics of flood risk study area between the border and Sobat Junction with White Nile (Source: Created with QGIS Platform at ENTRO)

The study will include all the villages along the banks of Sobat, from the border with Ethiopia to the junction with the White Nile (see series of Google images below).


Tiura
Bol
Pawien
Uriang
Buong
Luakping
Ulang
Roradwei
Rogrog
Riek
Pagwar
Bulbuong
Kwat
Yomding
Nasir
Torbar
Faurei
Sullup
Nor
UPPER NILE
Dorading
Luai
Biel
Nyarian
Mankaich
Biim
Ajungmir
ETHIOPIA
Layers
3D
Google
100%
Data attribution
10,000 m
Camera: 82 km 8°34'55"N 33°10'04"E 426 m


Longnum
Abwong
Bilalwal
Kegh
Kir
Miakol
Wunkir
Wunaget
JONGLEI
Akot
Kormayom
Fankur
Luing
Atoing
Nyangwath
Rouweng
Yarkwaich
Nyang
Ding Ding
Buong
Shwai
Raichum
Rokok
JONGLEI
JONGLEI
Pawien
Layers
3D
Google
100%
Data attribution
10,000 m
Camera: 82 km 9°00'33"N 32°45'03"E 426 m



8.3 Annex III: Eastern Nile Flood Forecast and Early Warning (EN-FFEW) System

Eastern Nile Flood Forecast and Early Warning (EN-FFEW) service is a key component of ENTRO activities that has been continuously conducted every flood season (June/July through September/October) since 2010. The EN-FFEW activities strengthened regional collaboration through sharing of information, strengthening of national flood forecasting institutions and overall reduced the risks of flood devastation for 2.2 million people living in flood-prone areas of the Eastern Nile sub-basins in Ethiopia, South Sudan, and Sudan.

The Eastern Nile Flood Forecast Early Warning System (EN-FFEWS) are focusing on the riverine floods, and are conducted for Lake Tana (LT), Baro-Akobo-Sobat (BAS), Blue Nile (BN), Tekeze-Setit-Atbara (TSA) flood-prone areas. The EN-FFEWS is an integrated real-time forecasting and early warning system that supports ENTRO, as well as regional and national stakeholders in flood forecasting and early warning. The EN-FFEWS has three major components: (a) meteorological forecast, (b) hydrological forecasts, and (c) flood forecasts that are integrated into a combined forecast and warning system. In the following sections, a summary of daily rainfall forecast, flood forecast, as well as detailed flood forecasts and warnings mechanism for Lake Tana, Blue Nile, BAS, and TSA flood prone areas are provided.

Meteorological forecast: Rainfall is forecasted with the Weather Research and Forecasting (WRF)[2] model. The model is a regional customization for the EN with global input from NCEP's GFS to provide initial and boundary conditions. WRF produces 3-day forecasts with a spatial resolution of 6 km, and the forecasts are updated daily. The temporal resolution of the rainfall forecasts is hourly. The meteorological forecast process starts with a scheduled download of NCEP's Global Forecast System (GFS) to provide initial and boundary conditions. To ensure that the hydrological forecasts

[2] https://www.mmm.ucar.edu/models/wrf.

don't suffer lack of rainfall inputs, there are alternative provisions for using GFS rainfall forecasts for three days lead time – in case WRF doesn't run. The process is automated.

Furthermore, Near-Real-Time (NRT) satellite rainfall estimates for quantitative precipitation estimations (QPE) are available with 1-day lag and are used to quantify biases of the rainfall forecasts.

Hydrological forecasts: In the EN-FFEWS runoffs in the catchments of the four EN-basins and flows at key locations in the river network are forecasted with the hydrological modelling tool NAM of DHI. The inputs for forecasting runoffs in the catchments and flows at key locations in the river network come from meteorological forecasts with the WRF. The forecasted flows are archived for further analyses in the integrated forecast system. The input to the hydrodynamic models is direct.

Flood forecasts: In the EN-FFEWS flood water levels at key locations in the flood prone areas in the river network of the basins are forecasted with MIKE 11. The inputs to the hydrodynamic forecasts of flood water levels are flows from hydrological forecasts.

Integrated Forecast System: The MIKE Operations platform integrates the meteorological, hydrological and flood forecast operations. Near-real-time and forecasted data are regularly imported from diverse sources to the central database (Postgres SQL) through scheduled data import jobs. The rainfall-runoff and hydrodynamic models have been integrated in MIKE Operations so that simulation runs are triggered from the platform. The input timeseries are regularly updated using the real-time and forecasted data. The NAM rainfall-runoff models and the MIKE 11 hydrodynamic models for the 4 basins of the EN run every 6 hours. When a model run is completed, results are summarized to be analysed in the GUI of MIKE Operations. If simulated or observed water level values exceed pre-defined threshold values, warning triggers.

8.4 Annex IV: Guide for determining Key Characteristics of Flood Prone Communities

In short, the scope of the socio-economic survey will focus on the linkages between hydrological characteristics in the flood prone areas and socio-economic indicators of the flood prone communities in the BAS-ETH and BAS-SSD Flood Risk study areas.

The consultant will propose, at inception stage, the specific sample locations (at up to five sites in each country) and population sample size (> 30) for the survey implementation, to be approved by ENTRO and the countries experts.

The Consultant shall conduct field surveys in the identified/selected flood prone communities accordingly. During the field surveys, the Consultant shall capture local knowledge on flood preparedness and mitigation through consultations with the people in the flood prone communities. In these field surveys, it is important to envisage that recommendations for implementing flood preparedness and mitigation measures should build on what is already in place, including traditional approach, and what locals evaluate as important.

The report will include the findings, structured under the following areas:

- Flood preparedness
    - local knowledge on the history of flooding.
    - community organization.
    - household preparation (for example, high beds, food silos).
    - early warning systems based on local knowledge.
    - communications infrastructure.
    - structural preparedness, such as terraces, drains and levees.
- During a flood event
    - loss of lives, livelihoods, properties and businesses.
    - damage to properties, food stocks, livelihoods, and businesses.
    - physical isolation and displacement.
    - damage to public infrastructure such as roads, and telecommunications; and

sanitary, drinking water and health facilities.
    - loss of economic productivity.
    - human and animal diseases.
    - environmental damage.

- Post-flood recovery
    - access to public relief and rehabilitation assistance.
    - rehabilitation of residential buildings.
    - rehabilitation of public facilities and services.
    - rehabilitation of croplands.
    - recovery of local businesses.
    - management of water-borne diseases and other disease vectors.
    - Issues of voluntary resettlement away from flood prone areas.
    - Adoption/access to alternative livelihoods.