Report on River Barge System Feasibility Study Project, South Sudan

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Table of contents

Figures

Tables

Abbreviations and Acronyms

AfDB	African Development Bank
bbl	Barrel (of crude oil)
CEMAC	Communauté Économique et Monétaire de l'Afrique Centrale
CEVNI	European Code for Inland Waterways
CPA	Comprehensive Peace Agreement
CSD	Cutter suction dredger
DEM	Digital elevation model
DG	Dangerous goods
DTIS	Diagnostic Trade Integration Study
EA	Environmental audit
EIA	Environmental impact assessment
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GoRSS	Government of the Republic of South Sudan
HDM-4	Highway Development & Management-4
IAP	Integrated action plan
IDP	Internally displaced person
ILO	International Labour Organisation
IRND	Inland River Navigation Department
JICA	Japan International Cooperation Agency
kHz	Kilohertz
kVA	Kilovolt-ampere
kW	Kilowatts
m^2	Square metres
MODIS	Moderate-resolution Imaging Spectroradiometer
MoT	Ministry of Transport
mm	Millimetre
m/s	Metres per second
t	Metric tonne (1,000kg)
t-km	Metric tonne-kilometre
N/A	Not available
NBI	Nile Basin Initiative
NDVI	Normalized Difference Vegetation Index
NGO	Non-governmental organisation
NRTC	Nile River Transport Corporation
OD	Origin and destination
PoC	Protection of Civilians
QGIS	Quantum Geographic Information System
RTC	River Transport Corporation
RUC	Road user cost
SEA	Strategic Environmental Assessment
SPLA	Sudan People's Liberation Army
SRTC	Sudan River Transport Company
SRTM	Shuttle Radar Topography Mission
SSOC	South Sudan Operations Centre
SSTC	South Sudan Transnile Co.

TIN	Triangular Irregular Network
UN	United Nations
UNEP	United Nations Environment Programme
UNJLC	United Nations Joint Logistics Centre
UNMISS	United Nations Mission in South Sudan
UNOPS	United Nations Office United Nations Office for Project Services
USAID	U.S. Agency for International Development
USGS	United States Geological Survey
WFP	World Food Programme

Executive Summary

River transport in South Sudan has a long history of successful operation while currently showing a strong decline due to the challenging security situation in the country. Humanitarian interventions in South Sudan must rely on expensive air transport and challenging road conditions so that river transport is seen as an opportune way to transport bulk supplies for humanitarian assistance and at the same time providing opportunities for economic development in the country. UNOPS has respectively commissioned HYDROC GmbH to develop a river barge transportation study and assess the current situation as well as develop the necessary interventions for sustainably reviving river transport on the White Nile River.

The objective of the 'River Barge System Feasibility Study Project' is to enable donors and GoRSS to make a well-informed decision on whether to fund the implementation of a river barge transportation system on the White Nile River. The project scope includes surveys and assessment of the conditions of White Nile River between Juba and Renk, including assessing flow velocities, depths and widths, conducting a bathymetric survey between Juba and Bor, assessing the conditions of existing major ports, as well as analysing long-term economic benefits of the transportation system, provide recommendations of proposed upgrades to achieve a full-scale river barge transportation system, conduct an environmental audit, and providing technical specifications and preliminary cost estimates.

The surveys (Section 3) were conducted using remote sensing data from satellite imagery as well as carrying out fieldwork both for bathymetric data collection using an echo sounder as well as assessing the environmental conditions on the river. All major ports that were accessible from a security perspective were assessed on-site. The collected data was analysed, and bathymetric maps produced for the measured river stretch between Juba and Bor. In addition, historical data available with the consultant was utilised. Hydrodynamic modelling was conducted to confirm hydraulic conditions in the river including water depth and current velocities. The results were utilised to establish boundary conditions for barge transport and identify dredging requirements for deepening and widening the channels. Most significant dredging needs have been identified between Juba and Bor as well as between Bentiu and Lake No, where significant volumes need to be dredged. Dredging requirements downstream of Bor along the White Nile River are mostly punctual as well as for widening the partly narrow and sharply bending navigation channel.

The port assessments (Section 4) showed partly good (Mangalla) and partly significantly deteriorated conditions (Bentiu) in the ports. While the ports are sufficient to deal with the current very low transport neds, the planned future increase in river barge transport will require significant upgrades of the port assets to be able to cope with increasing number of port calls and the respective need for faster loading/offloading times.

Stakeholder interviews were conducted to understand the current institutional and management situation and establish the immediate needs and problems. The main stakeholder of the river barge transportation system is the Ministry of Transport.

Based on the initial assessments and situation on-ground as well as identified needs and opportunities, the economic case for investment in river transport in South Sudan was assessed (Section 5). Considering historic peak barge transport numbers of approximately 140,000 tonnes per year in 1981-1982, and current transport numbers of about 10,000 tonnes, a huge

potential is seen. It was calculated that under competitive market conditions barge transport should cost around $0.05 per tonne-km, i.e. around 25-50 percent of road transport costs. Under current conditions prices charged for barge transport anyhow differ little from those charged by truck operators. Nevertheless, barge transport would be possible year-round, while trucking operations are challenging and partly impossible in the rainy season. The currently available operational fleet is sufficient to manage this, although much of it badly needs improvement if a barge transport system is to be the result.

Examining the benefits of dredging Juba to Bor and rehabilitating Juba port, over a five-year period estimated the present value of gross benefits is $11.4m. Given that Bentiu may be supplied by road, the case for dredging Lake No to Bentiu and rehabilitating Bentiu port is unlikely to be compelling from an economic perspective.

The long-term economic benefit associated to a river transport system with its lower transport costs is seen in long-term development benefits, i.e. making available large-scale supplies of building materials that are currently expensive due to high transport costs. By the same token South Sudan's goods stand little chance in export markets. Recently, access to East African markets has improved enormously, but the lack of any viable transport connection to Sudan has resulted in isolation for much of the north of the country and fostered uncompetitive transport markets. Consequently, provided the key assumptions are met (see above), investment in improving river transport is expected to result in long-term economic benefits.

Based on the technical and economic assessments, proposed activities in form of an options catalogue have been developed (Section 6). The options describe in detail the necessary actions for dredging the different stretches of the White Nile River, i.e. Juba - Bor, Bor - Malakal, Bentiu - Lake No and Malakal - Renk, specifically listing calculated dredging volumes and related activities like vegetation clearing. Cutter suction dredgers are proposed for the works, supported by hydraulic excavators on pontoons for vegetation clearing and workboats. Dredged material is suggested to be discharged by pipelines and deposited at specified locations on land or in the reed fields.

Navigation aids are currently non-existent along the White Nile River and experienced captains lead the barges. With the proposed increasing transport numbers more, barges will travel the river for which only less experienced staff will be available. Navigation aids will therefore become essential for safe passage.

Port development options have been developed individually for each of the assessed ports, i.e. for Juba, Mangalla, Terekeka, Mingkaman, Bor, Shambe, Adok, Bentiu, Malakal, Melut and Renk, considering quay structures, handling and storage areas, loading/lifting equipment, warehousing, security, office and auxiliary facilities. It is suggested that developments will be implemented driven by market needs, as currently the ports can handle the calling barge numbers while increased capacity with faster loading and turnaround times will be needed once traffic picks up and cargo quantity increases.

The number of barges on the White Nile River has been assessed as sufficient for current and near future transport requirements and it is strongly recommended to utilise and rehabilitate existing assets before procuring new equipment.

Environmental aspects (Section 7) are an important consideration in developing a river transportation system through the Sudd swamps. The Sudd is a pristine wetland area and

Ramsar site that has so far been relatively undisturbed by human activities. The designation of the Sudd wetlands as a Ramsar wetland in 2006, along with its source, the White Nile, made its protection a prime task of international importance. This international status obligates the Government of South Sudan to protect and manage the Sudd effectively, yet there is a challenge in building capacities for the monitoring and enforcement of environmental regulations.

It is global best practice that for cases where a Ramsar site could be seriously affected by anthropogenic interventions, dedicated social and environmental impact assessments are being carried out. It is therefore recommended that international donors only fund navigation projects in South Sudan if the results of a foregoing detailed environmental impact assessment show that the negative impacts are outweighed by the social benefits, especially for local communities and people most affected by the negative environmental impacts. Based on these considerations, the aim of the proposed strategic environmental assessment is to identify a proper balance between the improved navigation sector to support both humanitarian and human development as well as environmental controls that secure sustainability of the White Nile River and the Sudd ecosystems.

The navigation project has therefore also to be considered in perspective of future trends (e.g. climate change) and planned developments (on the river sections and in the upstream river, e.g. hydropower) to ensure that the combined activities do not trigger an ecological tipping point. Without proper environmental controls (for example on the allowed level of canalisation, sediment control, or dangerous goods risk management), there is a chance of the Sudd ecosystem functions changing, or retreating, which could possibly trigger an ecological disaster.

The environmental audit as performed in this report concerned the different aspects of the project:

1. direct impacts of dredging and disposal,
2. direct impacts of recommended upgrades to surveyed ports,
3. longer-term impacts of increased navigation along the White Nile River, also associated with port operations.

For the direct impacts of dredging the main environmental concerns are that the chemical, physical and biological classification of the dredged material are largely unknown and need to be analysed, especially for locations with higher population densities, a more-detailed assessments need to take place on habitat-level impacts on the to be dredged locations and their associated placement sites, and a detailed plan should be developed on the level of canalisation allowed on the White Nile River; as increased canalisation will directly affect the White Nile River and Sudd ecosystem functioning

For the recommended upgrades on the surveyed ports a qualitative assessment was done based on environmental concerns. For each of the ports, the concerns are combined for issues as described in the field surveys. There are some general gaps in environmental knowledge concerning the distribution of critical habitats or the occurrence of threatened species along the White Nile River. These issues would require more-detailed ecological knowledge at a resolution which is currently not available. But since many of the ports are already existing, and since the ports occupy small localities along the 1300 kilometres of the White Nile River, it is unlikely that the proposed activities will affect critical habitats or species.

From the port surveys, it also became evident that currently some dangerous goods are stored along the riverbank, close to the places where ships are berthing. In many of the ports it is suggested to upgrade the storage of goods in the port, yet even with such improved stores, the issue of "no dangerous goods stored near the river channel" needs to be consistently addressed.

Third, for the longer-term impacts of increased navigation along the White Nile River, associated with port operations, the main concern would be to establish an institutional setup that facilitates environmental regulation. The setup should address current environmental issues and provide feedback mechanisms for mitigation. It is recommended to approach the institutional aspects of environmental regulation from four different perspectives, as follows:

1. The Directorate of River Transport, under the Ministry of Transport, should be strengthened with capacity on environmental assessment, regulation and enforcement. The directorate should be established on the mandate to facilitate navigation on the White Nile, while addressing also addressing the environmental concerns that arise from increased navigation. It should also act as an inter-sectoral organization which connect to other ministries and sectors, for example the Ministry of Water Resources, or the Ministry of Environment.
2. Each individual port would require a Port Manager under the Directorate of River Transport- who is to ensure environmental regulations are met at each port. The inland ports in South Sudan are geographically very isolated and environmental legislation and enforcement, both surrounding and between the ports, will become a major challenge in this context. An important role of the Port Manager would be to maintain an open relation with the local communities and keep them involved and updated of the project activities. It is therefore of importance that there is consistent cooperation among the different ports and that, as a regulator, the ports operate independently from the shipping operators.
3. The shipping operators must ensure capacity on environmental regulations and enforcement en route by employing accredited boat masters. It might be worthwhile to introduce a boat master certificate (issued by the Directorate of River Transport) with the requirement to be trained as a captain on a vessel, and this capacity building should include environmental regulations. The role of the boat masters is to ensure that crew and passengers adhere to environmental regulations (e.g. waste management).
4. Another important aspect of these regulations would be the (re-)instatement of the River Police. The task of the police would be the guarantee security of the barges, the crews, and the passengers along the White Nile River. Monitoring and enforcing environmental regulations should also become part of their mandate, they would be an independent party in law enforcement. The technical centres for aids to navigation maintenance could be a possible starting point to enforcing an improvingly consistent environmental regulations regime.

Reoccurring environmental issues in the longer-term would concern regulations on overnight berthing on the White Nile River between the different ports, the issue of poaching and increased wildlife trafficking, waste management, and the transportation, storage and handling of dangerous goods. It is important that each of the four pillars is up to date of the latest environmental regulations, and that they cooperate, facilitate, and take responsibility for their part of environmental regulation.

River transport system operation and management (Section 8) is an important building block for sustainability of the system. It is evident that investing in physical infrastructure is only sustainable with the necessary institutional framework and management structure in place. It is therefore essential, that with the physical infrastructure development also institutional capacity including clear responsibilities, knowledge and systems will be developed that are able to manage the river barge transportation system. The Ministry of Transport has been identified as the main stakeholder in this regard and respective departments will need to be created under its River Transport Directorate that deal with dredging, navigation aids, ports and barges, considering their operation and fee collection for financial sustainability to cover ongoing operations and maintenance.

It is specifically recommended to outsource economically viable activities on order to reduce workloads for the government institutions, i.e. for dredging operations and port operations. This could be achieved through leasing assets to commercial entities or through implementing government owned companies as e.g. successfully established in Egypt.

Implementing the activities is described in an implementation roadmap (Section 9). While a detailed workplan cannot be drawn up as the funding situation is unknown and solving the security situation is a pre-requirement for investments, a general roadmap especially with regards to the necessary institutional developments and prioritisation of options has been drawn up.

The main elements for successful implementation include an agreement for overall implementation between implementing agency and government, a secured budget, solving the security situation, involving stakeholders as a priority for capacity building and institutional development, cooperation with the private sector and developing detailed implementation plans. The implementation of the roadmap to establish the river transport system requires an integrated approach with a clear understanding of required actions, risks, interrelations, policies, procedures and critical factors for success.

Critical factors for success and sustainability will further be continuing donor support and government commitment to mobilise and invest financial resources for system operation and maintenance. Government commitment to efficient practices and management is critical, as is buy-in from the local communities living near the port areas. It is considered critically important for the private sector to be convinced that river transport services are good business which to utilise. This can be promoted through respective transport sector taxation schemes. Finally, a regulatory environment which is conducive to fair competition among service providers, and protection of private property and assets is essential for creating the conditions required for long-term investment in the transport system.

Actions should be conducted in phases, namely budget approval and establishment of the project management (Phase 1), integrated action plan for institutional development, procurement and operations (Phase 2), implementation (Phase 3) and handover (Phase 4).

The project concludes (Section 10) that the development of a river transportation system would be very beneficial for South Sudan if working with the detailed boundary conditions is seriously considered. It is stressed that developments should be responsive to demands and that care should be taken not to develop White Elephants, i.e. not to invest in assets that will have no use considering actual transportation activities ant that will respectively result in unnecessary maintenance costs and are likely to deteriorate if not used.

A news that became available at the end of the assessment is that there is a probability of the border between South Sudan and Sudan reopening for commercial activities. Such border opening may lead to significant opportunities for the river transportation system by opening new markets and increasing access to availability equipment and construction materials as well as opening international import routes. Actual opportunities will need to be established once details of the development become available.

1. Introduction

1.1. Project Background

This project is funded by the Government of Japan and is being implemented by the United Nations Office for Project Services (UNOPS) South Sudan Operations Centre (SSOC), in cooperation with the Government of the Republic of South Sudan (GoRSS) during the period April 2017-March 2018.

This feasibility study builds upon existing literature on barge transport in South Sudan. It is important to note, that it will go further than previous studies, by identifying concrete activities that are required for implementing a comprehensive river barge transportation system.

The White Nile River has been the source of life for communities along its banks since ancient times, and it remains an economic lifeline for the people of South Sudan today. Considering South Sudan's ongoing civil conflicts and the very restricted road and air transport available, the White Nile River is recognised as an important means for transporting humanitarian supplies to the millions of internally displaced people (IDP) and people at risk due to security and food related crises in the country. At present, the United Nations (UN) and other humanitarian organisations are relying on less cost-effective air transport or impracticable road transport. Full utilisation of river transport needs to be achieved to enable these organisations to meet the country's urgent humanitarian needs, as well as create the conditions to enable economic development in the region.

The assessments, analysis and recommendations in this report are intended to lead to a full river barge transportation system, i.e. including all elements necessary for successful river transport operation. The elements include ensuring navigable river reaches through dredging, improving accessibility and security through setting up of navigation aids, improving cargo handling through port improvements and if necessary improving transport capacity through additional barge capacity. In addition, the institutional framework for enabling an efficient and sustainable system will need to be developed by enabling and building capacity of the government institutions in charge. Further, safety along the river transport routes, which is currently significantly disturbed by internal conflict, will need to be achieved.

1.2. Project Objective

The objective of the 'River Barge System Feasibility Study Project' is to enable Donors and GoRSS to make a well-informed decision on whether to fund the implementation of a river barge transportation system on the White Nile River.

1.3. Project Scope

The technical assessment took place over the course of eight months, cumulating in this feasibility study report. The report summarises the findings of the following main activities of the project:

- Survey and assessment results of the conditions of White Nile River between Juba and Renk, including flow velocities, depths and widths (Section 2).
- Bathymetric survey results between Juba and Bor/Mingkaman (Section 2),
- Assessments of current conditions of existing major ports: Juba, Mangalla, Terekeka, Mingkaman, Bor, Shambe, Adok, Bentiu, Malakal, Melut and Renk (Section 3).
- Assessment of long-term economic benefits of strengthened river transport including cost-benefit assessments of short-term interventions targeted specifically at shifting supply of humanitarian goods from road and air to river transport (Section 4).
- Information collected from the national and state authorities, as well as UN agencies, regarding the establishment of a full-scale river barge transportation system.
- Recommendations of activities required to achieve a full-scale river barge transportation system in South Sudan (Section 5).
- Environmental audit (EA) for the activities required to be undertaken (Section 6).
- Preparation of detailed information of respective proposed activities, that will enable donors to prepare of specification and tender documentation for procurement (Annex V).
- Preliminary cost estimates for the implementation of each recommended activity as part of full-scale implementation of a barge transport system (Annex VI).

Figure 1 provides an overview of selected ports from Juba to Renk, as assessed under Section 3. Figure 2 shows main rivers and locations referred to in the feasibility study.

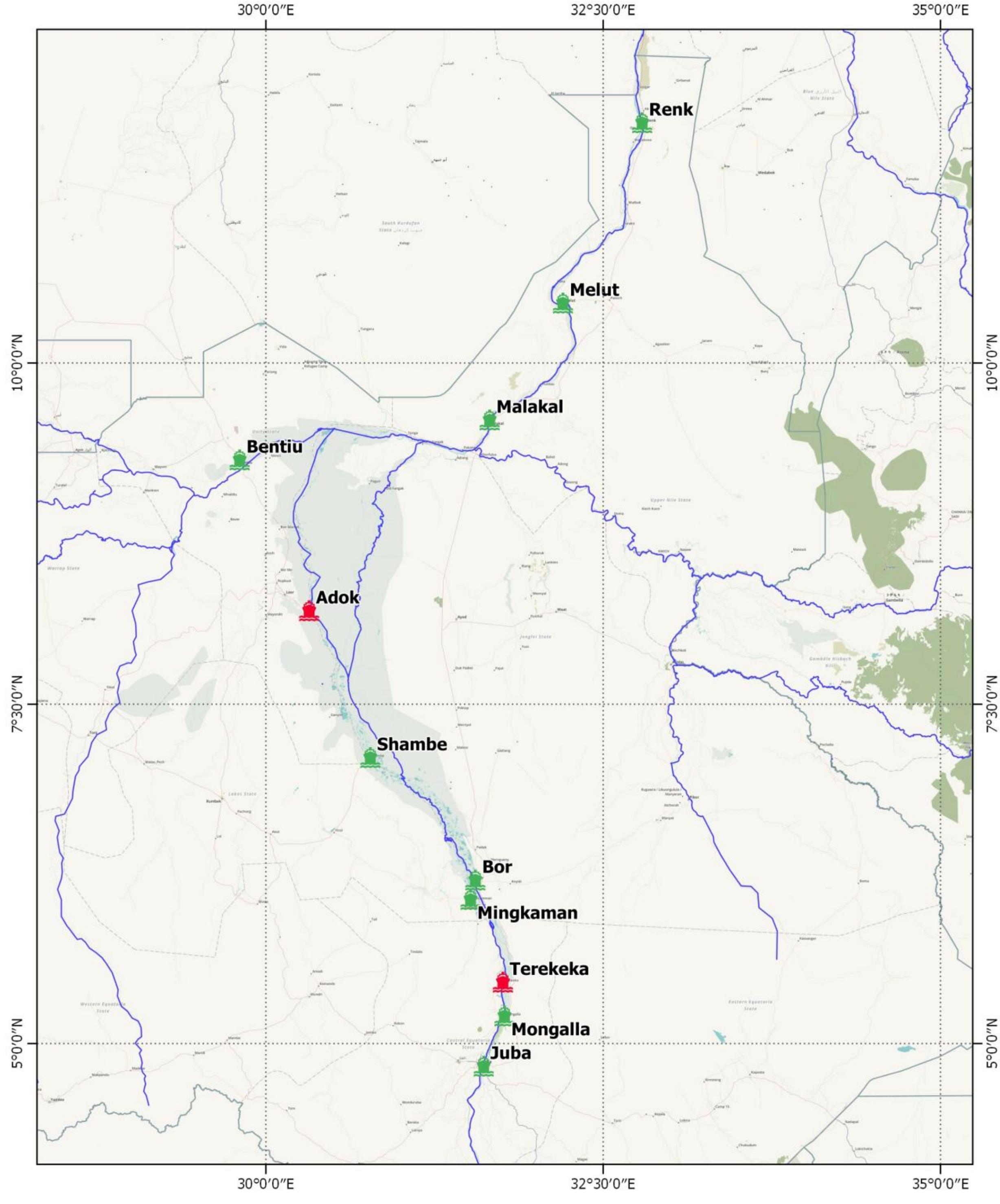

Figure 1: River port assessment - overview.

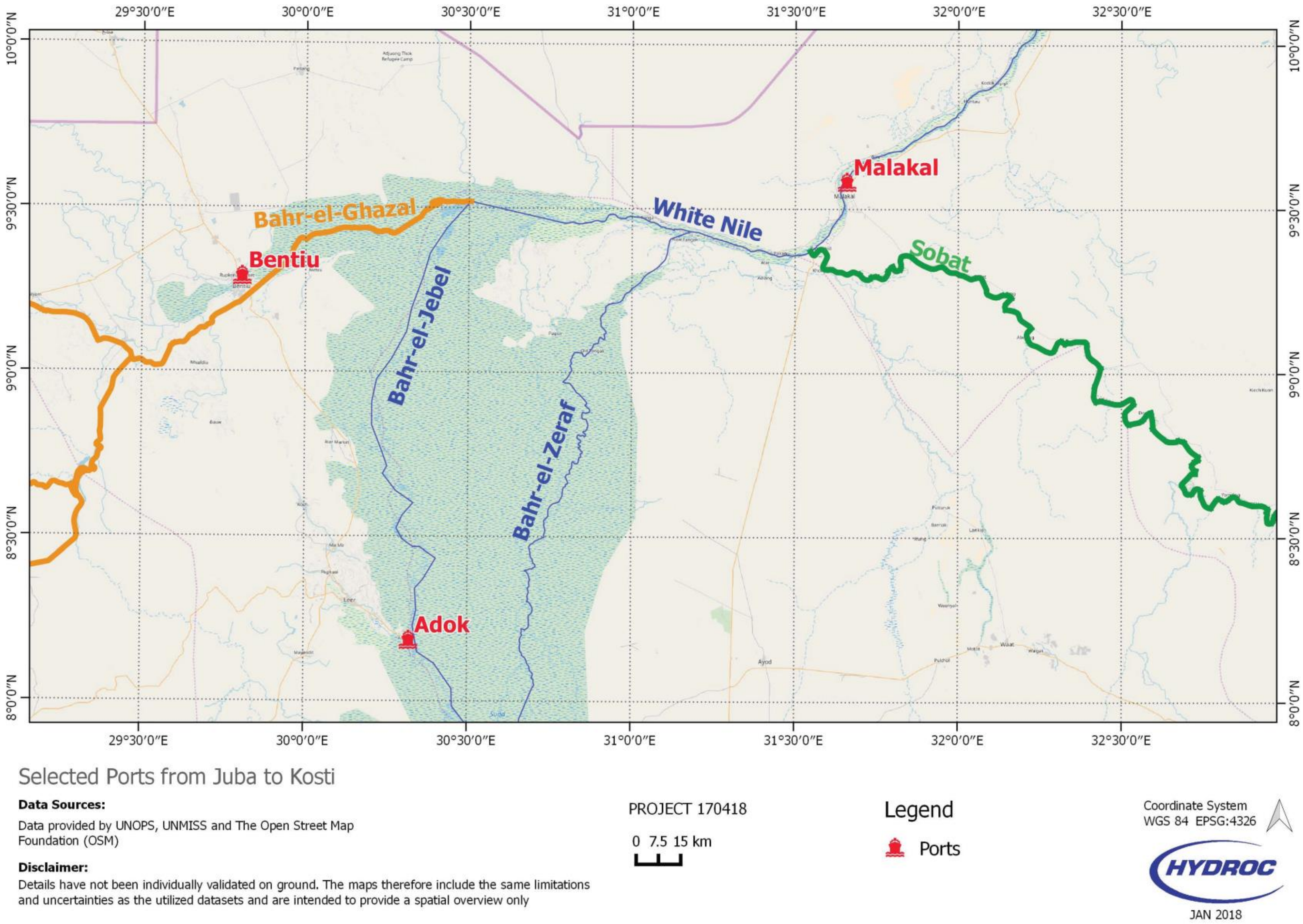

Figure 2: Main rivers in South Sudan.

2. Survey and Assessment of the Conditions of the White Nile River in South Sudan

2.1. Security Assessment

As of February 2018, United Nations Department of Safety and Security assesses that the overall risk level for the entire country is high and the projected risk level after the implementation of the recommended risk management measures is moderate, and the situation is generally calm. The security situation from Juba to Shambe has remained largely stable and the area is controlled by the Sudan People Liberation Army (SPLA). Owing to the overall challenged environment characterised by prevalence of acts of armed rebellion, highway banditry involving firearms and fractures in the government security infrastructure, various incidents have occurred along the river. Bangladesh Force Marine Unit (BANFMU-3) reported that there have been security incidents along the river up north of Shambe. Procedures are in place for reporting to South Sudanese officials about passengers and cargo lists on boats; depending on who is in control of particular areas. This procedure must be carefully followed for any current river transport in South Sudan. Requests for the type of information required can be obtained from Ministry of Transport (MoT) and the current practitioners of river transport on the White Nile River is South Sudan including private operators and United Nations Mission in South Sudan (UNMISS) or World Food Programme (WFP). Security can be extremely challenging and have been known to prevent passage of boats if the manifest and passenger list is incorrect. It is particularly emphasised that elaborate coordination must be done and double-checked to make sure information has gone down to the operatives on the ground. With the correct supporting documentation and foregoing information of military officials, safe and uninterrupted passage is possible.
Past incidents of violence on the river have prevented commercial movement north of Shambe except for the armed UNMISS BANFMU units travelling to Malakal and the WFP convoys.

The following threat mitigation table (Table 1), summarises the threats and mitigation found in the White Nile River port areas.

Table 1: Threat mitigation table

Description	Juba	Mingkaman	Mangalla
Control of the port	SPLA	SPLA	SPLA
Security situation at the port and risk at the port	The security situation is generally calm but contingent on the dynamics and volatile security environment. Security risk • Harassment/intimidation from security elements • Extortions from security elements and tax officials • Arrest & detention of staff	The security situation is generally calm. Security risk • Harassment/intimidation from security elements • Threats of extortions from security elements and tax officials • Arrest & detention of staff	The security situation is generally calm. Security risk • Harassment/intimidation from security elements • Threats of extortions from security elements and tax officials • Arrest & detention of staff
Description	**Bor**	**Adok**	**Bentiu**
Control of the port	SPLA	SPLA	SPLA
Security situation at the port and risk at the port	The security situation is generally calm but contingent on the dynamics and volatile security environment Security risk • Harassment/intimidation from security elements • Extortions from security elements and tax officials • Arrest & detention of staff	The security situation is generally calm Security risk • Harassment/intimidation from security elements • Threats of extortions from security elements and tax officials • Arrest & detention of staff	The security situation is generally calm Security risk • Harassment/intimidation from security elements • Threats of extortions from security elements and tax officials • Arrest & detention of staff

Description	Malakal	Melut	Renk
Control of the port	SPLA	SPLA	SPLA
Security situation at the port and risk at the port	The security situation is generally calm but contingent on the dynamics and volatile security environment <u>Security risk</u> • Harassment/intimidation from security elements • Extortions from security elements and tax officials • Arrest & detention of staff	The security situation is generally calm <u>Security risk</u> • Harassment/intimidation from security elements • Threats of extortions from security elements and tax officials • Arrest & detention of staff	The security situation is generally calm <u>Security risk</u> • Harassment/intimidation from security elements • Threats of extortions from security elements and tax officials • Arrest & detention of staff

Protocols and restrictions

All ports require permission from state authorities. Poor infrastructure and conditions at the port are the restrictive factors.

2.2. Current Conditions for River Transport

The current river conditions have been analysed and visualised in different graphs, referring to port locations or presenting longitudinal profiles along the White Nile River downstream of Juba.

Three main parameters have been assessed to judge navigability and identify intervention needs:

- River width
- River depth
- Flow velocities

Width-conditions: the required navigation channel width depends on the ship's geometry and river curvature and increases with increasing ship width, length and river curvature which causes drift. The calculations are carried out for a barge-setting of 2x2 barges (2 barges next to each other and behind each other, so 4 barges in total with an individual width of 11 metre (m) and length of 35m) plus pusher (10m x 25m) which amounts to a geometry of 95m length and 22m width. 12m buffer is assumed to be required at each side between the navigation channel and the banks.[1] The locations where the total width (barge geometry + width increase due to drift + buffer) is higher than the actual distance between banks have a negative 'Remaining width [m]' and are marked red in the result diagrams.

Depth-conditions: If water depths are too shallow, ship traffic is not possible. The draft of the barges-pusher setup is set to 1.5m and the freeboard to 0.75m, requiring at least a water depth of 2.25m. Therefore, the hydraulic model was used to calculate water depths for a 5% low flow scenario (low discharges that occur for a period of 5% over the observed time period). The locations where water depth is less than 2.25m have a negative 'Remaining depth [m]' and are marked red in the result diagrams.

Both the 'Remaining width' and 'Remaining depth' is used to calculate dredging requirements along the longitudinal profile (Section 5.2).

Flow velocity conditions: The ships sailing the river must be designed for the on-ground flow velocities in the channel. The hydraulic model was used to calculate flow velocities for the 5% high flow scenario (high discharges that occur for a period of 5% over the observed time period). The maximum velocity threshold for the barge traffic is set to 4 metres/second (m/s), above which flow velocities are marked red in the result diagrams.

Three important limitations have to be stressed:

1. Calculations downstream of Bor have been carried out with limited knowledge about the bathymetry and are therefore subject to uncertainties in the estimated depth range and flow velocity range (see in Annex III).
2. Conditions are analysed based on current bathymetric conditions between Juba and Bor as well as based on flow- and water level data collected during Anglo-Egyptian Sudan times, i.e. several decades ago. It must be expected that conditions may change over time and need to be re-assessed depending on the magnitude of changes and intentions for interventions.

[1] USACE, 1997. Engineering and Design, Inland Navigation and Canalisation.

3. Conditions may again significantly alter after dredging and river training interventions or over time based on natural changes caused by morphological processes such as erosion and sedimentation after flood events.

In addition to the data and methodology described in Annex III, useful information regarding river width, flow velocities and obstacles in the river was obtained during the river survey carried out from Juba to Bor. Three examples of narrow river sections, high flow velocities and rocks as obstacles are shown in Figure 3, Figure 4 and Figure 5 respectively.

Figure 3: Narrow sections observed during the survey near Mingkaman, (© HYDROC).

Figure 4: High flow velocities in the main channel, downstream of Juba, (© HYDROC).

Figure 5: Rocks observed in the main channel near Juba, (© HYDROC).

2.2.1. Juba – Bor / Mingkaman

The section Juba to Bor / Mingkaman is characterised by an average slope of 0.17m/km over a distance of 188km and the average width between banks and islands is 190m (638m maximum and 43m minimum). The average radius of the channel is 1.4km with a minimum of 54m. Mingkaman is located off the main channel and is currently not directly accessible from the main branch of the Bahr el-Jebel.

Figure 6a shows the remaining river width in metres after having subtracted the shipping channel. In sections around 120-150km and 180-200km from Juba, the Bahr el-Jebel is very narrow and at around 140km and 185km not sufficiently wide enough for design barges to pass. As already observed during the survey, water depths in the Juba to Bor section are low. This was also found by the simulations (Figure 6b) where remaining depth for barge traffic is not sufficient in most locations within the first 140km from Juba. Maximum flow velocities are mostly in the range of 1-4m/s with two locations, at about 75 and 100km downstream of Juba, where velocities are projected to be higher than 4m/s and where barge traffic may encounter difficulties during the highest discharges.

The section Bor to Malakal is becoming significantly flatter as it passes through the major body of the Sudd. It is characterised by an average slope of 4cm/km over a distance of 774km. The average width between banks and islands both of which are mostly defined through vegetation in the swamps is 97m (321m maximum and 33m minimum). The average radius of the channel is 1.9km with a minimum of only 34m in the very curved sections through the Sudd along the main channel. Figure 7 shows the width, depth and velocity diagrams for the section. Lake No is added for orientation, from which Bentiu and the Bahr el-Ghazal can be accessed.

Figure 7a shows the remaining river width in metres after having subtracted the shipping channel. In the sections around 200-330km and 430km from Juba, the Bahr el-Jebel is too narrow. Water depth in the section is highly fluctuating, which is realistic given the lagoons and complex hydraulic situation. Depths and also flow velocities from Bor downstream are more uncertain as upstream of Bor due to the lack of bathymetric data. In addition, the Sudd is subject to lower quality elevation data which also impacts depths and flow velocity simulations (Figure 101, Annex III). Therefore, depths and flow velocities in this section carry a higher level of uncertainty giving an indication of the hydraulic situation. Remaining depth for barge traffic may be not sufficient at around 400-500km and 840-890km from Juba. Again, flow velocities are mostly in the range of 1-4m/s and only 60km down-and upstream of Shambe, maximum flow velocities are projected to exceed 4m/s.

2.2.2. White Nile River – Bentiu

The section from the White Nile River, via Lake No to the port of Bentiu, i.e. the Bahr el-Ghazal is severely overgrown with vegetation over a distance of about 30km from Bentiu towards Lake No. Based on experience in the swamps the low water depth in the overgrown sections is considered as zero and on the open water section as one metre for calculation purposes. Observed discharges of the Ghazal are only available for a short period of time (1920s to 1930s) where discharges were mostly zero or very low. Even negative discharges exist when backwater effects, originating from higher water levels in the Bahr el-Jebel at Lake No, lead to a flow from Lake No into the Bahr el-Ghazal. This complex situation of external influences on the water level makes it impossible to simulate water depths and flow velocities from Bentiu based on the currently available data. The river width assessment has proven difficult, since the banks could not be identified clearly. Respectively the dredging assessment has been conducted based on minimal depth and results of estimating dredging volumes on the Bahr el-Ghazal between Bentiu and Lake No carry large uncertainties.

2.2.3. Malakal – Renk

The final section Malakal to Renk is characterised by an average slope of 3cm/km over a distance of 340km. The average width between banks and islands is 305m (615m maximum and 85m minimum). The average radius of the channel is 4.1km with a minimum of 90m. Figure 8 shows the width, depth and velocity diagrams for the section. Lake No is added for orientation, from which Bentiu and the Bahr el-Ghazal can be accessed.
Figure 8a shows the remaining river width and Figure 8b the remaining water depth in metres. Width and depth are fluctuating due to the many channel islands, but the river is wide enough for the barges. Water depths and flow velocities are again uncertain due to the lack of actual bathymetric data. Mostly, water depths should be sufficiently deep for the barge transport, with possible shallower sections around 100km upstream of Renk. Flow velocities are mostly low, in the range of 1-2m/s, are highest in the shallower sections but do not exceed the threshold of 4m/s.

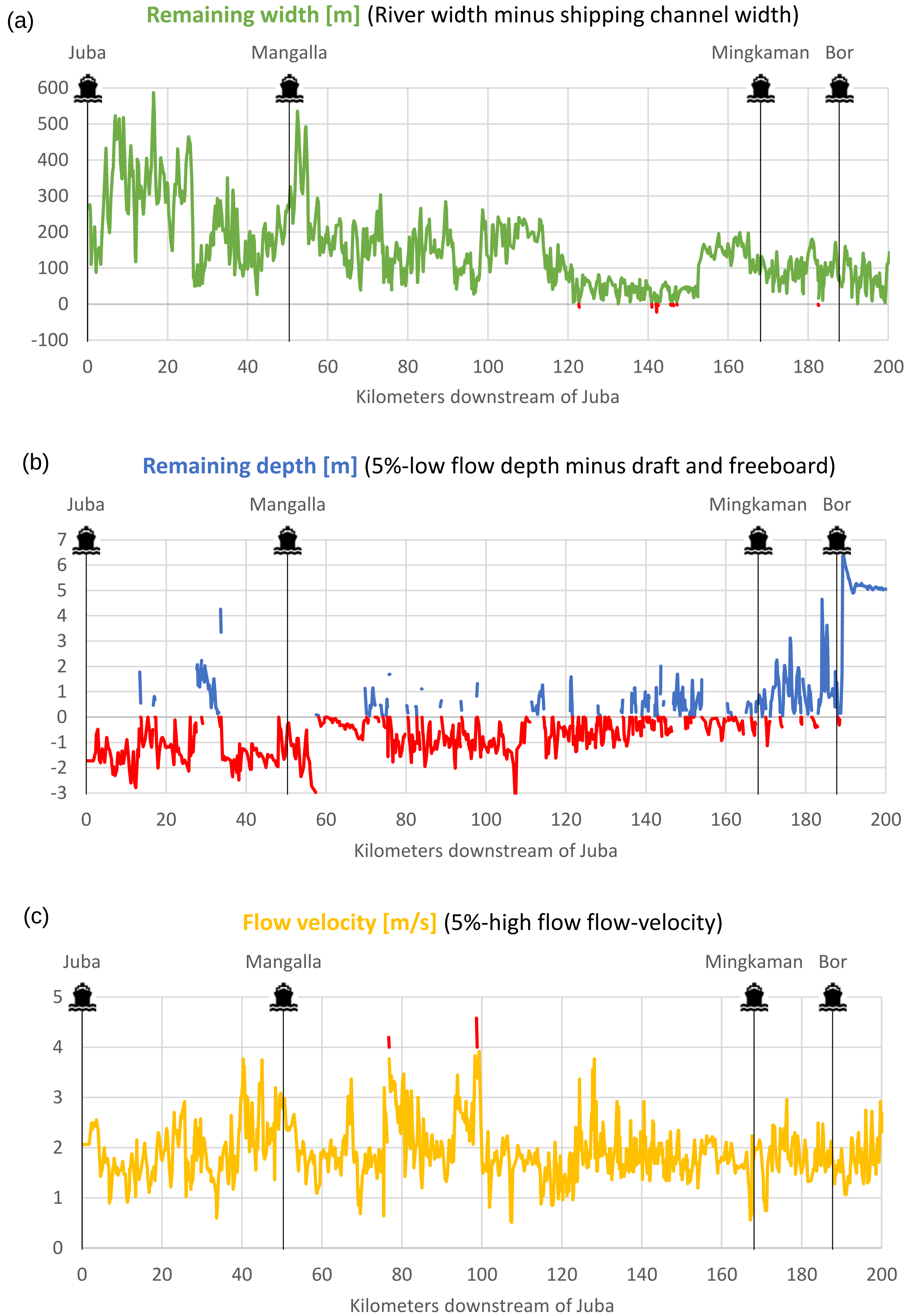

Figure 6: Longitudinal profile between Juba and Bor: (a) Remaining width in [m] which is calculated from the actual river width subtracted by the calculated shipping channel width, (b) Remaining depth in [m], which is calculated from the simulated water depth for the 5% lowest flows subtracted by the ships draft (1.95m) and freeboard (ground clearance) (0.75m), (c) Maximum flow velocity in [m/s] which is calculated from the simulated flow velocity for the 5% highest flows. Bor / Mingkaman – Malakal.

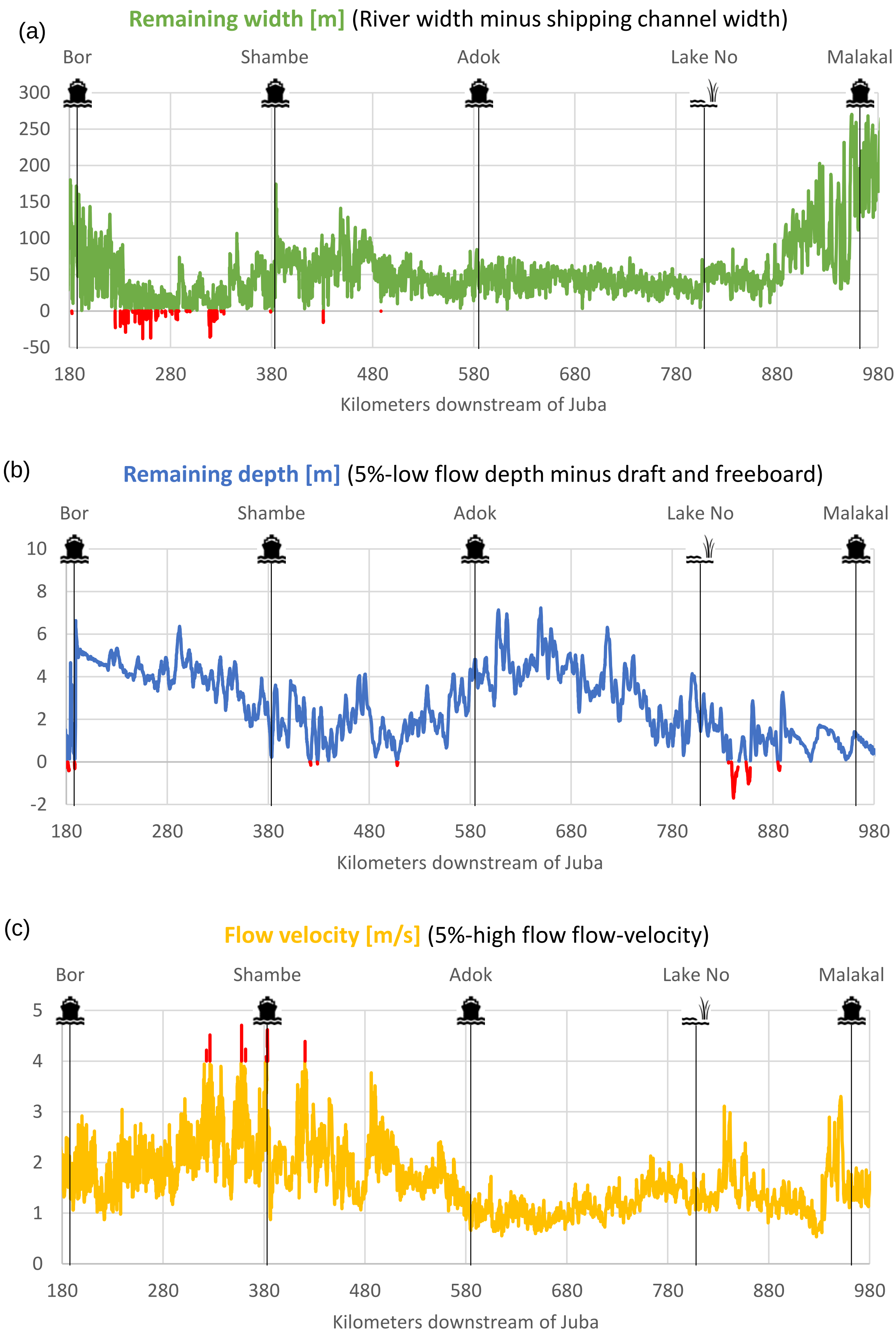

Figure 7. Longitudinal profile between Bor and Malakal: (a) Remaining width in [m] which is calculated from the actual river width subtracted by the calculated shipping channel width, (b) Remaining depth in [m], which is calculated from the simulated water depth for the 5% lowest flows subtracted by the ships draft (1.95m) and freeboard (0.75m), (c) Flow velocity in [m/s] which is calculated from the simulated flow velocity for the 5% highest flows.

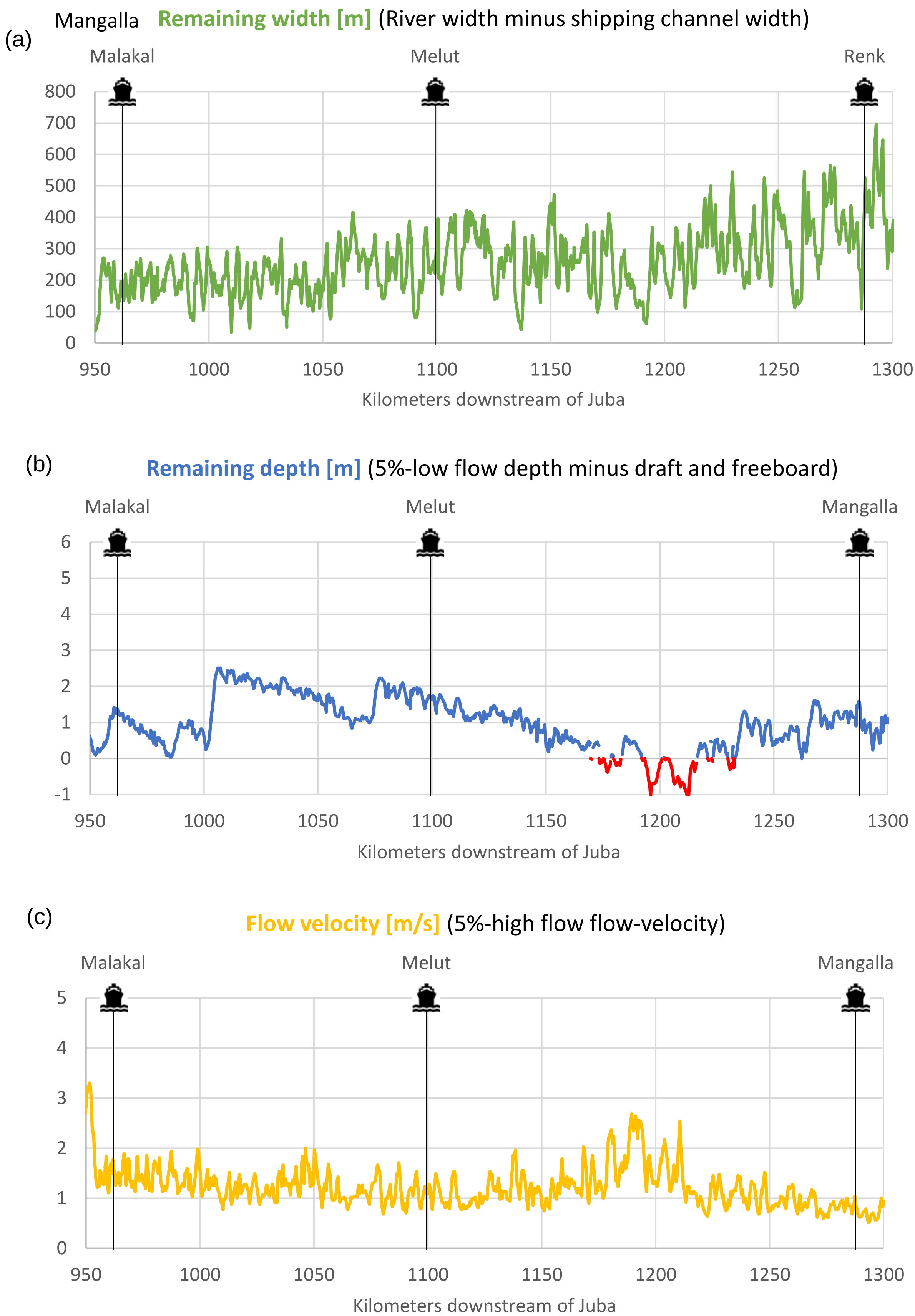

Figure 8: Longitudinal profile between Malakal and Renk: (a) Remaining width in [m] which is calculated from the actual river width subtracted by the calculated shipping channel width, (b) Remaining depth in [m], which is calculated from the simulated water depth for the 5% lowest flows subtracted by the ships draft (1.95m) and freeboard (0.75m), (c) Flow velocity in [m/s] which is calculated from the simulated flow velocity for the 5% highest flows.

3. River Port Assessments

3.1. Introductions

River ports are an essential part of a river barge transportation system, facilitating the effective loading and offloading of goods and passengers at key locations. Next to the important accessibility from both land- and river side, the port infrastructure itself is important and needs to relate to the services that the port is expected to provide.

Site visits have been carried out to the existing target White Nile River ports, including the following ports between Juba and the border to Sudan:

- Juba
- Mangalla
- Mingkaman
- Bor
- Shambe
- Bentiu
- Malakal (UN/WFP Port and Town Port)
- Melut
- Renk

Adok river port was not assessed on the ground due to imminent security threats but satellite imagery and third-party information was utilised to obtain an overview. A map showing the port locations is provided in Figure 1 above.

Ports have been physically assessed during December 2017, facilities inspected, and gaps identified for recommending necessary improvements to increase handling capacity in order to facilitate the increasing needs for humanitarian operations at the local Protection of Civilian (PoC) sites nearby. The main aspects considered during the assessments include: Port location, size of port area, geological condition of the port area, condition of port roads, condition of goods handling area, warehousing, riverbank stabilisation system, available offloading/lifting equipment, electric power supply, workshop facilities, fuel storage capacity and fuelling systems, storm water drainage, structures (offices, staff housing, warehouses), water supply and sanitation, security installations, frequency of port use, port management and staff, volume of goods transshipped /month, or year, availability of construction material, priority list of investment as identifies by port management. The findings of the consultant are summarised in inspection sheets that are appended to this report. Based on the inspection sheets, a description of the current condition of each port with recommendation for improvements is developed.

Proposed methodologies and technical specifications for construction work are provided for each of the proposed items for procurement purposes (see Annex).

3.2. Port Safety

The safety and health of workers and the environment in and around river ports is subject to available physical safety infrastructure and processes for emergency cases. An emergency could be e.g. accidents when handling heavy cargo, outbreak of a fire or spill of dangerous goods such as fuel and oil or chemicals. The existing port infrastructure has been assessed by the consultant and found to be generally in poor condition. The International Labour Organisation's (ILO) code of practice on safety and health in ports[2] lists specific safety measures including adequate lighting during hours of darkness, fire precautions (incl. protection, alarms, adequate firefighting equipment and means of escape in case of a fire), secure fencing at all places from which a fall may be likely, quay edge protection for vehicles, quayside ladders or life-saving equipment. None of these were found to exist or be in suitable condition at the river ports inspected.

3.3. Juba

Juba port (Figure 9) is situated in an industrial area of Juba town, approximately 800m downstream of the Juba White Nile River Bridge, bordering some commercial plots on the southern and northern side. Access to the port is provided by a partly paved, partly unpaved road (Figure 10 and Figure 11) traversing from town centre through the industrial area. The northern extend of the port area borders to undeveloped land with dense vegetation and some mango trees. The port boundaries are secured by chain-link fence on angle iron posts with concrete footing. A steel pipe, double wing main gate of 4.5m width secures the port entrance. The fence has been uprooted in some sections. The port road from the gate to the quay and the goods handling area, is a partly paved, partly unpaved gravel road in dilapidated condition. The goods handling area of approx. 350 square metres (m^2) adjacent to the quay consists of compacted gravel. There is no designated area for bulk goods storage. The quay wall/jetty consists of an I-beam frame work rammed into the riverbank with 6-millimetre (mm) steel plates cover over a length of 35m and a width of 12m, providing berthing facilities for one barge at the time. A light portal crane, is installed on the steel platform (Figure 12), but not suitable for effective loading and offloading. Mobile crane support may be obtained in Juba town on demand. In addition, the part of the port riverfront without a quay wall is being used temporarily as a docking facility for military ships. Port buildings are limited to one pre-fabricated office building, an unserviceable ablution block and a small store building.
During past works at the port, JICA has already successfully expanded the Juba river port facilities. The potential for the port to become fully operational again, after dredging the river bed between Juba and Bor, is significant. Any proposed options for port rehabilitation (Section 5.4.1) should be closely aligned with existing plans from JICA to upgrade the river port.

[2] ILO, 2005. Safety and health in ports - ILO code of practice.

Figure 9: Juba port, (Source: Digital Globe / Google Earth).


Figure 10: Access road to Juba port (looking towards West-North-West)in dilapidated condition, (© HYDROC).

Figure 11: Access road to Juba port (looking towards East-South-East) in dilapidated condition, White Nile River and Juba port crane in background, (© HYDROC).

Generally, Juba port lacks most of the facilities required for basic port operations. In particular, fuel storage, workshop facilities, warehouses and paved areas for handling bulk goods are not available. In addition, no appropriate lifting equipment to off load container or other bulk goods is currently available. The 35m long quay wall allows only one barge at the time to berth. However, during the past two years the port was only sparsely used by 2-3 barges calling monthly.

Figure 12: Crane Juba port, (© HYDROC).

The port is managed by a port manager and a harbour master posted by the Ministry of Transport, as well as mechanics, clerks, an accountant and 10-15 loaders on temporary terms. The service provided is limited to loading and offloading and minor repairs on the barges. The Ministry of Transport collects port charges and the Ministry of Interior charges customs duty for goods originating from abroad.

For a detailed port inspection checksheet, please refer to Annex IV.

3.4. Mangalla

The port (Figure 13 and Figure 14) is situated closed to Mangalla township, 40km north of Juba. The port has been upgraded in 2010, by provision of an 80m long quay wall, constructed with sheet piles and concrete capping. The quay provides berthing facilities for three barges. The geological conditions are of sandy black cotton soil, same as found in the entire area of Jonglei state. The complete port area of 4,900m^2 is paved with a compacted gravel layer which appears to be in sound condition. Goods handling and bulk goods storage areas are constructed to gravel standard and are intact. The port has an office building and five warehouse buildings with a total floor area of 336m^2. Staff accommodation is provided in containers. Water treatment plant and sewage disposal equipment is available and functioning. The port area is secured by a chain-link fence with guard houses and security lights. There are four units of power generating sets with a capacity of 44 kilovolt-ampere (kVA) in working order. Workshop and refuelling facilities are not available. The port is well maintained and in good operational condition.

Currently, the Ministry of Transport has leased to port to a private commercial enterprise TRISTAR, supplying jet- and diesel fuel in bulk. 4 fuel barges with pusher call at the port once in two months. The volume of fuel handled is 1,700,000l in 2 months.

Figure 13: Mangalla port, (Source: Digital Globe / Google Earth).

Figure 14: Mangalla port as seen during river survey in December 2017, (© HYDROC).

For a detailed port inspection checksheet, please refer to Annex IV.

3.5. Terekeka

Terekeka port (Figure 15) is situated at the left bank of the White Nile River near to the Terekeka town centre. The port has not been assessed on the ground but based on satellite imagery it was concluded that the port has no specific port infrastructure. Nearby houses may be utilised for storage, the river area in front of the port is silted up and overgrown with vegetation. The port itself seems to be frequented by smaller vessels only.

Figure 15: Terekeka port, (Source: Digital Globe / Google Earth).

3.6. Bor

The Bor (Figure 16 and Figure 17) port is situated closed to the town centre and occupies a ground area of 75,000m^2. The geological conditions are of sandy black cotton soil, as found in the entire area of Jonglei state. No quay wall or jetty has been constructed and the barges are docking on the fairly steep riverbank with a slope of approx. 1:2. Bollards have been provided along the riverbank to secure the barges. The designated, unimproved goods handling area is close to the riverbank and presents a challenge for offloading goods during the rainy season. There is no port owned lifting equipment available but the UN contingent in Bor have cranes of 12-25t capacity and there is a privately-owned crane with a capacity of 40t. No port owned container handling equipment is available. The UN have a 12t forklift. Apart from a two-room administration office, no other facilities are available at the port (including no warehouse or any other facilities). The port does not have a security fence and is freely accessible. Fuel storage facilities are not available. A hotel, 'Park Palace' is located close to Bor river port.

The port is currently managed by the Union of Boat Operators, the Revenue Authority and Port Security, provided by the county administration. The port is used by up to 120 small boats for local transport of passengers and goods, such as cattle, fish, charcoal, timber and firewood. A total of 150t of goods are handled per day. The access road to the port has a length of 800m and requires rehabilitation.

For a detailed port inspection checksheet, please refer to Annex IV.

Figure 16: Bor port, (Source: Digital Globe / Google Earth).

Figure 17: Bor port as seen during river survey in December 2017, (© HYDROC).

3.7. Mingkaman

Mingkaman port (Figure 18) was constructed in 2015 by UNOPS, funded by the Government of Japan, with a quay wall of 105m length (Figure 20 and Figure 21), constructed of sheet piles with concrete capping, providing berthing facilities for three barges. The approximate port area is 10,000m^2. The entire port surface area consists of compacted gravel. The port has a tower rotating crane (Figure 19) with a lifting capacity of 1.2 t, forklift and mobile crane, all unserviceable. A generator set is unserviceable. There are no workshop facilities and fuel storage at the port. There is a two-room office building with iron sheet roof and a floor area of 40m^2 and a 650m^2 floor area warehouse steel structure with iron sheet walling and roof. The port has its own borehole, which is currently unserviceable. The entire port area is fenced with chain-link fixed to steel posts. The fence includes one main gate and two pedestrian gates. The access road to the port has a length of 1km and requires maintenance. Although the port has capacity to handle large barges, only small boots are currently using the facility. Barges have not been calling at the port for an extended period of time.

The port is currently managed by the Union of Boat Operators, the Revenue Authority and Port Security, provided by the county administration. The port is used mainly by small boats for local transport of passengers and goods, such as cattle, fish, charcoal, timber and firewood. Based on local narrative, a total of 150t of goods can be handled per day.

Figure 18: Mingkaman port, (Source: Digital Globe / Google Earth).

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Figure 19: Light crane in Mingkaman, as seen during river survey in December 2017, (© HYDROC).

Figure 20: Onloading of cattle at Mingkaman port, (© HYDROC).

Figure 21: Traditional speed boats moored at the quay wall of Mingkaman port, (© HYDROC).

For a detailed port inspection checksheet, please refer to Annex IV.

3.8. Shambe

The port (Figure 22) has been upgraded in 2010, by provision of a 40m long and 15m wide jetty (Figure 23), constructed with sheet piles and concrete capping. The jetty provides berthing facilities for two barges. The riverbank adjacent to the jetty is eroded and needs to be secured. The geological conditions are of sandy black cotton soil. The complete port area of 4,900m^2 has been provided with a compacted gravel layer which appears to be in sound condition. 4 bollards are installed on the jetty (Figure 24). 600m^2 of goods handling -and 240m^2 of bulk goods storage area is available and in good condition. The port has one steel structure warehouse and four storage containers, totalling up to 336m^2. Four office containers in poor condition are on the ground. Lifting equipment, workshop facilities and fuel storage are not available. The port has a borehole with a submersible pump, small water treatment and elevated water storage tank. The port area is fenced with chain-link on steel posts and has two gates and one pedestrian door as well as a guard house. There are no security lights on the port compound.

The port is currently used by fishing boots only and is managed by officers from the county administration. Five fishing boat per month call at the port with a total load of 15t of fish. The 2.5km access road to the port is in serviceable condition.

Figure 22: Shambe port, (Source: Digital Globe / Google Earth).

Figure 23: Shambe port jetty, (© HYDROC).

Figure 24: Bollard installed at Shambe port, (© HYDROC).

For a detailed port inspection checksheet, please refer to Annex IV.

3.9. Adok

Adok port (Figure 25) could not be assessed on the ground. Utilising satellite imagery as well as scattered information from humanitarian sources Adok does not have any quay wall structure, jetty, or any other port infrastructure. Access is provided through an unpaved road of unknown quality but seemingly in serviceable condition. The port area serves as storage for bulk goods, some containers seem to be present. Images show the port being used by various small boats as well as large barges.

Figure 25: Adok port, (Source: Digital Globe / Google Earth).

3.10. Bentiu

Bentiu port (Figure 26) is not in operation since 1989 according to local statements. The port has been given up and is today overgrown with very little evidence of its former use. Based on an estimate the approximate port area may be about 24,000m^2. The area consists of black cotton soil with the port area showing very little elevation above the surrounding swamp area and water. The waterbody adjacent to the port area is completely overgrown with papyrus and reeds, not showing open water surfaces. Satellite images (Figure 27) and ground observations (Figure 28, Figure 29, Figure 30) show that significant stretches of river between Bentiu and Lake No, estimated with about 29km, are shallow and fully overgrown with vegetation. Full vegetation clearing, and dredging will be required to enable port access here. On the remaining approx. 50km to Lake No water depth may also be shallow.

Port roads are unpaved with a width of 5m and in bad condition. Cargo handling- and good storage areas could not be identified. Water depth is very shallow, and no quay wall or jetty exist. No equipment, buildings or any other installations are in place.

For a detailed port inspection checksheet, please refer to Annex IV.

Figure 26: Bentiu port, (Source: Digital Globe / Google Earth).

Figure 27: River channel between Bentiu and Lake No, with the first 28.8km completely overgrown and the following 49.4km assessed as very shallow, (Source: Digital Globe / Google Earth).

Figure 28: Bahr el-Ghazal, as seen from plane during Bentiu port survey, river completely overgrown with vegetation, (© HYDROC).

Figure 29: Former Bentiu port site, (© HYDROC).

Figure 30: The river is completely overgrown, (© HYDROC).

3.11. Malakal

There are two ports in Malakal, one is based in town and belongs to the port authorities. It is not used since 2013 due to insecurity. The second port is known as the ‘UN/WFP port’ and is mainly used by WFP, Esko and TRISTAR.

3.11.1. Malakal Town Port

The port (Figure 31, Figure 32 and Figure 33) is situated within Malakal, adjacent to the Malakal wholesale and retail market. The port area measures 45,000m^2. The geological conditions are of sandy black cotton soil. Part of the riverbank within the port area are overgrown with heavy vegetation. Port roads are in poor conditions. Along the riverbank, a section of 20m quay wall has been constructed in reinforced concrete. The water level at the quay wall was measured at 2m above river bed, top river water level to top of quay wall was 0.6m. In addition to the concrete quay wall, a small steel jetty has been constructed with I-beams and steel plates, size 15m x 8m. The jetty is in fair condition but requires repair on the steel plates welding. There are no designated areas for goods handling or bulk goods storage. Permanent office building, warehouses, ablution block are unserviceable and abandoned, however can be rehabilitated. Refuelling installations, workshop sheds, lifting equipment, generating sets, water supply and sewage disposal are not available. The port area is fenced with a chain-link fence and one serviceable steel pipe gate. The Ministry of Transport runs a guest house within the port area which appeared to be operational, small hotels are available in town.

The port is currently not in use, except for small fishing boats or passenger vessels. The port does not have a permanent management and staff, however administrative matters are handled by county officers.

For a detailed port inspection checksheet, please refer to Annex IV.

Figure 31: Malakal town port, (Source: Digital Globe / Google Earth).

Figure 32: UN equipment being unloaded of a Nile River Transport Corporation (NRTC) river barge, (©Francois Henepin).

Figure 33: UN vehicles being unloaded, (© Francois Henepin).

3.11.2. Malakal UN/WFP Port

The port Figure 34 is situated 10km north of Malakal, close to the UNMISS camp. The jetty was constructed with compacted earth fill to allow small barges offloading food items for WFP and other goods for humanitarian aid activities. (Size 105m x 10m). The jetty is however also used by the local communities from the surrounding areas for offloading fish and dropping off / taking on board passengers. There is no designated area for the port, access to the jetty is available by diverting from the road to the UNMISS camp at a distance of 500m (Figure 35). The extend of the area, allocated for access to the jetty and storage of material was roughly indicated by an UN officer on the ground. The earth fill material of the jetty is considered as a temporary solution and is in need to be reinforced by a retaining wall to improve its stability and prevent erosion at the base of the jetty. The jetty should rather be termed as a loading/offloading station for UN organisations and not as a fully operating port.

For a detailed port inspection checksheet, please refer to Annex IV.

Figure 34: Malakal UN/WFP port, (Source: Digital Globe / Google Earth).

Figure 35: Malakal UN/WFP port and feeder road as seen from aircraft, (© UNOPS).

3.12. Melut

Melut port (Figure 36 and Figure 37) is located approximately 7km north of Melut town and covers an area of 14,400m^2. The geological conditions are of sandy black cotton soil. The port road is slightly elevated, constructed with available un-compacted soil. No riverbank stabilisation system exists, barges berth at the inclined riverbank. Along the riverbank over a length of 80m, a cargo handling area has been created and stabilised with imported laterite material. A permanent office building with a floor area of 80m² has been built within the port. A timber structure warehouse is available but not in use. Apart from this, no other structures/ facilities are available at the port.

The port has not been used by river barges for over one year, only local fishing boats and small vessels for passenger and trade goods transport call occasionally. The port administration has been taken over by the county commissioner, however no permanent staff is assigned to the port.

For a detailed port inspection checksheet, please refer to Annex IV.

Figure 36: Melut port, (Source: Digital Globe / Google Earth).

Figure 37: Melut port, no infrastructure in place (© HYDROC).

3.13. Renk

The port (Figure 38 and Figure 39) is situated on the western outskirts of Renk town and occupies an area of 52,500m². The geological conditions are of sandy black cotton soil. The riverbanks next to the port are heavily overgrown with reeds and scrubs. The quay wall (Figure 40), measuring 60m length, and the cargo handling area of 1020m² are reachable by passing over a causeway of approximately 80m distance. At the time of inspection, the causeway was submerged, hence the cargo handling area was only accessible with a small boat. The quay wall is constructed of reinforced concrete and appears in good condition. 30 % of the cargo handling area is covered by a concrete slab, the remaining 70 % are paved with compacted granular material. 3 bollards are available at the quay walls. Warehouses, workshop sheds, refuelling facilities, water supply and offices are not available at the port. There are no useable structures or buildings at the port. Some semi-permanent houses are occupied by local mechanics who undertake repairs of boat engines. An unserviceable composite water treatment plant and an elevated water storage tank are situated on the premises of the port.

No port management was available. Port security is provided by county administration and SPLA. The county administration collects port charges. 1-2 barges are calling at the port per month. 550m chain-link perimeter fence is in place with some sections been uprooted. No main gate and security lights available.

For a detailed port inspection checksheet, please refer to Annex IV.

Figure 38: Renk port, (Source: Digital Globe / Google Earth).

Figure 39: Renk river port as seen from aircraft, (© Francois Henepin).

Figure 40: Renk port jetty, (© Francois Henepin).

4. The Economic Case for Investment in River Transport in South Sudan

4.1. Introduction

Transport investments always generate economic activity and may trigger economic development, but on their own do not generate net benefits. The demand for transport is a derived demand, it is not, generally, demanded in its own right. The merits of investing in river transport, or any other mode of transport, should always be compared with the alternatives, be it upgrading, building or reconstructing a road, or doing nothing. That said, there may be a good case for investing in river transport when the following preconditions are met:

- There is strong demand for regular deliveries of bulk or break-bulk goods with low unit values (grain, fuel, timber, cement etc).
- Hauls are long and transhipment costs are low.
- Waterways maintenance costs (in particular those of dredging) are low.
- Refuelling points are frequent.
- There is little alternative: Road access is lacking and the costs of developing it are high.

As with road and rail transport, there are economies of scale. Unit costs are minimised, if loading rates are high (i.e. barges carry loads close to their capacities and backhauls are similar to outbound loads) and utilisation is high (24h steaming and short waiting times).

The list above is a summary of conditions likely to favour investment in river transport. The benefits of such investment are transport cost-savings. In most cases these benefits are 'non-incremental' – investment results in transport being competed away from other modes. This is the case for most interventions aimed at humanitarian aid. There are some cases where the benefits are 'incremental', that is, when total transport increases as a result of the investment. This would be the case if investment triggered changes in land use or resulted in increased deliveries of humanitarian aid.

Economic appraisal should, strictly, make use of prices that reflect resource costs ('shadow prices'). Such prices seek to make adjustments for taxes and duties and labour (and other) market distortions. Under normal circumstances such adjustments would be quite small. In South Sudan, however, markets are highly distorted and adjustments difficult to estimate. It is also arguable whether an analysis based on economic prices would be of much value. As a result, assessments of benefits etc are made at financial prices.

4.2. Transport network in South Sudan

Table 2 summarizes the navigable reaches south of Kosti. For an overview of main rivers and locations referred to in this section please refer to Figure 2.

4.2.1. Network Changes Since the Early 1980s

Significant changes in the regional transport network have taken place since the heyday of barge transport on the southern reach of the White Nile River in the early 1980s.

First, the status of Kosti. Kosti remains a significant transport hub, though of less significance since almost all river traffic ceased, first in 1984 and again in 2012. From Kosti there are rail lines east to Port Sudan, north to Wad Madani and Khartoum, and west to Nyala and Wau, although the only operational section is from the refinery near El Obeid via Kosti, Sennar and Wad Madani to Khartoum.[3] Rail/river transport transhipment facilities at Kosti were reported to be poor in 2004 (principally because of the distance from rail to dockside). There are good road connections from Kosti to Khartoum, Port Sudan and El Obeid.

Navigation north of Kosti is impeded by the ship locks at Jebel Aulia dam, approximately 50km south Khartoum. The lock at Jebel Aulia cannot accommodate a four-barge train, which means that barge trains have to be broken up in order to pass through them.

Second, the completion of paved roads connecting Juba directly with the deep-water port in Mombasa, Kenya. The road from Juba to Nimule was realigned and paved and opened in September 2012, while the final unpaved section of the Gulu-Atiak-Nimule road was paved in May 2015.

These changes, along with the political and security situation, have conspired to re-orientate the economy of South Sudan towards the south, a development that has a large impact on the case for investment in river transport.

4.2.2. Other Modes

All-weather roads capable of taking heavy goods vehicles provide viable alternatives to river transport. Although the WFP Physical Access Constraints map[4] shows the following as open to 40t trucks, in practice they do not provide reliable all-weather access:

- Juba to Bor (with seasonal limitations).
- Malakal - Melut - Renk.
- Malakal - Bialiwal (94km south-east of Malakal on the Sobat river, also with seasonal limitations).

There is no viable road from Bor to Malakal, a primary route for humanitarian aid. Because of Bor and Malakal's proximity to the river, this is why most river transport of humanitarian goods takes place on this route today.

All sites of interest have landing strips. Ilyushin IL-76s are widely used for transporting humanitarian aid, supplies and personnel.

[3] UNJLC, 2004. Report on Logistics to Kosti.

[4] World Food Programme, 2017. Physical Access Constraints: 25 September 2017.

Table 2: Navigable river reaches south of Kosti

From	To	km[5]	Cumulative km	Navigability[6]	Commentary
White Nile River, Juba corridor					
Kosti (174,000[7]+153,000[8])	Renk	175	175	Believed to be open	Kosti is a transport hub; Rabak is an industrial city. Road and rail bridge across White Nile River.
Renk (138,000[9])	Melut	190	365	Open	Formerly a large supplier of locally grown sorghum and sesame.
Melut (49,000)	Malakal	147	512	Open	
Malakal (126,000)	Adok	347	859	Open	According to the 2011 statistical yearbook, Malakal has the highest population density of any county in South Sudan but has suffered extensive war damage. A road connecting Malakal and the Paloch oilfields to Ethiopia has long been planned.
Adok (N/A)	Shambe	162	1,021	Open	Adok had oil exploration importance.
Shambe (N/A)	Bor	154	1,175	Open	Access to Shambe National Park but no access to Rumbek, capital of Lakes province.
Bor (315,000[10])	Mangalla	135	1,310	Open but siltation limits access to	Mangalla has been the site of several

[5] taken from distance table in UN logistics cluster map dated 2011, reproduced in Henepin+
[6] 'open' refers to physical status as recorded on World Food Programme Physical Access Constraints map of 25.09.17.
[7] Kosti population dates from 1993.
[8] Rabak's population is a 2007 estimate.
[9] Renk, Melut and Malakal populations are from 2011 statistical yearbook[45].
[10] Bor's population is a Bor municipality estimate.

From	To	km[5]	Cumulative km	Navigability[6]	Commentary
				fully laden barges.	attempts at starting large-scale agriculture since the 1950s.
Mangalla[11]	Juba (493,000)	48	1,358	Open	
Bahr el-Zeraf, Juba corridor					
Confluence 56km upstream of Malakal	80km downstream of Lake No	280		Status uncertain; may be open to shallow draft vessels	The Bahr el-Zeraf river was cut in 1910 and is a navigable short cut, saving around 300km between Malakal and Juba.
Eastern corridor, Sobat River					
Malakal/Taufikia	Gambela (Ethiopia)	560 (363km to Nasser)		Navigable Jun-Nov. RTC stopped in 1964; WFP continued in early 2000s Shown as open as far as Akobo and Jiakao on Ethiopian border	
Western corridor, Bahr el-Ghazal/Jur					
Malakal	Bentiu (10,000[12])	200		Not navigable west of Lake No	
Bentiu	Wau (151,000[13])			Jur river barely navigable. Reach blocked by water hyacinth; not used since the 1970s, not open	

[11] Part of Juba county.

[12] Excludes United Nations High Commissioner for Refugees refugee camps.

[13] 2010 estimate.

4.3. Historic Demand to 2012

4.3.1. River transport from 1973 to 1993

Up to 1972, river transport was part of Sudan Railways. In 1972 the Addis Ababa agreement was signed, under which the south achieved limited autonomy, and in 1973 river transport on the White Nile River was transferred to a new parastatal, the River Transport Corporation (RTC). RTC enjoyed a monopoly of goods and passenger transport, it also owned all the port and harbour facilities. The RTC's monopoly continued until 1993, when the Sudan government divested itself of the RTC, along with other public corporations. Two successor organisations took over RTC's assets, one responsible for the northern and one for the southern reach (i.e. the reach south of Kosti).

Between 1973 and 1982 RTC's fleet appears to have grown substantially, first by a fleet of tugs and barges assembled at RTC's shipyard at Khartoum North (a fleet referred to as 'Jonglei type'), and then by a fleet of tugs and barges financed by a Norwegian loan (see El Kider[14]).

The Addis Ababa agreement collapsed in 1983, following the discovery of oil near Bentiu in 1978. The outbreak of the second civil war in 1983/4 led to a collapse in traffic on the river. Transport south of Kosti came to near standstill.

Table 3 and Figure 41, taken from data reproduced in a PhD thesis written in 2000 (El Kider[14]), show RTC goods and passenger traffic from 1972 (actually 1972/3) to 1993. The goods traffic statistics show:

- Dominance of the southern reach, accounting for at least 90 percent of total tonne-kilometre (t-km).
- The peak goods traffic years of 1981-2, when 130-140,000t were carried, followed delivery of a fleet of Norwegian tugs and barges[15], and the discovery of commercially viable quantities of oil in the Unity and Heglig fields north of Bentiu, and
- The collapse in traffic after 1983.

The historic peak of 130-140,000t is consistent with the Riverine Project Capacity Assessment in South Sudan's assessment of a peak 1984 capacity of 154,000t.[16] Note that Table 3 does not include shipments made under the UN's Operation Lifeline Sudan programme, which started in 1991. At its peak in 1993-1994 this programme was shipping approximately 20,000t per year.

Even at its peak, goods traffic on the White Nile River was comparatively insignificant in national (Sudanese) terms: in the mid-1970s Sudan Railways was carrying 2-2.5m t per year[17], while Port Sudan handled around 3m t a year.[18]

The average goods haul is around 850km.[19] In the absence of any origin and destination data it is difficult to interpret this. It would though be consistent with around 60 percent of goods transported from Kosti to Malakal and 40 percent from Kosti to Juba. Available evidence

[14] El Khider, Mohammed, 2000. A Socio-Economic Appraisal of Inland Water Transport in Sudan.

[15] 16 tugs and 64 barges (of which 50 were conventional 500t open barges) financed by a loan from Norway and delivered between 1979 and 1982

[16] Henepin, F, 2013. Riverine Project Capacity Assessment in South Sudan.

[17] World Bank, 2014. Republic of Sudan Diagnostic Trade Improvement Study – Update.

[18] CIA, 1984. Sudan – Transportation and Development.

[19] Estimated by taking average t-km on the southern reach and dividing it by the average number of t.

suggests that almost all goods were transported south from Kosti to Juba; return loads were tiny by comparison.

The standard configuration was one pusher tug and four barges, each with a capacity of 300-500t. Service frequencies are not well documented, but to achieve annual delivery of say 80,000t from Kosti to Juba would require at least four trips per month. This is consistent with El Kider's reference to service frequencies in the 1970s and 1980s southbound from Kosti to Juba falling from four to two round trips per month as a result of fuel shortages and a lack of spare parts.

Passenger transport showed secular decline throughout almost the entire period tabulated. Latterly this was no doubt the result of security concerns, but it may well also have arisen from a lack of capacity, the vessels purchased from Norway in the late 1970s (see above) were exclusively for goods transport.

Table 3: White Nile River transport traffic, 1972-1993[14]

Year	Southern reach				North and south	
	1,000 t	t-km million	1,000 pax	pax-km million	t-km million	pax-km million
1972	80.1	68	200	85	72.2	89
1973	71.4	60	102	75	65.4	85
1974	87.5	73	157	76	77.1	87
1975	74.3	62	216	55	66.6	67
1976	69.8	59	142	101	65.2	114
1977	65.6	56	171	36	63.6	48
1978	70.8	60	95	37	65.2	54
1979	62.1	52	47	45	56.2	62
1980	76.3	64	53	51	63	32
1981	143.2	121	53	54	123.8	58
1982	131.6	111	64	30	113.6	35
1983	105.4	87	32	2	89.1	5
1984	43.0	36	6	2	37.4	4
1985	41.0	35	4	1.5	36.2	9.5
1986	51.0	43	0	0	43.6	2
1987	46.0	39	0	0	40	3
1988	56.0	47	4	2	47.4	3
1989	55.0	46	0	0	46.8	2
1990	48.0	41	1	0.6	41.6	0.8
1991	29.0	24	12	6	25.3	7
1992	54.0	46	5	2	43.6	3
1993	53.0	45	6	3	46.4	3

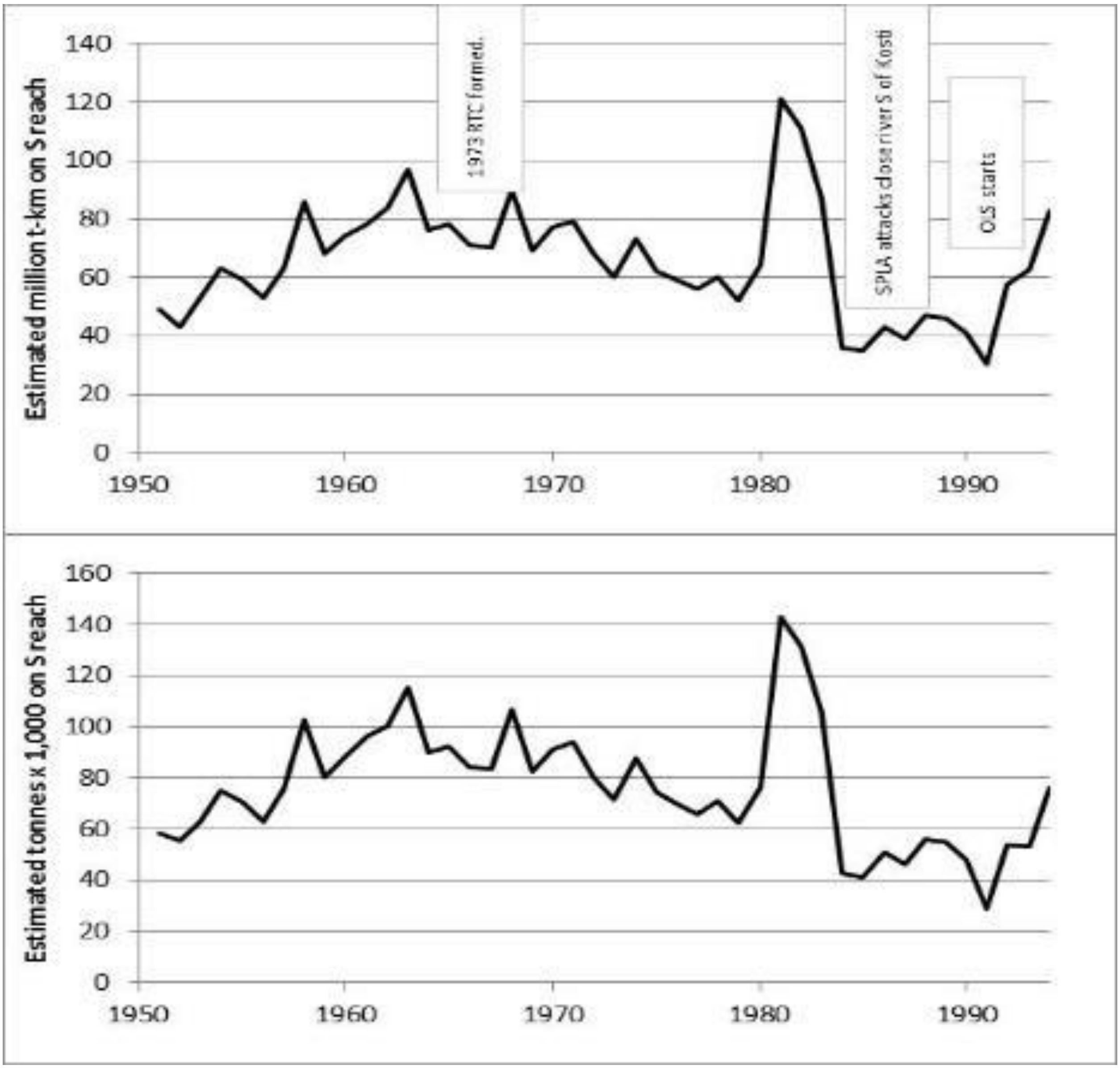

Figure 41: Goods transported on the southern reach, 1951-1994.

4.3.2. River Transport from 1993 to 2012

Since 1993 river transport on the White Nile River has been characterised by fragmentation and frequent changes of ownership. In 1993 RTC was reorganised. RTC operations in the south were placed within the Peace and Development Corporation. In 2007 RTC was privatised and its assets acquired by the NRTC, part owned by the South Sudan government, the Sudan government and private middle eastern interests. At present, there are two semi-privatised bodies providing services: the NRTC and the South Sudan Transnile Co Ltd (SSTC). There are several private operators, of which TRISTAR, Keer Marine and the Nile Barge Company are the most significant.

Records of goods and passengers transported are also fragmentary since 1993. Table 4 summarizes available information.

Table 4: Goods transport by river transport 2005-2012

	Goods transported (annual estimate)	Commentary
2005-12[20]	Average 75,000t/yr.; peak 120,000 (2010), minimum 8,000t (2012)	Oil production stopped in Jan 2012
2005	43,000t landed Juba 1,700t loaded in Juba	Japan International Cooperation Agency (JICA) observations at Juba port[21]. Comprehensive peace agreement (CPA) signed 2005
2006	58,000t landed in Juba	JICA[22]
2008	95,000t landed in Juba	JICA[10], based on Jan-Jun 2009 observations

4.4. Lessons Learned from Historic Demand

In general, there is little overlap between the factors listed in Section 4.1 and the historical situation on the White Nile River up to 1993.

Table 5: Factors encouraging investment in river transport

Factors encouraging investment	Historic situation on the White Nile River
Steady demand for bulk goods	Generally, not: intermittent and seasonal demand for bulk goods (emergency food aid from 1950s)
Low unit value of goods	Yes
High loading efficiencies	No: low/negligible backloads
Low transhipment costs	No: organised labour ensured high costs
High cost of building alternative road access	Yes

Under these circumstances the peak in traffic in 1981-2 is particularly striking. While it is impossible now to know how this came about, it is worth identifying relevant historic factors:

- Increased availability of tugs and barges (the 'Norwegian fleet' was delivered between 1979 and 1982) – and RTC freight rates that were well below cost recovery levels (see El Kider[14], who acknowledges that RTC operations were explicitly subsidised).
- Increased investment in agriculture and infrastructure in the Kosti-Malakal-Bentiu area:
    - Kenana Sugar was incorporated in 1975 in Rabak (opposite Kosti) and began production in 1980.

[20] African Development Bank, 2013. South Sudan: An Infrastructure Action Plan.

[21] Ishiwatari, M, 2015. Redevelopment of Inland Water Transport for Post-Conflict Reconstruction in Southern Sudan.

[22] JICA, 2009. Follow-up Co-operation for Emergency Study on the Planning and Support for Basic Physical and Social Infrastructure in Juba Town.

- In 1978 the Jonglei Canal began construction from its proposed confluence with the White Nile River close to the Sobat/ White Nile River confluence.
- Oil exploration in the late 1970s and early 1980s which ultimately led to production from the Heglig and Unity oilfields north of Bentiu.

Thus, it seems likely that there was a surge in demand and supply at approximately the same time and this led to increased river transport.

4.5. Current Demand for River Transport to Supply Humanitarian Aid

Significant river traffic is currently limited to barges contracted by UNMISS and WFP. The table below collates available information. Ignoring the rather intermittent peacekeeping claims on river transport by UNMISS, tonnages in Table 5 imply annual t-km of roughly 17m (or a tonnage of approximately 20,000), i.e. about 30 percent lower than the lowest historic transport activity between 1972 and 1993 (Table 3). This is consistent with supply chain information contained in WFP's Logistics Cluster report for 2016[23], which reports that around seven percent of the annual total of 265,000t transported by WFP's logistics operation was moved by river. The reasons for this are manifold:

- Attacks on barges, arising from armed conflict.[24]
- Suspension of river traffic between Sudan and South Sudan in 2012.
- Delays in security assurances by local authorities.[25]
- Lack of operational barges and pushers, most of which remain in Kosti or Renk.
- Lack of fuel supplies.
- Siltation of river reaches.
- The poor state of port infrastructure.

Figure 42: Mangalla river port with UNMISS barge convoy being loaded for departure to Malakal as seen during river survey in December 2017, (© HYDROC).

[23] World Food Programme South Sudan Logistics Cluster, 2016. Standard Project Report.

[24] In 2014 and 2015 attacks on humanitarian barge convoys were reported. One approx. 80km south of Malakal and one north of Malakal. This region was reported to be very difficult to operate as SPLA-IO / SPLA frontlines are within the area.

[25] World Food Programme South Sudan Logistics Cluster, 2015. Standard Project Report.

Table 5: Goods transport by river transport from 2013 to date

River reach	Traffic
Juba-Malakal	UNMISS hired barges on seven occasions in 2015.[26]
Mangalla-Malakal	Mangalla is principal origin port for UNMISS river transport, refer to Figure 42. Numbers obtained from UNMISS/MOVCON suggest that 6 TRISTAR fuel convoys per year to Malakal, each carrying 850-1,300t fuel and 100t food.[27]
Bor-Malakal	WFP storage facilities in Bor are principal origin port for WFP Logistics Cluster river transport (port and storage facilities maintained by WFP, refer to Figure 43 and Figure 44). WFP transports around 200-300t food aid per month and around 30,000t per year of its own supplies, but only around 10,000t by river transport. Each convoy consisted of four barges, each carrying around 300t. WFP uses a separate WFP jetty adjacent to the UNMISS facilities at Malakal for unloading.[28]
Bor-Melut	WFP sometimes ('rarely') sends barges to Melut.[28]
Bahr el-Ghazal to Bentiu	None by WFP (security and not navigable); Rubkona IDP camp supplied by road.[29]
Bahr el-Zeraf	No river transport by WFP or UNMISS on this river. Air access used by WFP to Old Fangak.[28]

Figure 43: WFP storage facilities in Bor as seen during river survey in December 2017, (© HYDROC).

[26] Barge Movement to Malakal spreadsheet data for 2015 provided by UNMISS MOVCON.

[27] Based on consultations of consultant with MOVCON. Fuel consumption in Malakal was reported to be 20,000l/day. Approx. 7,300,000 l/year total fuel consumption and capacity of max. 1,300,000 l/fuel-convoy from Mangalla.

[28] Source: World Food Programme South Sudan Logistics Cluster coordinator, personal communication.

[29] World Food Programme Khartoum press release dated 30 March 2017.

Figure 44: WFP storage facilities and adjacent loading/offloading area, (© HYDROC).

For images of Mangalla river port, please refer to Section 3.4.

4.6. Demand Forecasts

4.6.1. Introduction

In this section three forecasts are made:

1. A **short-term** forecast, where demand is dominated by the supply of humanitarian aid. This forecast becomes the basis for the economic appraisal of short-term humanitarian aid interventions in Section 4.10.
2. A **near-term** forecast, under which humanitarian aid continues to be important but no longer dominant and full river transport connections to the north are resumed.
3. A **longer-term** forecast based on assumed economic growth following the resumption of normal transport services.

4.6.2. Short-term Demand for Supply of Humanitarian Aid

In the very near-term, humanitarian aid deliveries are expected to dominate the demand for transport.

The supply of humanitarian aid follows requests by the humanitarian community. There is no five-year plan for the demand for humanitarian aid transport. Current indications (see UN Office for the Coordination of Humanitarian Affairs [30]) are that the need for assistance in South Sudan in 2018 will be greater than that in 2017. The proportion diverted to river transport will however depend on improvements to the physical infrastructure and security.

Three main logistics corridors are used to bring humanitarian supplies into South Sudan: southern (Kenya, Uganda and Tanzania into Juba), northern (Sudan by road through Kosti) and eastern (Djibouti via Gambela in Ethiopia and then air-dropped). Within South Sudan, most is moved by road from Juba, either down a western corridor via Rumbek and Wau, or to Bor. From Bor some goes by river transport to Malakal (see below) and the remainder by air or road from Bor to locations in Jonglei and Upper Nile provinces. The northern corridor has assumed greater importance in recent months, with supplies delivered by road from Sudan to Bentiu and to Malakal via Renk. The use of Renk to tranship from road to barge for onward transport to Malakal took place for the first time in February 2018. 500t of food was delivered on this occasion and WFP plans to extend use of this route in future.[31]

The principal scope for diverting humanitarian aid to barge transport is along the Juba-Bor-Malakal axis. Food transport is currently around 10,000t to Malakal from Bor. In addition, there are fuel convoys from Mangalla to Malakal and intermittent use of river transport in connection with the deployment of peacekeeping personnel and equipment. Current total annual use of river transport is around 20,000t (Table 5).

If river transport access becomes possible at Old Fangak, Baliet and Bentiu, humanitarian deliveries could rise by 25 percent to 24,000t. This assumes that river transport access to Bentiu can be developed cost-effectively, which is open to doubt. Clearly future demand for humanitarian aid transported by river transport depends not only on improvements to physical access but also on budgets and political will. The WFP Logistics Cluster coordinator in Juba believes that, at most, transport by river transport could roughly double over the next five years.[32] For planning purposes the consultant doubled the Table 6 total excluding Bentiu, which gives a total tonnage of 40,000t. This is of course less than the near-term forecasts in the following section which would see 40,000t arriving at Malakal alone, but this should not surprise, as the near-term forecasts assume a resumption of normal trading conditions.

Also, if river transport access becomes possible at Old Fangak (Bahr el-Zeraf River), Baliet (Sobat River) and Bentiu (Bahr el-Ghazal River), humanitarian deliveries by river transport could rise by 50 percent to 30,000t. This is a reasonable basis for planning, even though it is likely that river access to Bentiu will be very costly to develop and this would compete with cheaper supply by road from Sudan (Section 4.10).

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[30] UN Office for Coordination of Humanitarian Affairs, 2017. *Humanitarian Needs Overview, 2018: South Sudan.*

[31] UNMISS, 2018. *World Food Programme COMPLETES FIRST FOOD DELIVERY BY BOAT IN UPPER NILE.* Retrieved from: https://unmiss.unmissions.org/wfp-completes-first-food-delivery-boat-upper-nile

[32] World Food Programme Logistics Cluster coordinator, Juba. Personal communication, February 2018

Table 6: Short-term humanitarian aid demand for river transport

Location	Commodity	Demand - annual quantity
Malakal	Food	10,000t[32]
	Fuel for local use	6,000t[30]
	Fuel for barge transport	1,000t (50t per southbound convoy[33] x 20 times/year)
Old Fangak	Food	8,600 IDPs reported in 2014.[34] Say 9,000 at 110kg/head/yr.[35] = 1,000t
	Fuel for local use	Pro rata to Malakal, 600t
Sobat area (Baliet)	Food	Maximum 30,000 people[30], but 11,000 assessed as being in need in April 2017: 1,200t
	Fuel for local use	As Old Fangak, 600t
Bentiu	Food	20,000 people reported in 2014 as needing food aid[36], i.e. approx. 2,000t needed
	Fuel for local use	Pro rata to Old Fangak, 1,200t
	Fuel for barge transport	120t (10t per westbound trip[31] from Malakalx12 times/year)
Totals	**Food**	**14,200t**
	Fuel for local use	**8,400t**
	Fuel for barge transport	**1,100t**

4.6.3. Near to Long-term Forecasts for Demand for River Transport

JICA Forecasts

JICA made forecasts in 2009 as part of their work preparing for the new Juba port. Assuming no cargo handling limitations, they forecast 174,000 to 260,000t per year in 2016, based on growth rates of 8 and 12 percent respectively from 2008.

The JICA forecasts naturally assumed that traffic from Kosti would continue. They also did not consider the opening of a paved road from Juba to Nimule. The latter, to date the only paved highway in South Sudan, opened in September 2012.

JICA also took some account of demands at Malakal, where they also intended port rehabilitation work. They considered that Malakal's demand would be roughly the same as that at Juba. They assumed a two month round-trip journey time (including waiting, loading and unloading) from Kosti to Juba (compared with 48 days estimated here – see Table 11) and about one month for a Kosti-Malakal round-trip (compared with 29 days here using the Table 11 approach but reducing the outbound haul to 512km).

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33 Basis is Table 12.

34 Coordinated Assessments, 2014. Initial Rapid Needs Assessment: Old Fangak, Fangak County, Jonglei State.

35 Guideline cereal consumption per head per year[46]

36 UNMISS press release, 11 Feb 2014.

4.6.4. Importance of Resumption of Sudan-South Sudan River Transport

The resumption of river transport from Kosti is important. As stated above (see section 4.2) Kosti remains an important transport hub, with operational rail lines to Wad Madani and Port Sudan via Khartoum, and west to the refinery near El Obeid and good road connections from Kosti to Khartoum, Port Sudan and El Obeid. Rail/river transport transhipment facilities at Kosti were reported to be poor in 2004 (principally because of the distance from rail to dockside). There are good road connections from Kosti to Khartoum, Port Sudan and El Obeid. Fuel supplies (gasoline and diesel) are available both at Kosti and in the industrial city of Rabak on the right bank of the White Nile River. There are unconfirmed reports of a cement works in Rabak.[37]

In 2011, i.e. just before formal north-south transport links were broken, imports through Kosti into South Sudan were 187,000t by all modes. This tonnage was entirely food, predominantly grain (60 percent), groundnuts (20 percent) and sugar (15 percent).

Thus, Kosti provides alternative logistics channels for imports and (it is hoped) exports and access to Sudanese supplies of food and building materials. It is likely (though not certain) that logistics costs via Kosti to Malakal, Renk and Bentiu would be lower than those via Juba and East Africa, but in any event more competition in the South Sudanese haulage market is greatly to be welcomed.

4.6.5. Study Near to Long-term River Transport Forecasts

Premise for Forecasts

The consultant makes forecasts of river transport for two-time horizons:

- Near-term (a notional five years from now).
- Long-term (a notional 20 years from now).

The following assumptions apply to both forecasts:

- River transport resumes from Kosti.[38]
- Prices are those of a (reasonably) competitive market and bear a close relationship with costs.
- Fuel is readily available at a price of around $1 per litre.[39]
- Security concerns abate.
- The delivery of humanitarian aid is no longer a principal determinant of transport demand.
- No new competing all-weather road links open.

Previous Growth Forecasts

Under normal circumstances the demand for transport is closely related to gross domestic product (GDP), and traffic growth to GDP growth. South Sudan is the most oil-dependent country in the world, with oil accounting for almost all exports, and around 60 percent of its

[37] Mentioned online (Wikipedia) but there is no definite confirmation that a factory in Rabak exists.

[38] For a qualitative assessment of the impacts of continued cross-border river transport with Sudan, please refer to Section 4.6.4.

[39] At 2017 crude oil prices, refined product before all taxes and delivered in Juba (from Mombasa) should cost approximately $0.80 per litre.

GDP. Growth forecasts for South Sudan therefore depend crucially on oil revenues and how they are used. In 2014 the Economist Intelligence Unit forecast that imports would grow from $1.8bn in 2013 to $2.9bn in 2015, predicated on oil production rising from 115,000 barrel (bbl)/day in 2013 to 250,000 bbl/day in 2015.

These forecasts have of course been overtaken by events. Oil production was just 165,000 bbl/day in 2014-15 and was expected to fall to 120,000 bbl/day in 2015-16.[40] GDP fell by 6.3 percent in 2015-16. Poverty is now widespread, with the incidence of poverty increasing from 44.7 percent in 2011 to 65.9 percent in 2015[34]. Long-term growth depends not only on increasing oil production in the short to medium term but critically for the long-term on developing its non-oil resources.[41]

Nathan Associates made trade forecasts for the transport corridors between Kenya, Uganda and South Sudan in 2012.[42] Their base case forecasts are shown in Table 7. Although the forecasts are reasonable within their contemporary context, they now appear optimistic. Nathan used oil price forecasts made in 2011, when the average Brent crude price was $110/bbl, i.e. double today's price. Their oil production forecasts for 2018 were 160,000bbl/day (low) and 300,000bbl/day (high). This suggests that, at today's oil prices and production levels, revenue could be as low as a quarter of that implicitly assumed by Nathan.

Table 7: Nathan Associates 2012 trade forecasts (t)

		2009	2015	2030
Agriculture	Import	187,000	596,000	1,740,000
	Export	68,000	125,000	366,000
Other non-oil	Import	1,515,000	4,830,000	19,105,000
	Export	281,000	518,000	2,048,000

The African Development Bank (AfDB), in its 2013 infrastructure action plan[43] estimated import tonnage in 2020 of 2.5m t, roughly half that of Nathan Associates.

Development of revised near-term forecasts

Historically, barges have carried 'dry goods' (grain, flour, cement etc) and refined product, and this is unlikely to change. This is also the case when used for humanitarian aid. Conventional barges carry grain and materials needed for shelter, flat bed barges can carry vehicles, equipment and containers while specialised barges are used for fuel.

Cereals deficits are the best available indicator of potential demand for bulk transport, at least in the short to medium term[44], while the 2011 Kosti trade volume of 187,000t (see above) indicates what bulk food transport from the north could amount to in the absence of better developed southern transport links. Deficits in 2010-11 ran at around 250,000t per year[45], but have since

[40] World Bank, 2016. South Sudan Economic Overview.

[41] The World Bank expects long term oil production to fall and become negligible by 2035.

[42] Nathan Associates for U.S. Agency for International Development (USAID), 2012. South Sudan Corridor Diagnostic Study and Action Plan.

[43] African Development Bank, 2013. South Sudan: An Infrastructure Action Plan.

[44] World Food Programme and others procure staples locally, where possible, but the tonnages so procured represent a tiny proportion of the total.

[45] Southern Sudan Centre for Census, Statistics and Evaluation, 2011. *Statistical Yearbook*. (Table 7.17).

risen steadily as a result of conflict, poor crop yields and reductions in cropped areas: the Food and Agriculture Organization of the United Nations (FAO)/WFP estimate for 2017[46] is 500,000t. By the end of August 2017 WFP had distributed 224,000t. (These volumes resemble those forecast by Nathan Associates, but this is coincidental).

Table 8 matches deficit areas with river transport access. River transport is, at least in principle, a transport option for *some* of Jonglei, Upper Nile and Unity states. The table below shows estimated 2017 cereals deficits in these three states and the scope for access by river transport.

Table 8: Cereals deficits in Jonglei, Upper Nile and Unity states, 2017[40]

State	2017 estimated cereals deficit (t)	River transport access
Jonglei	150,000	Via Bor, Fangak (Bahr el-Zeraf), Akobo (Sobat)
Upper Nile	73,000	Via Malakal, Melut, Renk and Sobat river
Unity	82,000	Via Bentiu
Total	**305,000**	

Cereals deficits may increase in the short-term, though once security concerns abate it is to be hoped that deficits will stabilise and then fall. As an upper bound, river transport might account for the transport of around 200,000t (two-thirds of the 2017 total) provided secure inland trucking routes can be developed to reach population centres away from river transport access points. It is difficult to estimate volumes of non-cereals transport by river transport given the lack of historic cargo breakdown. 50,000t would represent a reasonable upper bound, giving a base case total of 250,000t, or nearly double the historic maximum recorded tonnage.

The supply chain for food imports has changed significantly since 2012, however, with imports from Uganda now dominating supplies to the markets in Juba. This of course is the result of much improved road connections via Nimule to Uganda[47] as well as closure of the northern border.

While reliable percentages are not available, much imported food is now sourced in Uganda. A simple comparison of unit transport costs between Kampala (say) and Juba by road and Kosti and Juba by river transport suggests that each would be priced at around $100-$150/t under competitive conditions (see Section 4.9 below), although river transport could be preferred if loading and fuel efficiencies were realised (Figure 45). While supplies of preferred goods (sorghum from Renk, for example) and any that are advantageously procured in Sudan would resume, flexibility and comparatively short delivery times would continue to favour Juba.

The origin-destination (OD) matrix shown below is an attempt to show what a near-term matrix of river transport goods under near-term settled conditions flows might look like.

In t-km terms, Table 9 is equivalent to 155m t-km, or about 30 percent higher than the historic maximum in Table 3.

[46] FAO/WFP, 2017. Crop and Food Security Assessment: Mission to South Sudan.

[47] Although the upgrade of Juba-Nimule road was complete in Sep 2012, upgrading of the final section of the road from Nimule to Kampala was not complete until May 2016.

It shows a complete change for Juba, with around three-quarters of goods traffic being outbound, rather than nearly all inbound as was the case up to 2011. Around 60 percent of goods bound for the Malakal area, Bentiu and the Sobat area are shown as being supplied from Kosti and other points north.

Table 9: Near-term OD matrix (t/year x 1,000)

		Destination						
		Kosti	**Malakal**	**Bentiu**	**Sobat**	**Bor**	**Juba**	**Total**
Origin	**Kosti**		20	20	30	0	20	90
	Malakal area	5		5	20	0	10	40
	Bentiu area	0	0		0	0	0	0
	Sobat	0	0	0		0	0	0
	Bor	0	0	0	0		5	5
	Juba	0	20	20	20	55		115
	Total	**5**	**40**	**45**	**70**	**55**	**35**	**250**

Longer-term forecasts

In the longer-term the consultant can envisage the following trends:

- With more settled conditions, normal local rural exchange (livestock for grain etc.) will resume and should reduce the demand for imported grain.
- The conditions for the realisation of wider benefits discussed materialise.
- Population growth will increase the demand for staple foods (Nathan Associates assumed growth of 3.5 percent per year for five years, allowing for returnees, dropping to 3 percent thereafter, while AfDB[43] took eight growth scenarios with non-oil GDP growth rates ranging from five to nine percent).
- Once economic growth resumes, grain consumed per head will rise from its current level of around 110kg per head per year towards the projected 141kg for Sub-Saharan Africa in 2025.[48]

For a longer-term (say fifteen years from the near-term) projection the consultant assumes an annual growth from near-term conditions in Table 9 of 4 percent a year – see Table 10. Under present circumstances this must be seen as containing a large measure of conjecture and optimism concerning wider benefits. Goods movements at Juba port under this scenario amount to 270,000t per year, approximately the same as those forecast by JICA in 2009. Tonnage originating at Kosti is 162,000t, slightly lower than the 2011 total by all modes of 187,000t (see section 4.6.4). Total t-km are 280m.

[48] Organisation for Economic Cooperation and Development / FAO, 2016. Agricultural Outlook.

Table 10: Long-term OD matrix (t/year x 1,000)

		Destination						
		Kosti	**Malakal**	**Bentiu**	**Sobat**	**Bor**	**Juba**	**Total**
Origin	**Kosti**		36	36	54	0	36	162
	Malakal area	9		9	36	0	18	72
	Bentiu area	0	0		0	0	0	0
	Sobat	0	0	0		0	0	0
	Bor	0	0	0	0		9	9
	Juba	0	36	36	36	99		207
	Total	**9**	**72**	**81**	**126**	**99**	**63**	**450**

Treating tonnages originating at Kosti and Juba as imports gives an import tonnage of 370,000t. This represents 2 percent of the Nathan Associates forecast of total non-oil imports for 2030 (see Section 4.6.5).

4.7. Required Barge Capacity to Match Near-term Forecasts

For an assessment of the required barge capacity to meet short-term demand for humanitarian aid, please refer to Section 5.5.2.

Using the values in Table 9 and Table 10 it is possible to make a rough estimate of the barge and pusher capacity needed.

Five routes are assumed. Each is operated independently, and each is operated as a round-trip:

- Kosti/Renk via Malakal to Juba
- Kosti/Renk via Malakal to Sobat (Nasser is assumed as the Sobat destination)
- Kosti/Renk via Malakal to Bentiu
- Juba-Bor
- Juba-Bentiu

The peak tonnage is assumed to determine the required capacity (e.g. the near-term peak tonnage for Kosti via Malakal to Juba is 30,000t, the return tonnage of 20,000t from Juba to Malakal does not require any additional capacity).

A total of 13 pushers and 48 barges is needed to meet near-term demands with an average service interval of 1-2 weeks. This is quite similar to the size of the Norwegian fleet, intended of course for the entire White Nile River in Sudan, reported in El-Kider[14]. No allowance is made for breakdowns or service, or for the seasonal variation in demand. There are complicated trade-offs at work here. Improving service frequency reduces loading efficiency and, other things being equal, increases costs. On the other hand, if service intervals reach a month, shippers may lose trust in the service.

Because this capacity is close to the current fleet capacity in South Sudan (refer to Section 5.5.1), one may assume that the existing fleet capacity will likely be insufficient. However, under the assumption that the cross-border river transport will be revived, the supplemental fleet capacity currently available in Sudan will be sufficient to meet the demand.

4.8. Passenger Transport

Formal passenger services (such as those formerly operated by RTC) began a rapid decline in the mid-1970s. They have never recovered, and indeed there seems to have been no provision for passenger services when RTC was broken up in 1993.

There is no basis for estimating local passenger transport costs, but work elsewhere (e.g. in Bangladesh[50]) suggests that for full cost recovery the cost per passenger-km is roughly the same as the cost per t-km. This would imply a fare of approximately $10 for Juba to Bor. While the GDP per head in 2014 was estimated at $1,100, this is heavily biased by the oil sector, and 85 percent of the population is engaged in non-wage work. Thus, passenger transport would either have to be heavily subsidised by the state or be cross-subsidised by goods transport.

Within the scope of this study it is not feasible to make passenger transport demand forecasts. It is though suggested that, provided it can be achieved without comprising the efficiency of goods transport, limited provision for fare-paying passengers is made on any new goods barges in order that some assessment of the market can be made.

4.9. Supply of River Transport Services

4.9.1. Freight Rates and Costs

Freight rates are prices quoted to users and shippers; unit costs are built up from knowledge of fuel, labour and capital costs. In a competitive market, rates and unit costs should be reasonably close.

Table 11 below sets out White Nile River freight rates drawn from available sources between 2003 and 2017. Even the rates in 2003, when White Nile River traffic was relatively unaffected by security concerns, were several times those found internationally. Typical costs per t-km for bulk transport by barge are around 1-3¢ per t-km (see World Bank studies of Vietnam[49], Bangladesh[50] and China). As can be seen see later, this mismatch arises from factors that are peculiar to transport on the southern reach of the White Nile River.

Prices evidently increased sharply after 2012, when barge traffic south from Kosti was halted, and are now three to four times those in 2003. The reasons for this include lack of operating stock (which remains in Kosti), lack of fuel supplies north of Juba, coercive extraction of passage fees north of Bor and collusion between operators. Prices clearly depart from costs by a large margin.

[49] World Bank, 2014. Facilitating Trade through Competitive Low Carbon Transport: The Case for Rehabilitating Vietnam's Inland and Coastal Waterways.

[50] World Bank, 2007. Revival of Inland Water Transport, Options and Strategies. Bangladesh Development Series Paper no 20.

Table 11: White Nile River freight rates

Source and basis	Load, OD pair and km	Price or cost $/t	Price or cost $/t-km
2003 Barge Operation Capacity Assessment[51] Basis: RTC & other operators' prices	Non-food, Kosti-Malakal, 512km	25[52]	0.05[52]
	All goods, Kosti-Juba, 1,358km	110[52]	0.08[52]
2013 Riverine Project Capacity Assessment[16] Basis: NRTC/Keer prices	20ft container[53], Juba-Malakal, 846km	320-420	0.38-0.49
	40ft container[54], Juba-Malakal, 846km	440-530	0.52-0.63
	1 t, Juba-Malakal, 846km	275-310	0.32-0.37
	Single barge carrying 500t, Juba-Malakal, 846km	180-220	0.21-0.26
2017 Personal communication[55] Basis: prices	Non-food, Bor-Malakal, 663km	390	0.59
	20ft container, Bor-Malakal, 663km (20t)	325	0.49
	40ft container, Bor-Malakal, 663km (27t)	400	0.60
2017 UNMISS/MOVCON[56]	Minimum three barges Bor-Malakal, 663km (say 1,500t) at $0.75m/barge	1,500	2.30

4.9.2. River transport Operating Expenses

Table 12 below shows calculation of the total annual cost of a barge operation from Kosti to Juba and back. The final result, $129/t, is close to the 2003 freight rate estimate of $110/t (at 2017 prices). At $0.10/t-km, the unit cost is approximately 60 percent of truck freight rates from Mombasa to Juba.

Unit costs are sensitive to loading efficiency (just 40 percent in the example shown) and fuel costs (accounting for a very high 80 percent of total costs in the example shown). The chart below illustrates this, as well as the benefits of being able to sail 24h per day.

51 World Food Programme South Sudan Logistics Unit, 2003. *Barge Operation Capacity Assessment.*

52 Brought from 2003 to 2017 prices using Brent crude oil price index.

53 20ft container assumed to have a 20t payload.

54 40ft container assumed to have a 27t payload.

55 Personal communication from a local logistics expert.

56 Spreadsheet data provided by UNMISS MOVCON.

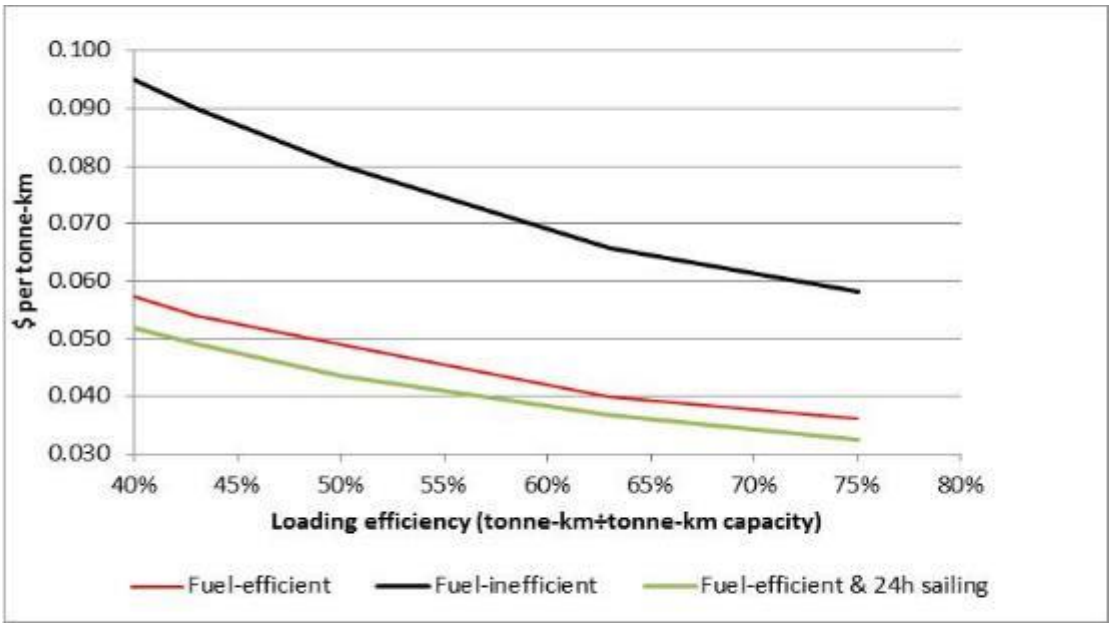

Figure 45: Unit cost of barge transport by loading and fuel efficiency.

All the rates discussed omit loading and unloading costs. They are high, currently around $10-$20 per t[16], up from a reported $5/t in 2009 (United Nations Joint Logistics Centre (UNJLC)[57]). At $10/t this increases the total cost per t for Kosti-Juba from $110 to $150.

4.9.3. Costs of Competing Modes of Transport

Road Transport

In the case of road transport there is standard software that can be used to estimate road user costs (RUC), which in turn can be used to estimate the cost of transporting a t of freight. This software is Highway Development and Management 4.0 (HDM-4).[58] HDM-4 requires extensive inputs of vehicle and road characteristics. If a transport market is reasonably competitive it can be used to estimate freight rates. It is especially well suited to estimating freight rate changes that arise from changes in road and/or vehicle characteristics.

Juba is fortunate in being accessible to the competitive East African trucking market.[59] Table 13 below shows the rates charged for transport from Mombasa to Juba. Although the data are taken from a Nathan Associates study in 2012, more recent values from a 2014 World Bank Sudan Diagnostic Study[17] and correspondence of the consultant with local logistics experts in Juba suggest that there has been little change.

[57] UNJLC, 2009. River Cargo Transportation Assessment White Nile River.

[58] Highway Development & Management 4 (highway evaluation software developed by TRL, World Bank et al).

[59] World Bank, 2009. Africa Transport Prices and Costs.

Table 12: Typical river transport operating costs

Item	Unit	Value	Remark
Transport duty			
One-way trip length	km	1,360	Kosti-Juba
Hours per day sailing	h	12	Daylight sailing only
No of round trips per year		8.0	Result
Load	t	1,500	
No of barges	no	4	Typical set
No of backhaul trips per year		8.0	Result
Load during backhaul	t	100	Assumption
No of barges loaded for backhaul	no	1	
Total t-km per year	t-km/yr.	17,408,000	Result
River current	km/h	5	Assumption
Design speed rel. to river	km/h	10	Typical value
Sailing time against current	days	23	Result
Backhaul journey time	days	8	Result
Loading/unloading & waiting time per round-trip	days	18	Result
Fixed costs			
2000HP pusher	$	1,000,000	Value from consultations with local expert $1.5m
500t barge	$	200,000	Value from consultations with local expert $0.45m
Pusher life	years	20	Assumption
Barge life	years	20	Assumption
Discount rate	percent	12%	Top end of dev bank discount rates
Equiv. annual cost	$/yr.	240,982	Annuity calculation
Maintenance & insurance	$/yr.	74,000	

Item	Unit	Value	Remark
Crew cost (semi-fixed)			
Captain, cost/month	$/mon	400	Value from consultations with local expert
Crew, cost/month	$/mon	200	Value from consultations with local expert
Total crew	No	8	Consultations with local expert revealed 8-12
Total crew cost	$/yr.	24,000	
Fixed cost per day	$/day	929	
Fuel cost (variable)			
Fuel consumption southbound	litre/100t-km	4.0	Kosti assessment report, UNJLC 2004
Fuel consumption northbound	litre/100t-km	0.4	Value from consultations with local experts was lower at 50t for Renk-Juba
Fuel cost per litre	$/litre	2.0	
Annual fuel cost	$	1,315,271	
Total cost	$/year	1,654,253	
Cost per t-km	$/t-km	0.10	
Cost per round-trip	$/round-trip	206,782	
Cost per t	$/t	129	

Table 13: Truck freight rates, Mombasa-Juba[42]

Route	km	Price ($US)			Time (h) per truck	
		Containers		break-bulk		
		20ft	40ft	dry, per truck load	Container	Bulk
Juba via Nimule	1,713	4,814	7,845	7,363	453	209
Juba via Oraba/Kaya	1,854	6,094	9,041	5,833	470	202
Juba via Kampala	1,835	5,251	8,376	7,093	462	205

Assuming (as before) that 20ft and 40ft containers hold, respectively, 20t and 27t payloads, the rates in Table 13 are equivalent to $250-350 per t. As with river transport, backloads from Juba are negligible and the freight rates are equivalent to approximately $0.17 per t-km. Freight rates in Sudan between Port Sudan and Khartoum, a distance of 1,190km, are reportedly also competitive and a rate of $0.05 per t-km appears in the 2008 Diagnostic Trade Improvement Study.[60]

Within South Sudan the consultant uses an estimate of $10,000[61] for Juba-Bentiu (1,028km via Wau), equivalent to $370/t or $0.36/t-km (zero backhaul). A rate of $0.36/t-km is approximately double the rate for Mombasa-Juba. WFP gives a price of around $100/t for Juba-Bor (183km), which equates to a high freight rate of $0.55/t-km.

Assuming that changes in RUC are a guide to changes in competitively established freight rates, HDM-4 can be used to estimate freight rates on extremely poor roads under competitive conditions. Table 14 indicates that RUCs roughly double, when compared with travel on fair to good East African bituminous roads, if the following conditions are met:

- The road is unpaved (with an international roughness index (m/km) of 15-20).
- Fuel is priced at $2 per litre.[62]
- A truck's useful life is reduced to 5 years.

Doubling Mombasa-Juba freight rates brings the rate to $0.4/t-km, the same as that reported by Henepin for Juba-Bentiu, though still much less than the WFP price for Juba-Bor. This suggests that even for road transport prices depart considerably from costs, suggesting that a competitive market may not operate.

[60] World Bank, 2008. Republic of Sudan Diagnostic Trade Improvement Study.
[61] Based on consultations with local logistics experts.
[62] Fuel prices are very volatile.

Table 14: Predicted RUCs under very adverse conditions[63]

	Road user cost, ($/t-km) HGV (3 axle rigid, assumed at 10t payload)	Truck-trailer, (assumed at 40t payload)
Good paved conditions (e.g. Mombasa-Juba)	0.2	0.1
Poor unpaved conditions, high fuel price and curtailed vehicle life	0.4	0.2

Air Transport

Air transport is used to move UNMISS equipment and WFP food deliveries. UNMISS contracted 192 sorties by Ilyushin IL-76 freighters in 2015-17. WFP has quoted a typical price of $1,400 per t for Juba-Malakal, equivalent to about $1/t-km, as usual assuming no backload.

The IL-76 is a four-engine freighter with a payload capacity of 40-60t, depending on version and range. It first entered service in 1974. It is widely used as a military transport aircraft and has a ramp.
Capital, fuel and crew costs can be roughly estimated using widely available IL-76 operating data; see Table 15 below. The result, $1,000/t, is sufficiently close to the charge faced by WFP for us to conclude that this market is fairly competitive.

4.9.4. Summary of costs per t-km

Figure 46 compares costs per t-km by air (A), truck (B1, B2) and barge (C1-C3). All are average costs, and all exclude any transhipment, loading and unloading costs. In the cases of air and truck transport average costs are reasonably representative of market prices, but prices currently charged for barge transport are several times costs, as shown by the Bor-Malakal data point (C1, indicated in red). This is significant, for it implies that at prices currently charged, barges cannot compete with truck transport, even on a poor-quality road. The reasons for such high barge freight rates include lack of operating stock (which remains in Kosti), lack of fuel supplies north of Juba, coercive extraction of passage fees north of Bor and collusion between operators.

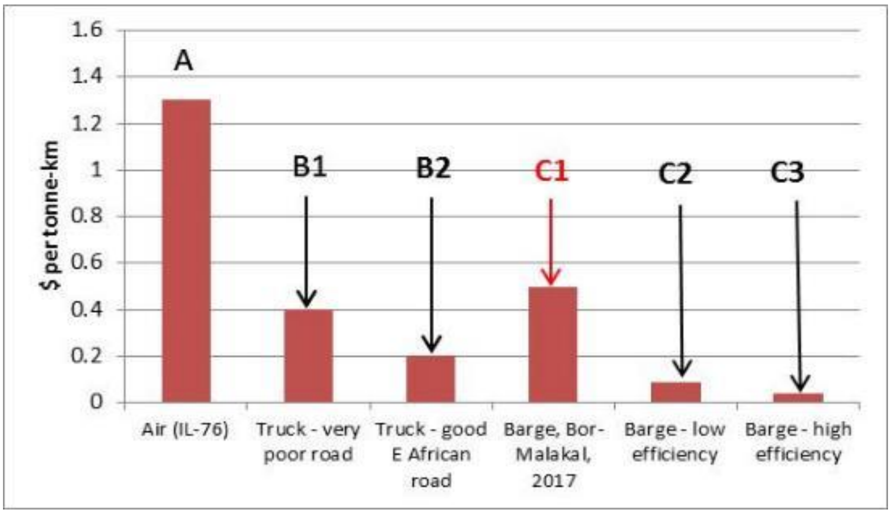

Figure 46: Costs per t-km by alternative transport modes.

[63] Based on consultant's assumptions.

Table 15: IL-76 unit freight cost estimate[64]

Item	Unit	Value	Comment
Flight			
Payload	t	60	Range is 40-60t
Distance	km	1,300	
Cruising speed	km/h	750	
Block hours	hours	2.0	Block hours include take-off, landing and taxi
Capital cost element			
Initial cost	$m	35	Second hand price
Equiv. annual cost per round-trip	$	150	Assumes 2,000 block hours per year, 12% discount rate, 30 yr. life
Fuel			
Specific fuel consumption	kg/kgf-h	0.595	
Take-off power	kgf	58,000	4x14,500kgf
Cruising power	kgf	14,000	4x3,500kgf
Fuel cost per round-trip	$	49,000	Assumes $1 per litre
Crew			
Crew cost per round-trip	$	1,000	Assumes one day's pay per round-trip. 6 crew (may be 6-9)
Sum (capital+fuel+crew)	**$**	**50,200**	
Add for servicing, admin & insurance at 20%	$	10,040	
Total per round-trip	**$**	**60,240**	
	$/t	**1,000**	
	$/t-km	**1.3**	

4.10. The Benefits and Costs of Short-term Interventions

Previous sections have convincingly demonstrated that the prices charged for river transport in South Sudan render barge transport uncompetitive, except where the alternative is air freight or access is impossible except by river transport. The reasons behind this have also been made abundantly clear. They are a mixture of the high costs of operation (low loading efficiencies, old, fuel-inefficient vessels, high loading and unloading costs, daytime-only steaming etc) and lack of competition between transport operators (collusive behaviour).

[64] Based on industry sources and www.airliners.net.

Table 16 sets out the scope for reducing river transport freight rates.

Table 16: Scope for reducing river transport freight rates

Factor	Scope for improvement
Fuel inefficiency	Fitting modern engines to existing pusher tugs; new fleet.
Loading efficiency	In short-term, unlikely that much can be done about this.
Loading/unloading costs	Provision of mobile and gantry cranes as part of port services would reduce loading/unloading times (and increase annual utilisation).
Daytime-only steaming	Some improvement possible if vessels fitted with GPS and better lighting and navigation aids installed on the river, but 24h steaming unlikely in near future due to security concerns.
Lack of competition	Introduction of new service at disruptive freight rates. Might require acquisition of a new fleet.

Dredging Juba to Bor and Rehabilitation of Juba Port

Juba port is vital transport infrastructure for South Sudan. It was rehabilitated by JICA in 2007, which according to JICA reduced the unloading time per barge from two days to one day.[22] It should also provide comparatively secure storage for goods. Based on the consultant's port inspection further investments in Juba port infrastructure are recommended (Section 5.4.1). During consultations with barge operators in Juba, it was reported that the river stretch between Juba and Bor is the most difficult to navigate on the White Nile River in South Sudan. It is heavily silted which has led to barge operators moving their operations from Juba to Bor (and Mangalla for TRISTAR). Juba port is currently not being used for large-scale river transport operations.

In terms of logistics, goods bound for Malakal will no longer be taken by road from Juba and transhipped at Bor for onward transport to Malakal by barge. Instead they will be loaded at Juba and unloaded at Malakal. UNMISS shipments from Mangalla will be re-routed via the new port at Juba.

Reduced costs and improved security at Juba can be expected to induce additional traffic but is likely to be small and is not included in the benefits calculation below.

The benefit calculation (Table 17) shown below assumes that:

- The annual tonnage of food rises from approximately 12,000t to 24,000t over five years.
- River transport freight rates are at competitive levels (as calculated in Table 12). (Annual benefits are unaffected if current commercial rates are applied, provided that the rate from Juba-Malakal after improvements is $7/t lower than the pre-improvement rate from Bor to Malakal).
- Barge loading time at Juba is reduced by one day (compared with Bor) and loading costs at Juba are 20 percent lower (thanks to mechanisation and improved loading areas) than they are at present.
- Project fuel consumption when steaming upstream is reduced from 4 litre/100t-km to 3 litre/100t-km.
- Pilferage is valued at a Juba white sorghum market price of $0.7/kg.
- Using a discount rate of 10% the present value of benefits over the five-year period is $11.4m.

Table 17: Juba-Bor annual benefits

Item	Year 1	Year 5
Without project:		
Road transport Juba-Bor at $100/t	1,200	2,400
Transshipment at Bor at $10/t	120	240
Barge Bor-Malakal at $106/t	1,272	2,544
10% spoilage/pilferage of 10,000t food at Bor at $0.7/kg	840	1,680
Total annual cost	3,432	6,864
With project:		
Loading at Juba at $8/t	96	192
Barge Juba-Malakal at $99/t	1,188	2,376
Total annual cost	**1,284**	**2,568**
Annual benefit	**2,148**	**4,296**

The capital cost alone, of the cheapest option for dredging (dredged material disposal via floating pipeline only), are estimated at $12.2m (Annex VI). If split barges are required, the capital cost are estimated at $34.2m. This does not yet include any operation cost, which are estimated with $2.2m and $4.8m respectively. It can be seen, that from an economic point of view, dredging the river between Juba and Bor cannot be recommended for short-term improvements in river transport targeted at more cost-effective supply of humanitarian aid. Despite this, it must be emphasised that for the sake of the long-term development of the country, reconnecting the river transport system with South Sudan's capital city and the country's major markets in Juba is an urgent need.

Dredging Lake No to Bentiu and Rehabilitating Port at Bentiu

Bentiu is the site of the largest camps in South Sudan. In 2017 their population was put at 120,000[46], although the food aid requirement is only (Table 6) put at 2,000t.

Bentiu is no longer accessible by barge. To reinstate barge access, the Bahr el-Ghazal needs dredging from Lake No and a jetty needs to be reconstructed. Road access is possible, however, from Sudan and from Wau. Humanitarian aid was delivered in March 2017 from El Obeid in Northern Kordofan, a corridor that WFP has used since 2014.

Assuming that without the project food is delivered by road from El Obeid, a distance of 500km, the annual transport cost would be approximately $0.36m (using a freight rate of $0.36 per t-km – see Section 4.9.3 above).

The most cost-effective alternative would be from Kosti to Renk by road (160km by reasonable road), then by barge from Renk to Bentiu (540km). At current freight rates the Kosti-Renk-Bentiu alternative would have the higher financial cost (a total of $0.54m for 2,000t). If however barge rates could be brought down to a rate that reflects average costs of around $0.10/t-km, then the total cost (including one additional transshipment in Renk) would be approximately $0.21m.

The maximum gross benefits would be $0.21m per year, i.e. a present value over five years of $0.8m (at a 10% discount rate).

Clearing the stretch from Lake No to Bentiu requires significant dredging and vegetation clearing efforts. At present, the Bahr el-Ghazal is completely overgrown with vegetation, making it inaccessible for any large-scale river transport operations (Figure 28). Considering the remoteness of the location for dredging operations and the significant investments required (Annex VI) it is obvious that dredging the river stretch solely for the purpose of delivering humanitarian aid will not be cost-effective. Despite this, it must be emphasised that historically the Bahr el-Ghazal and the connecting Jur river have been utilised for river transport operations as far as Wau. Together with the Sobat river which reaches far towards the east, crossing the Ethiopian border, a whole East-West river transport axis could be revived. The potential for long-term economic development of South Sudan is significant.

Old Fangak Improvements

Although beyond the scope of the current study, the consultant has looked at the scope for improving the cost-effectiveness of humanitarian aid deliveries to Old Fangak, which has an IDP population put at 8,600 in 2014 and an estimated annual food requirement of 1,000t (Table 6). Old Fangak is currently only accessible by air. Access by barge, either from Malakal or Juba, would require improvements to Bahr el-Zharaf navigability and barge access at Old Fangak. Even at current commercial rates the direct transport cost saving would be around $1m (1,000t at a saving of $1,000 per t). Again, these cost-savings are very small compared to the investments required for dredging and vegetation clearing.

Baliet (Sobat) Improvements

Although beyond the scope of the current study, the consultant has looked at the scope for improving the cost-effectiveness of humanitarian aid deliveries to Baliet county on the right bank of the Sobat river, which has an estimated annual requirement of approximately 1,200t (Table 6). Food aid is deliverable by road from Malakal (approximately 56km distant) but only during dry season. Assuming an annual 1,200t of food aid (Table 6) is delivered, at a unit value of $0.7/kg, the gross benefit of supplies over a four-month period would be $0.28m. Again, these cost-savings are very small compared to the investments required for dredging and vegetation clearing.

4.11. Long-term and Wider Benefits of Improved River Transport

4.11.1. Introduction

Transport costs in South Sudan unavoidably high as a result of distance and poor-quality infrastructure; it is an extreme case of the high ‘cost of being landlocked’.[65] Collusion and security concerns have also served to push prices well beyond costs. Any kind of long-term development in South Sudan will depend on large-scale supplies of building materials, but high transport costs has meant and continues to mean that South Sudan has faced some of the highest building materials costs in the world. By the same token its goods will stand little chance in export markets. Although access to East African markets has improved enormously since the opening of the upgraded Juba-Nimule road, the lack of any viable transport connection to Sudan has resulted in isolation for much of the north of the country and fostered uncompetitive transport markets.

It is worth repeating the conditions most likely to support a case for investing in river transport:

[65] World Bank, 2010. The Cost of Being Landlocked.

- There is strong demand for regular deliveries of bulk or break-bulk goods with low unit values (grain, fuel, timber, cement etc).
- Hauls are long and transshipment costs are low.
- Waterways maintenance costs (in particular those of dredging) are low.
- Refuelling points are frequent.
- There is little alternative: road access is lacking the costs of developing road access are extraordinarily high.

With economic growth comes higher values of time and reduced willingness to pay a high price (unless subsidised - see Section 4.8) for transport that involves long (and uncertain) journey times. Thus, the long-term case for large-scale passenger transport by river transport is even less compelling than that for goods transport. However, in a situation where there are effectively no bridges, as in South Sudan, demand for cross-river ferry transport will remain high.

4.11.2. Simplified Approach to Long-term Transport Benefits

The difference in transport cost per t-km between (a) a project case of barge transport in a competitive market (say $0.05/t-km) and (b) a mixture of heavy goods vehicles and truck-trailers on some poor and some fair paved roads (at say $0.2/t-km on average) is a very simple approach that can be applied to the t-km between any OD pair in Table 9 or Table 10, and then interpolated and discounted to give a present value of benefits. This approach assumes that any short-term gains, e.g. by substituting barge for air transport, have already been made, and that the other conditions favouring barge transport (bulk goods, high loading efficiencies etc) are satisfied.

There are no established discount rates for South Sudan. While discount rates in developed countries (and at Asian Development Bank) have fallen in recent years, AfDB continues to use 12 percent and the World Bank 10-12 percent.

At 10 percent the PV of benefits is $280m, while at 12 percent it is $240m. (Both figures are based on evaluation periods of 25 years, with no further growth after year 15).

4.11.3. Wider Benefits

The wider benefits of transport cost reduction include:

- Encouragement of the exchange of goods and labour between places of production and places of consumption, thereby increasing the returns to agriculture (for example).
- Changes in the location of activities.
- Reduction of the costs of inputs into physical development (building materials etc).
- Increases in the welfare of households by reducing the cost of access to public services.

Despite the above, the evidence that transport infrastructure brings about regional economic development is weak and contested. Improved transport infrastructure is a necessary but not a sufficient condition for development. That said, if transport improvements are part of a process whereby changes in land use are triggered, large benefits can result. As described in Section 4.4, the surge in river transport in 1981-2 probably came about when a surge in demand from agricultural, oil-related and infrastructural development coincided with increased supply of barges and pushers.

The project terms of reference call for a '*review of all documents [...] in relation to economic activities in the project study area*'. They also instruct the consultants to '*[…] research the market needs which would be potentially accelerated by the establishment [...] of a river barge system*'. It is probably no exaggeration to say that there are no reliable sources of information on current economic activities, but there have been several surveys of agricultural and mining activities that include limited information on activities 10-20 years ago and some indication of potential.

In 2010, agriculture was the mainstay of the non-oil economy, accounting for an estimated 36 percent of non-oil GDP and primary source of livelihood for most households.[66] The main cereal crops are sorghum and maize, with maize grown in the wetter south-west of the country and sorghum in the drier north. Sudan was famous for gum arabic, extracted from acacia senegal and acacia seyal. The so-called 'gum belt' extends south to Malakal, but production is now very small (global trade is roughly 100,000t per year). Livestock, mainly cattle, are also a main source of livelihood and are concentrated in Upper Nile, Jonglei, Eastern Equatoria and Bahr el-Ghazal. Forestry has considerable potential (natural forests and woodlands cover an estimated 33 percent of the total land area) but, illegal logging of teak apart, there has been little formal exploitation of this resource. There has so far been little or no mineral extraction or quarrying.

Although almost all agriculture has been on a low input, low output subsistence basis, there has been a large transfer of land to foreign companies, governments and individuals, evidently for mechanised exploitation. Between 2007 and 2010 at least 26,400km^2 of land for projects in the agriculture, biofuel and forestry sectors was transferred. If domestic investments are added, the pre-war mechanised agriculture schemes of Upper Nile State, and investments in tourism and conservation, the figure rises to 57,400km^2, or nine percent of the total land area of South Sudan.[67]

Table 18 shows large-scale agricultural projects which, *a priori*, may benefit from investment in barge transport, given its suitability for transporting dry goods in bulk with low unit values. Little information is available about their current status, but it is likely that few, if any, are growing crops on any significant scale. Based on this table the scope for benefits is greatest on the following reaches:

- Malakal/Sobat to Renk (69m t-km per year based on Table 10)
- Malakal to Bentiu (29m t-km)
- Juba to Bor (20m t-km)

This prioritisation is consistent with AfDB's maps showing commercial farming potential[66] (map 6.3) and irrigation potential (map 6.4). It is also consistent with the Southern Sudan Regional Government's efforts between 1972 and 1983 to develop agriculture around Malakal. Conspicuous by its absence is the Bor-Malakal reach. This reach is flanked by swamp or pastoral lands (depending on water levels) which do not lend themselves to large-scale commercial activities of any sort and are therefore unlikely to provide long-term benefits to barge transport investment.[68]

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[66] AfDB, 2013. Chapter 6 of South Sudan Infrastructure Plan – A Program for Sustainable Strong Economic Growth.

[67] Norwegian People's Aid, 2011. The New Frontier: A Baseline Survey of Large Scale Land-based Investment in South Sudan.

[68] Livestock transport requires specialised transport; the extension of rail services to Wau in 1961 was in part to transport livestock.

Low unit value minerals are also a potential market for barge transport. As stated above, there are currently no active minerals or quarrying activities in South Sudan. Dangote Cement of Nigeria had plans to build a plant in Torit on the Juba –Nadapal road, but they have been put on hold (see United States Geological Survey[69]). The United States Geological Survey (USGS) also reported that two companies held gold exploration licences. As matters stand there is no indication that barge transport will have any impact on the minerals industry, although clearly the ability cost-effectively to transport cement from an eventual factory in Torit, and other building materials, will be of considerable benefit.

4.11.4. The Long-term Case for Investment

If all the preconditions listed in Section 4.6.5 are met (transport south of Kosti, fuel supplies etc) there is a fair chance that investment in river transport will capture a good share of the market for the long-haul transport of bulk goods, as it did in 1981-2. The demand risk is high, however, and public sector and development bank support will be essential.

[69] USGS, 2016. 2014 Minerals Yearbook, South Sudan.

Table 18: Large-scale acquired land that could benefit from river transport[66,67]

River reach	Past/current activities	Potential	Benefit from improved river transport
Juba-Bor	CEDASS (Canadian Economic Development Assistance for South Sudan) 12,200ha (so far limited trial planting) on left bank of White Nile River approx. 30km N of Juba.	In 2017 concluded partnership with Global Group with a view to expansion.	Alternative to existing left bank road from Juba.
	Mangalla sugar project (Madhvani group of Uganda). Ambitious plans for 60,000ha of sugar cane and factory. Plans date from 2009 but unclear whether any development has taken place. (The Madhvani proposal is on the site of an experimental sugar station dating from the 1950s).		Relevant for domestic supplies of refined sugar but road would probably be preferred for export market (planned output 80,000t sugar per year).
Bor-Malakal	Some mechanised agriculture around Maar (near Jonglei), possibly sponsored by Yen Thumb Group. Current situation unknown.	Area has 'medium potential' status on AfDB map.	Uncertain.
White Nile River - Bentiu	Aweil irrigation scheme on Lol river. Founded in 1944, expanded in 1976 and rehabilitated in 2007. In 2012 600ha of rice were reportedly planted.	Area has 'medium to low potential' status on AfDB map.	None: Lol river unlikely to be navigable at reasonable cost.
	Jarch Management Group acquired 400,000ha near Mayom on the Bahr el-Arab (tributary of Bahr el-Ghazal) in 2009.	Area has 'medium to low potential' status on AfDB map.	Uncertain: Mayom is c 90km upstream of Bentiu. High cost to render river navigable. Location of land relative to river unknown.
	Prince Budr bin Sultan acquired 105,000ha in Gwit in c 2009 on a tributary of the Bahr el-Ghazal.	Area has 'medium to low potential' status on AfDB map.	None: tributary unlikely to be navigable at reasonable cost
	Citadel Capital/Concord acquired 105,000ha in Gwit around 2009 and in Pariang (Bahr el-Ghazal/ White Nile River confluence).	Area has 'medium to low potential' status on AfDB map.	May be potential for Pariang, depending on exact location of cropped area and nature of crops.
Malakal-	Three pre-1983 irrigation schemes	High irrigation potential (FAO).	Alternative to right bank road to Kosti and of clear

River reach	Past/current activities	Potential	Benefit from improved river transport
Melut-Renk	(Magara, Gaiger and Abu Khadra) along road north from Renk to Sudanese border. Total area c 13,000ha. All thought to be defunct.		benefit if area can supply competitively to Juba.
	Melut sugar scheme, originally planned for 14,700ha. Pilkot area of 42ha planted. Irrigation infrastructure started in 1979 but stopped before 1983. Subsequent rehabilitation plans have come to nothing.	As above.	As above.

5. Proposed Activities (Options Catalogue)

5.1. Introduction

Four main types of actions for investment are being considered for the establishment of an improved river barge transportation system in South Sudan, including:

1. Dredging and widening of shipping channels and clearing of vegetation.
2. Installation, operation and maintenance of navigation aid systems.
3. Rehabilitation and expansion of existing ports.
4. Procurement, operation and maintenance of additional pushers and barges (including self-propelled systems).

5.2. Dredging and River Training

To calculate the approximated dredging volumes, the consultant did draw on a combination of expert knowledge, consultation with South Sudanese barge operators and literature review. The calculations on depth and width of shipping channels are based on the vessels using the channel. The most common type of vessel on the river is the 'Hashab' model/type. The pusher is an average of up to 25m long and 10m wide with a draft of up to 1.5m. The barge (normal type) are 33 to 35m long and 10.5 to 11m. In the 1980s, Chevron brought in a large barge of 45m length and 14m width[16]. So, the largest single vessel using the shipping channel would be no larger than 45m long and 14m wide with a draft of 1.5m. Pushers normally push 3 to 5 barges, the width in this case would be 11m times two barges, resulting in a width of 22m.

5.2.1. River Dredging (Width and Depth of Shipping Channel).

Dredging depth was calculated based on required channel depth for the fleet operating on the White Nile River (1.5m draft + safety clearance of 0.75m leading to a total depth of 1.5+0.75=2.25m) during low water conditions. (Reference US Army Corp of Engineers EM 1110-2-1613, dated 31 May 2006). The width was calculated with 54m. A slightly wider channel is required in bends because vessels and barges take an oblique position as they round a curve.

The calculations of the volumes to be dredged are based on the bed conditions described in Section 2.2. The results described therein on remaining width and depth (Figure 6ab - Figure 8ab) are used to estimate dredging volumes along the longitudinal profile from Juba to Renk using geometric volume calculations. The calculations are based on the necessity to fit a barge setup of 2x2 plus pusher (dimensions: L=95m, W=22m; draft=2.25m) and appropriate buffer widths through the channel. In total, the channel is longitudinally divided from Juba to Renk into 5668 individual locations (sections) where the volume to be dredged is calculated.

At locations where the remaining depth is smaller zero, dredging is required so that the barges do not run aground. The volume required to be dredged there is calculated through:

$$V_{depth} = D_{lack} \cdot W_{Nav} \cdot L_{section}$$

where V_{depth} is the dredging volume needed because the section is too shallow, D_{lack} is the lack of depth that needs to be dredged (see Figure 6b-Figure 8b), W_{Nav} is the required width of the navigation channel (see Annex III) and $L_{section}$ is the length of the section.

Similarly, at locations where the remaining width of the channel is smaller zero, dredging is required so that the barges can pass these locations. These volumes are calculated through:

$$V_{width} = W_{lack} \cdot H_{Bank} \cdot L_{section}$$

Where V_{width} is the dredging volume needed because the section is too narrow, W_{lack} is the lack of width that needs to be dredged (see Figure 6a-Figure 8a), H_{Bank} is the average height of the channel banks, which is taken from the hydraulic model where channel banks are around 10m high, and $L_{section}$ is the length of the section.

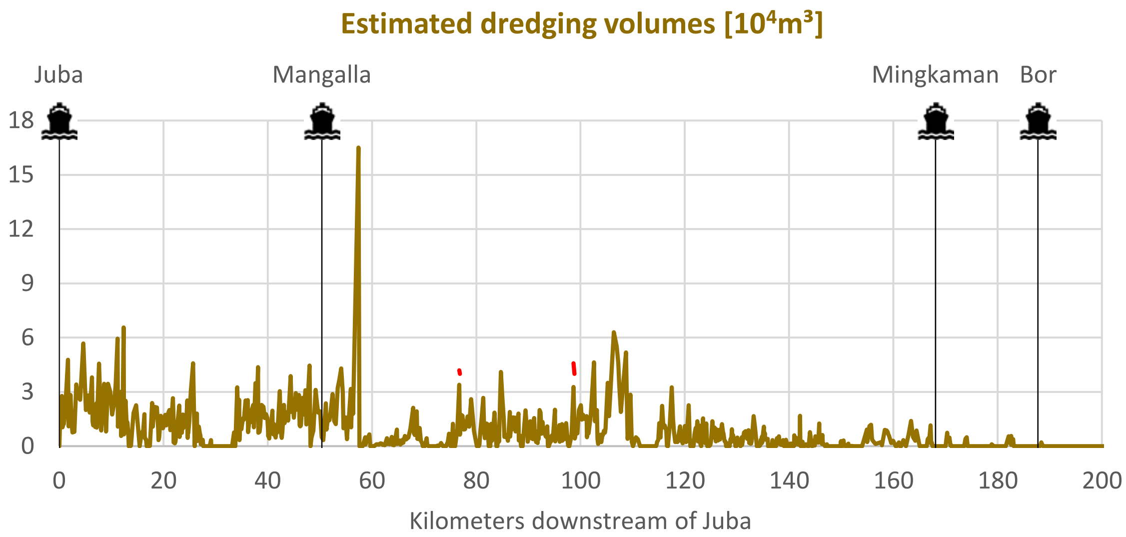
The total amount within each section to be dredged is then the sum of V_{deoth} and V_{width}. The volume can be summed to the total volume required for the different investigated stretches. Especially downstream of Bor, dredging volumes and distribution are uncertain due to the lack of bathymetric data.

For the river stretch from Bentiu to Lake No assumptions had to be made to deal with the lack of survey data. Total digitised channel distance is about 78.2km of which 28.8km is completely overgrown with vegetation while 49.4km shows open water. Based on experience in the Sudd swamps the assumption was made that water depth in the overgrown part during dry season conditions would be zero while in the open water part water depth would be one metre. Respectively the dredging volume was calculated with results being displayed in Table 19 and Figure 47.

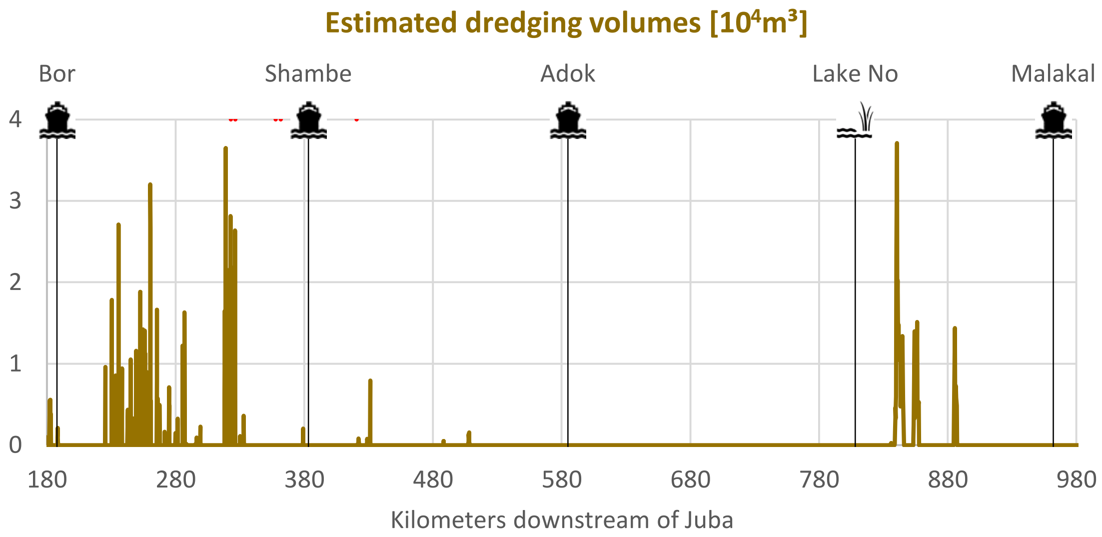
Table 19: Dredging volumes per river stretch

River stretch	Volume due to lack of depth [m^3]	Volume due to lack of width [m^3]	Total volume [m^3]
Juba to Bor	6,898,000	48,000	6,946,000
Bor to Malakal	460,000	913,000	1,373,000
Bentiu to Lake No	6,832,000	n/a	6,832,000
Malakal to Renk	618,000	0	618,000
Total volume [m^3]	**14,808,000**	**961,000**	**15,769,000**

Juba to Bor / Mingkaman



Bor - Malakal



Malakal - Renk

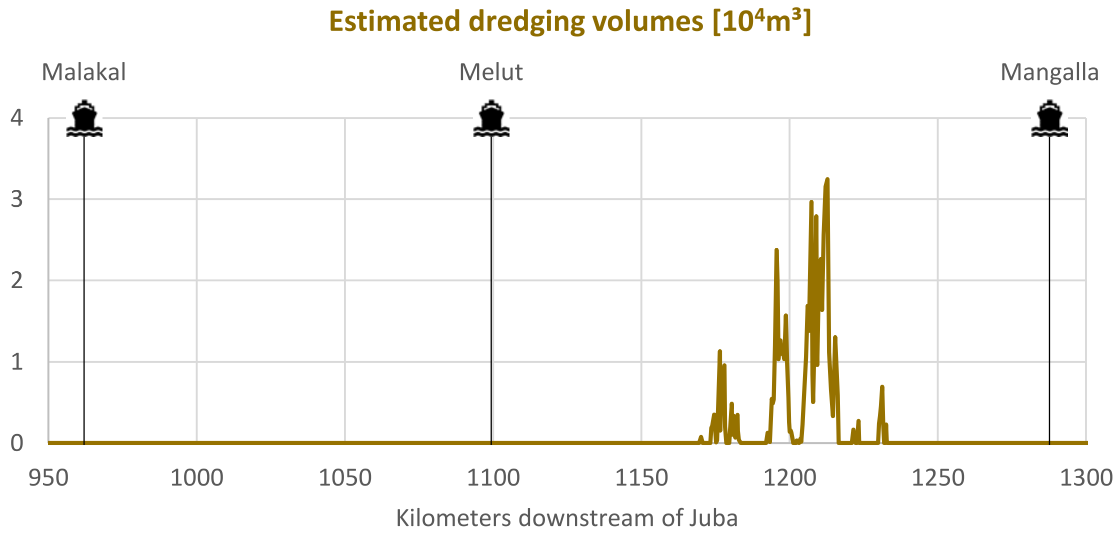


Figure 47: Estimated dredging volumes along selected river stretches.

Dredging and River Training Juba - Bor

Dredging and river training between Juba and Bor is the priority section for dredging works. The section is currently impassable for barges and will require the highest volumes to be dredged as compared with the other sections of the White Nile River. The dredging will benefit from the vicinity of Juba with respective access to workforce and logistics to maintain production especially during the first weeks after commencement of the works. Dredging will include dredging of port areas as described in a later section. Rocks may be removed through blasting.

Dredging and River Training Bor – Renk

The river between Bor and Renk is currently passable by barges though not during all flow events and will respectively need to be dredged to safe depths for conditions covering the most common river water levels. Next to depth dredging this river section contains several bottlenecks where channel width is not entirely sufficient, or bends need to be widened so that respective vegetation clearance and side dredging will be required.

Dredging and River Training Access Bentiu

The Bahr el-Ghazal between Lake No and Bentiu carries significantly less flows than the White Nile River. Based on satellite data, some 29km of the total 79km of river channel are completely overgrown with vegetation that will need to be cleared. Specialised equipment may be required here in order not to block dredger capacity. The dredging will need to be conducted prior to any port rehabilitation or reconstruction activities.

Dredging and River Training Shortcuts to Mingkaman

The River Port at Mingkaman is located at a sidearm of the White Nile River that meanders through the widening floodplain area south of Bor. The port is not accessible for barges as channel width, depth and curvature are not suitable for larger vessels. To connect the port, respective adjustments to the channel systems have to be made that go beyond the deepening and widening of the main channel that is proposed for other sections. Various options are available to connect Mingkaman to the main channel with three options shown in Figure 48. All options are making use of existing smaller channels, deepening and widening them, but do also require dredging new channels through reed fields. Option 1 requires about 4km of dredging through reeds though making use of some water bodies along the way, followed by about 13km dredging of existing small canals. Option 2 requires about 2km of dredging new canals as well as about 8km of improving smaller existing channels. Option 3 entirely follows existing channels, though partly very small ones, requiring a total of about 19km of dredging.

As any of the above options as well as other alternatives will interfere with the current canal system the discharge pattern and respectively the erosion/sedimentation pattern as well as vegetation pattern may change, leading to blockages and/or opening of new channels. The likely effects would need to be specifically studied before implementing interventions to understand the potential impacts and consequences.

Figure 48: Potential dredging options for connecting Mingkaman port to the main White Nile River channel, (Source: Google Earth / Digital Globe).

5.2.2. Port Dredging

Dredging in the port areas is required to allow for a save approach, mooring and departure of vessels from the quays. Dredging depth shall be the same as in the shipping channels. It is suggested to dredge at least a vessels length beyond quay wall length and at least three times vessel length out into the river to allow for sufficient approach and turning areas.

5.2.3. Assumptions and Limitations

Certain assumptions and limitations have been applied when considering dredging operations in South Sudan. For mobilisation, transport constraints and modularity should be considered. The political situation as well as dams and cataracts on the White Nile River, north and south of South Sudan means that dredgers can only be brought into Juba by land from Mombasa. This means they must be modular and fit into 40ft containers and/or capable of transport by truck. Considering the rough working environment, only quality products with excellent after sales support should be selected in order to ensure long-term utilisation. Once the dredger is mobilised, it is assumed that it will be operating continuously, conducting initial- as well as maintenance dredging.

5.2.4. Dredger Type

In selecting respective dredgers, suitable to perform the required dredging operations, the following criteria are considered:

- Manoeuvrability needs.
- Disposal of dredged material.
- Performance requirements (critical in calculating how much time will be required to complete the dredging task).

- The available budget for procurement and operation of the dredger.

For the conditions prevailing along the White Nile River downstream of Juba as well as considering the transport conditions in South Sudan, a modular cutter suction dredger (CSD) is suggested (Figure 49). CSDs are designed to dredge sand, clay, gravel and silt. With a heavy-duty cutter head also, some soft rock cutting is possible. It is anyhow expected that very little rock is to be removed down river from Juba which may be done through blasting. Production rates of CSDs vary with size and conditions but may reach up to 2000m^3/h for typical dredgers.

Figure 49: Picture of a CSD.

The cost for procuring, shipping, commissioning and maintaining a dredger are significant and may be in the range of $10,000,000 per unit considering capital costs, training, spare parts and service. In addition, operation costs (fuel, staffing) need to be considered depending on utilisation time. Considering the significant distances and volumes to be dredged, several dredgers including the necessary auxiliary equipment (floating pipeline, barges, workboats) are required, depending on the time limitations desired for finalising the dredging works.

5.2.5. Dredged Material Disposal (Dredging Operation)

Materials that are being dredged will need to be disposed. Along the White Nile River between Juba and Bor dredged material may be disposed through pipes that spill the material on the adjacent land. Dredged sediments will settle there while the water will flow back into the river. As the area is partly overgrown with forests and partly used by the local population, demarcated areas will need to be agreed and used for disposal, considering that ideally pipe length shall not exceed two kilometres. For the area downstream of Bor the swamp area widens, and the navigation channel is accompanied by wide reed and papyrus belts with no dry land accessible for dredged material disposal. Three options are potentially technically possible but require further investigations. Cutting of side channels into the reed fields to be able to rout floating discharge pipes there, loading of split barges that may haul the dredged material to elsewhere and as a third option the disposal of the dredged materials into the current of the main channel. The three options are discussed in detail below, though the split barge option, considering the involved significant additional cost, is seen as less likely to be implemented.

Disposal Through Floating Pipelines Into Natural Or Artificial Side Channels
Existing side channels may be used, or artificial side channels cut into the reed and papyrus fields in order to place a floating pipeline far into the reeds and dispose the dredged materials there. It is expected that artificially cleared channels may quickly overgrow with vegetation again after the discharge pipe has been removed and that deposited sediment will as well be overgrown soon by the riparian vegetation.

Disposal Through Split Barges
A fleet of split barges may be loaded from a loading pontoon, carrying away dredged material from the dredging site and dumping it in selected areas e.g. in lagoons. High water levels would facilitate this operation as split barges would have more room for manoeuvring. The number of split barges needs to be suitable for the required transport distances in order to ensure uninterrupted production of the dredger. The approach is seen as questionable as the split barges form a significant additional budget, given the narrow channel system of the Sudd a large number of split barges may be needed. Transport of split barges into South Sudan may be very difficult and operations may be restricted during the dry season in areas that have not yet been dredged.

Disposal into the Current of the Main Channel
Dredged material may be dumped into the current of the main channel, with which it is transported downstream. The approach will significantly simplify the disposal procedures though it will also lead to increasing dredging volumes as part of the dredged sediments are expected to settle in the main canal downstream. In addition, sediment load in the channel may increase significantly, potentially leading to impacts on the aquatic habitats. Respectively the conduct of a sediment transport modelling study as well as a specific environmental impact assessment (EIA) will be essential in preparation for this option.

All approaches would need to be thoroughly reviewed and respective specific EIA need to be conducted as the works will inevitably significantly alter the Sudd wetlands despite of their status as a Ramsar site.

Figure 50 below shows a typical setup for a CSD using an anchor-cable system for movements as well as a floating discharge pipe and dredged material handover pontoon.

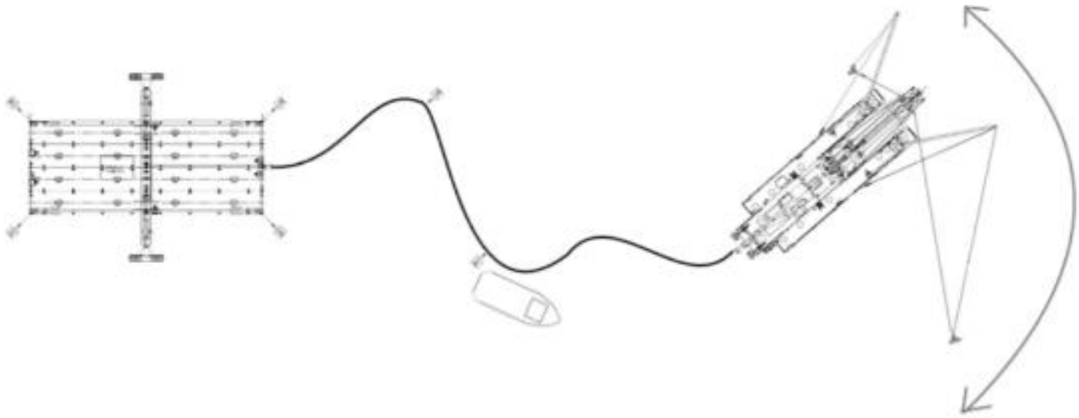


Figure 50: Dredging activity using anchor blocks and winches for the dredgers sideward movements as well as a discharge pipe connected to a handover pontoon used for mooring barges during loading. The floating pipe may also be extended to discharge dredged material directly to suitable places. A working boat is necessary to move anchor blocks and discharge pipes.

To ensure productivity and an adequate lifespan, it is critical that the investment into the dredger and barge fleet is adequately supported by respective service and maintenance packages by qualified suppliers. In addition the staff to be deployed on the dredgers as well as logistic and administrative staff that support the operation will need thorough on-the-job training to be able to safely and efficiently operate the dredgers and auxiliary equipment. In setting up the dredgers the contracted company shall develop and hand over custom-tailored operation manuals that consider the environmental conditions in the deployment area, i.e. specifically describe dealing with the densely vegetated areas for dredging and dredged material disposal operations. All operations shall be thoroughly tested on-site, and method statements drafted and included in the operation manuals.

5.3. Navigation Aid Systems

Navigation aids are important for marking shipping channels, dredged areas and obstacles as well as to identify routes in the various channels of the Sudd system. Considering the highly diverse and also partly dynamic system, a flexible approach is recommended, also considering the technical limitations that operation of a barge fleet in South Sudan is facing.

Channel markers are recommended as a means to identify dredged areas, being anchored strategically at intervals depending on needs. Markers will especially be needed to identify dredging limits at ports, to mark dredged passages through lagoons as well as dredged channels in wide river channels where the centreline is not obvious.

5.3.1. River Beacon Navigation Aides

River beacons refer to all marks or beacons, fixed or floating, specifically intended to assist navigators in determining their safe course or to warn of dangers or obstruction to navigation. There is a wide range of services and equipment to match all the requirements for inland waterways beaconing, in accordance with applicable regulations of each country, such as:

- IALA guidelines and recommendations
- European Code for Inland Waterways (CEVNI)

- Communauté Économique et Monétaire de l'Afrique Centrale (CEMAC) code for Inland navigation in some African countries (Gabon, Cameroon, Central African Republic, Chad, Republic of Congo and Equatorial Guinea)

Navigation Aids Option for White Nile River between Juba to Renk. The option proposed includes specific expertise and services as follow:

1. The first stage of establishing a river beaconing system in the White Nile River is a technical survey by a contracted company to determine the exact locations and types of installations required to provide reliable aid to navigation along the 1,400km stretch of the White Nile River. The survey shall define the type and exact quantities of equipment to be installed/deployed along the river, according to the bathymetric survey and local studies. The equipment must be built in accordance with local site conditions (mooring depths, current, type of river banks, etc.) and logistical constraints. It is recommended to develop a navigation inventory and distribute it to MoT and other relevant agencies. The inventory shall contain a description of the river with kilometric index and location of the navigation aid equipment).
2. Following the technical survey, the company shall design, manufacture and supply the equipment on-site.
3. Sufficient equipment and tools are to be procured to create several technical centres along the river, spaced at selected intervals, that allow quick deployment for setup and maintenance of the navigation aids. It is recommended that the centres are located in the nine ports surveyed in this study. The centres can e.g. be accommodated in 20-foot containers or in a similar sized small space in a building.
4. The contracted company shall train the local staff who will then be used to install and maintain the equipment along the entire length of the river. Work boats with a crane will be required to install and maintain the equipment.
5. It is recommended that a supply reserve of spare parts and equipment for a period of several years of operational maintenance will be established by the contractor.

The proposed solution includes a mix of fixed and floating beaconing equipment. A majority of the equipment will be fixed beaconing which is easier to maintain. Floating beaconing (buoys) shall only be used to mark wrecks, dangers, or narrow channels. The quantities estimated to mark 1,400km include:

- 200 polyethylene buoys
- 700 fixed beacons, to be installed along the river banks
- 200 plastic poles, when buoys cannot be deployed (shallow waters) and when the river banks panels installation is not possible
- 20% of the equipment shall require operational maintenance in a multi-year support package

Fixed Beaconing Solution - River Banks Marking System. A river bank marking system (Figure 51) should be implemented to indicate the kilometric index, create an alignment. River banks panels shall be:

- Modular.
- Easy to transport on small boats.
- Ideal for remote areas.
- Robust and protected against theft/vandalism.
- High resistance of the material, no maintenance.
- Security against vandalism (no salvage value, inviolable bolts).
- Panels shall be coated with retro-reflective vinyl to enhance visibility at night.

Figure 51: Fixed navigation aid beacon.

Fixed Beaconing Solution: Plastic Poles**.** When buoys cannot be deployed (shallow waters) or when the implementation of river banks panels is not possible (access channel far from banks due to vegetation, no accessible supports), the solution is installation of plastic poles with retro-reflective materials (Figure 52). They shall have the following characteristics:

- Poles made of PVC, 5m high, that shall be fitted in a concrete block of 150kg, to be equipped with a lifting ring to facilitate handling and installation on-site.
- The poles shall be equipped with retro-reflective tapes to enhance navigation by night, the deployment of such poles is very easy as the assembly and lifting operations can be performed directly on the service boat.

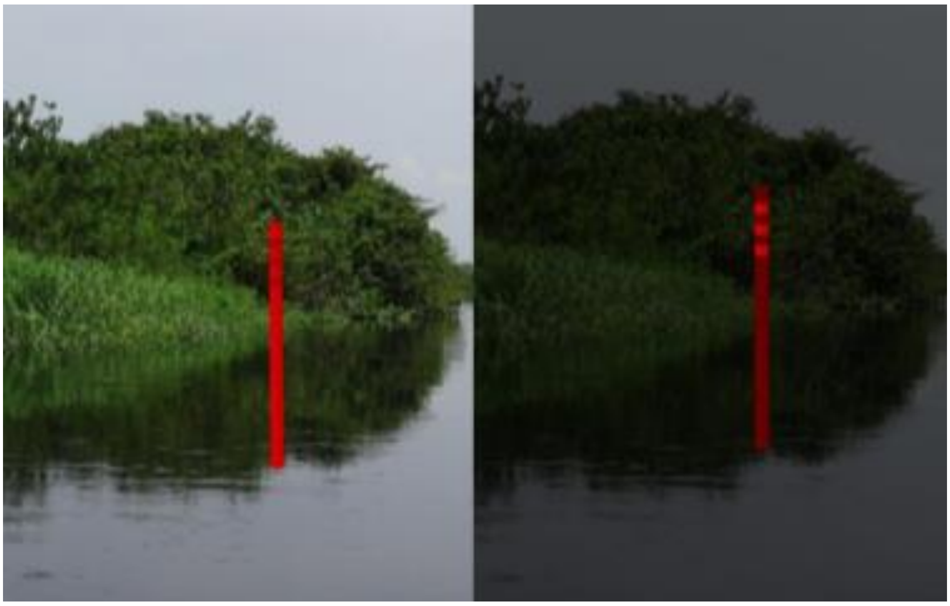


Figure 52: Navigation aid plastic pole.

Floating Beaconing Solution: GSB-600 Spar Buoy. The proposed solution for the floating beacons (Figure 53) has the following characteristics:

- Convertible day mark according to beaconing requirements (specifically suitable for unstable environments with sandbanks).
- 3 mooring eyes and adjustable ballast to ensure high stability of the buoy according to current intensities.
- Submersion and self-righting capabilities, ideal for waters with debris flow or jacinth floating island.
- Technical specifications: Float diameter: 0.60m, float volume: 0.4m^3, focal height: 1.40m, maximum current: 7 knots.

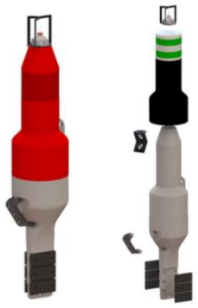


Figure 53: Floating navigation aid buoy.

5.3.2. Installation of the Equipment by Trained Local Staff

It is proposed that the installation of the equipment will be by locally trained staff. This will build capacity and provide a trained maintenance team after the installation. Installation operators will attend classroom instruction and specific on-the-job training session by the contractor engineer before installation. It is estimated that the number of students will be limited, and the period of instruction will be two weeks.

5.3.3. Technical Centres for Aids to Navigation Maintenance and Deployment

It is essential for the safe navigation and long-term viability of the navigation system investment to have technical centres established by the contractor. The establishment of a number of technical centres along the river (approx. each 150km) is recommended. It is suggested that the contractor should supply a respective number of units of 20' shipping containers that can be transformed in workshops. The contractor should also supply all the required and specific tools for the maintenance of the equipment including boats for transport.

5.3.4. Operational Maintenance of the Equipment

To keep the system fully operational, protect the investment, and also provide safe navigation for shipping, it is recommended that the contract include a supply of spare parts to maintain the equipment during a period of several years after final acceptance of the installation works. It is estimated that the quantity of spare parts shall be about 20% of the total quantity to be installed.

5.4. Rehabilitation and Expansion of Existing Ports

5.4.1. Proposed River Port Upgrades

Port Safety

Internationally recognised codes of practice[2] should be followed during detailed design of port rehabilitations or expansions to ensure maximum safety of workers and the surrounding natural environment of the port. Section *12.1.3. Environmental aspects of port operations* of the ILO code of practice for the safety and health in ports lists the following main environmental concerns that may arise from port operations:

1. Emissions to air
2. Releases to water
3. Land contamination
4. Nuisance and other local community issues, e.g. Noise, dust and odours
5. Waste and its management

Precautions that should be considered in detailed port designs include that

1. Every effort should be made to prevent dust or fumes becoming airborne and spreading into the atmosphere and the surrounding neighbourhood.
2. Every effort should be made to avoid spillage of cargo into the water.
3. Any spillage should be cleared up as quickly as possible and safely. It should not be washed into the drains where it might pollute the water or the land.
4. Every effort should be made to reduce noise emissions that might disturb nearby neighbourhoods, especially during work outside normal hours.
5. Port structures as well as port operations should be designed to avoid hazards and risks to port personnel and passengers.

It must be noted that the upgrade and rehabilitation measures proposed in this section were developed with a focus to rapidly achieve operational efficiency under humanitarian emergency conditions while working towards improving port standards in line with the MoT River Port Standards.[70] It is strongly advised that during detailed design of individual port related projects internationally recognised codes of practice will be considered to assure maximum compliance and resulting safety for workers and the surrounding natural environment of the White Nile River ports.

Juba Port

It must be noted that the port is scheduled for rehabilitation under a JICA funded project. Any plans for rehabilitating the port should be compared before deciding on a final scope of rehabilitation measured to be implemented.

A main task identified by the consultant, which is to be aligned with any planned upgrades by JICA, is the extension of the quay wall by 150m to provide berthing facilities for three barges and passenger vessels. This should go in line with a 2,250m^2 cargo handling, loading/offloading platform adjacent to quay wall and the installation of ten bollards. For increasing loading capacity, the supply of a new overhead rail crane with 40t lifting capacity including containers, a fixed jib crane with a lifting capacity of 5t and the procurement of a mobile cane with a capacity of 9t and a 12m long boom was requested by Juba port authorities and is recommended by the

[70] Republic of South Sudan's Ministry of Transport (no date). White Nile River Ports & Navigation Channel Dredging Standards.

consultant. In addition, construction of 10,000m^2 bulk storage area, procurement and construction of a weigh bridge with a weighing capacity of up to 50t, procurement of a 10m long conveyor belt, propelled by electric motor, procurement of a cargo truck with loading gear with a capacity of 20t, procurement of a tractor with trailer (70 HP) for transportation of goods within the port area and procurement of a forklift with 20t capacity will significantly improve the ports cargo handling capacities. For refuelling, provision and installation of a 100,000l. underground fuel tank, including pumping-and fuelling equipment is required.

To facilitate operations, construction of a warehouse 100m x 30m, steel structure with profile iron sheet cladding and roofing and construction of a workshop shed is required. Rehabilitation of 750m port roads and construction of 6,000m^2 parking area is needed as well as the construction of a new ablution block with sewage disposal installation, construction of a new office block, with a total floor area of 200m^2, construction of a passenger waiting shed, with floor area of 100m^2, construction and equipping of a small workshop, construction of a new guard house, the supply of generating sets (2 x 150 kVA), including construction of a generator house (Juba town has a central power distribution system, however not reliable), the repair of gate and fence, the installation of security lights, construction of 350m storm water drains, provision of an oil/water separator and provision of gabion protection to stabilise river banks.

Mangalla Port

The port and its installations are leased out to TRISTAR, a fuel supply company, and is in satisfactory conditions, not requiring repair-or improvements at this point in time.

In the event, the Ministry of Transport terminates the lease with the fuel supply company and the port shall be used to handle other general goods, procurement of lifting equipment may be considered. Due to the closeness to Juba, provision of workshop facilities is deemed not to be required. Specific needs under these conditions include the construction of a passenger waiting shed, improvement of parking area, rehabilitation of access road, supply of cargo truck with lifting boom, 20t, supply of a conveyor belt 10m long, procurement of a forklift and provision of gabion protection to river banks

Mingkaman Port

Generally, the port facility in Mingkaman is in operational condition and appreciated by local people who use it daily. Minor recommendations for rehabilitation include the repair of currently unserviceable equipment i.e. crane, forklift, generating set and the submersible water pump, the extension of the office by two additional rooms to accommodate all officers, improving the access road to the port that requires pothole filling and some re-gravelling., construction of 300m storm water drains and strengthening of port management to avoid misuse of the facilities.

Terekeka Port

Full recommendations for Terekeka Port can only be provided after a thorough on-ground assessment. Nevertheless, the port will need an entire upgrading with all relevant assets, including a 70m quay wall with bollards and gabion river bank protection, paved cargo handling and bulk storage area, construction of port roads, warehouse and office building construction including auxiliary facilities, perimeter fencing, guard house and lighting, the installation of a 100 kVA generator set, water supply, drainage and water/oil separator as well as the procurement of a mobile crane with 20t lifting capacity, a 10m conveyor belt, and a 70 HP tractor with trailer.

Bor Port

Bor is the State Capital of Jonglei State and the hub for provision of commodities and distribution of humanitarian aid goods within the state. The improvement of the port facilities would make the port more attractive to shipping companies hence greatly benefit the population of Jonglei State. In this regard the consultant recommends the construction of a 150m long quay wall with ten bollards to provide berthing facilities for three barges and passenger vessels, the construction of 4,500m^2 loading/offloading area and 10,000m^2 bulk storage area as well as provision and installation of 50,000l underground fuel tank, including pumping-and fuelling equipment. Construction of a warehouse 30m x 100m, from steel structure with profile iron sheet walling and roofing and construction and equipping of a small workshop. Procurement of a mobile crane with a lifting capacity of > 15t, an overhead rail crane with 40t capacity, a conveyor belt, propelled by electric motor, a cargo truck with loading gear with a capacity of 20t, a tractor with trailer for transportation of goods within the port area, a forklift with 20t capacity and a jib fixed crane with 5t lifting capacity. Further works shall include construction of workshop shed for ship maintenance and minor repairs, construction of a new office building with a floor area of 100m^2 consisting of six offices, construction of an ablution block and of a small water supply with composite treatment unit and elevated steel tank. Security shall be enhanced by provision of a perimeter chain-link fence, including entrance gate for the port area and provision of security lights. Provision of diesel propelled generating set (100 kVA), including shed and fuel tank. Improvement of 800m port access road and construction of 600m port roads as well as 4000m^2 parking area and construction of 400m storm water drain. Provision of gabion boxes for river bank protection and provision of an oil/water separator.

Shambe Port

Shambe port features an existing concrete quay wall in need for repair. Recommendations include an increment of the quay wall by 50m and the installation of gabion protection for river banks. Enlargement of cargo handling area by 750m^2 and construction of 3000m^2 bulk storage area and 3000m^2 parking area, construction of a new port office with a floor area of 80m^2 and construction of one additional warehouse with floor area of 500m^2 as well as provision for cold storage, passenger waiting areas and ablution blocks. Provision of oil/water separator and procurement of generating set with a rating of 100 kVA. Recommendations for lifting- and goods handling equipment include the procurement of a fixed jib crane with a lifting capacity of 5t, a forklift with 20t capacity, a conveyor belt, a 20t cargo truck with lifting boom. Additional assets should include security lights, a generating set with a capacity of 100 kVA, and 150m storm water drains.

Adok Port

Full recommendations can only be provided after a thorough on-ground assessment. Nevertheless, the port will need an entire upgrading with all relevant assets, including a 70m quay wall with bollards and gabion river bank protection, paved cargo handling and bulk storage area, construction of port roads, warehouse and office building construction including auxiliary facilities, perimeter fencing, guard house and lighting, the installation of a 100 kVA generator set, water supply, drainage and water/oil separator as well as the procurement of a mobile crane with 20t lifting capacity, a 10m conveyor belt, and a 70 HP tractor with trailer.

Bentiu Port

Bentiu port utilisation will depend on opening up significant lengths of waterway to connect to the main White Nile River shipping route at Lake No, including vegetation clearing and dredging. The estimated distance to Lake No is 80km, all to be dredged. In addition, vegetation will need to be cleared on about 30km. Currently there are hardly any traces of the port visible, the port itself requires complete reconstruction including elevating the port surface area for flood protection and all relevant infrastructure and assets. As the port is practically not existing, a needs assessment is necessary to establish cost-benefit analysis of the necessary waterway works and identifying necessary port facilities. Based on the current assessment, the basic requirements for port operations that have been identified for Bentiu Port assume that a 100 x 100m (1 ha) plot of land adjacent to the river may be utilised for the purpose. For this land, it needs to be ascertained that access to the port area is available throughout the year, including the rainy season. For this purpose, construction of a new access road with cross drainage structures is inevitable. The port will require construction of 90m quay wall with bollards for two barges/vessels and provision of gabions for river bank protection, construction of paved cargo handling area and paved bulk goods area, construction of port roads. Further recommendations include the construction of a steel structure warehouse, construction of an office building, construction of passenger waiting shed, provision of perimeter fence with guard house and security lighting. In addition the supply of a generating set of 100 kVA will be required. For lifting and cargo handling, supply of a mobile crane with 20t lifting capacity, a 10m long conveyor belt, a tractor and trailer with 70HP and the installation of a water /oil separator are recommended. Further, an office container for port administration should be provided, inclusive of water supply, ablution and sewage disposal facilities.

Malakal Town Port

In Malakal Town Port, the extension of berthing facilities, the rehabilitation of offices, warehouses and sanitary installations as well as procurement of basic equipment could revive the port operations for the benefit of the population of Malakal. Recommended measures include the construction of a quay wall to close the gap between the concrete wall and the steel jetty (50m) and an additional 100m length of quay wall connected to the steel jetty to increase berthing space. In addition gabions for river bank protection should be installed. Construction of 200m port roads, rehabilitation of 500m access road, and construction of 2,000m^2 parking area are required. Enlargement of cargo handling area by 4,000m^2 and construction of 2,000m^2 bulk storage area as well as 2,000m^2 parking area are recommended. For lifting and cargo handling, procurement of a mobile cane with a lifting capacity of 2-3t, a fixed jib crane with a lifting capacity of 5t, a forklift with 20t capacity, an overhead rail crane with 40t lifting capacity, a conveyor belt, a 20t cargo truck with lifting boom, a tractor with trailer and a weigh bridge with a weighing capacity of 50t are recommended. Structural requirements include the construction of one additional warehouse with floor area of 1,000m^2, construction and equipping of a small workshop and construction of passenger waiting shed

Further recommendations include provision of security lights, rehabilitation of abandoned buildings, restoration of water supply and sanitary facilities for port users, construction of an ablution block, procurement of a generating set (100 kVA) and refuelling installations, an oil/water separator and construction of 150m storm water drain.

Malakal UN/WFP Port

Malakal UN/WFP port has been developed to cater for the needs of a nearby UN camp. The intervention at this station should be restricted to the basic needs for the humanitarian operations. Recommended measures include the construction of a retaining wall along the outer limits of the current jetty fill with sheet piles, totalling to 170m. The upper limit of the piles should reach 1m above the current level of the jetty. The sheet piles walls shall be capped with a reinforced concrete beam. The void between the level of the jetty and the upper end of the retaining wall shall be backfilled with approved and compacted fill material. Further recommended works include the provision of gabion boxes for river bank protection, construction of 1500m^2 cargo handling area and 1,500m^2 bulk storage area, as well as the construction of 2,000,00m^2 parking area and 300m new port road. Recommended facilities include an office container to be placed at a suitable position for the jetty manager, fencing of the allocated area of the station including provision of a double wing gate, a passenger shed and ablution block, a small water treatment plant and elevated water storage tank. Further, the provision and installation of a generating set (100 KVA) with shed. For improving loading and cargo handling, the procurement of a conveyor belt, a 20t truck with lifting boom, a fixed jib crane with lifting capacity of 5t and a forklift with 20t capacity are recommended. Further, security lights, 100m storm water drain and an oil/water separator are recommended.

Melut Port

Recommendations for Melut port include the construction of 120m quay wall, consisting of sheet piling with concrete capping as well as the provision of gabion boxes for river bank protection, construction of 1500m^2 cargo handling area and 3,000m^2 bulk goods storage area as well as 2,000m^2 parking area. Structural requirements include a passenger waiting shed, rehabilitation of office and warehouse, and construction of an additional warehouse with floor area of 800m^2. Works further required are 400m port road, 1500m access road to port and 400m perimeter fence. Additional assets include a generating set (100 kVA) and security lights, 200m storm water drain, a small water supply and ablution block as well as an oil/water separator. For improving lifting and cargo handling, a conveyor belt and a mobile crane with 20t lifting capacity are recommended.

Note:
During the inspection of the port the consultant requested by county officials to assess a new port side in addition to the existing port, located some 3km downstream. The proposed site nevertheless appeared to be unsuitable for construction of a port due to the following observations:

- Slopes of riverbank too gentle >1:5
- Dense vegetation along the river banks
- Long distance to road network

Renk Port

Recommendations for Melut port include the construction of 120m quay wall, consisting of sheet piling with concrete capping as well as the provision of gabion boxes for river bank protection, construction of 1,500m^2 cargo handling area and 3,000m^2 bulk goods storage area as well as 2,000m^2 parking area. Structural requirements include a passenger waiting shed, rehabilitation of office and warehouse, and construction of an additional warehouse with floor area of 800m^2. Works further required are 400m port road, 1500m access road to port and 400m perimeter fence. Additional assets include a generating set (100 kVA) and security lights, 200m storm water drain, a small water supply and ablution block as well as an oil/water separator. For improving lifting and cargo handling, a conveyor belt and a mobile crane with 20t lifting capacity are recommended.

5.5. Barges and Pushers for Supply of Humanitarian Aid

This section assesses if a need for river transport fleet expansions is required to meet likely short-term demand for river transport by humanitarian actors in South Sudan (Section 4.6.2).

Procurement of additional pushers and barges includes the following advantages:

- Higher reliability compared to old equipment available in country (often 40+ years, low maintenance levels).
- Increased river transport capacity.
- Possible mitigation of high prices currently imposed by private operators, if the equipment is owned by UNMISS and operations leased out.

The main issues of purchasing new barges and pushers in South Sudan are local unavailability and inflated prices for very limited numbers of low quality builds. Internationally, modular systems are available and have the advantage that they are made of building blocks that can be transported by ship to Mombasa and from Mombasa by road to Juba for local assembly.

Two main types of vessels are required for river transport in South Sudan, river barges and pushers to move joined groups of barges up- and downstream on the river. According to the UNMISS Riverine Project Capacity Assessment in South Sudan[16], the '*general configuration of a set/convoy* [in South Sudan] *is one (1) pusher and 4 barges, with a capacity of 350 to 450t each. The barges can be general cargo type, flat top type […] or fuel tanker.*' This matches numbers reported to the consultant on the ground. The average pushing capacity can be assumed to be around 1,200t for one pusher.

Barges

Barges come in various sizes and are intended to transport bulk commodities such as grain, water or fuel, food items, containers and heavy equipment (Figure 54). Considering their flexible use they meet the requirements of the humanitarian community as they allow to transport an array of different types of goods. Barges can also include crew accommodation, offices or fuel water tanks. They can be modified to be self-propelled (Figure 55 and Figure 56). This makes them attractive to many companies in that they are not required to wait for an additional one to three other barges to be filled before they depart. Some need to transport their goods immediately.

Figure 54: River transport is particularly relevant for easy transport of heavy goods and equipment, (© Francois Henepin).

Figure 55: Barges motorised (above) and using a pusher (below).

Figure 56: Pusher 'Nile Princess' docked with multiple barges in front as seen during river survey in December 2017, (© HYDROC).

In the World Food Programme Logistics Capacity Assessment[71] an assessment for loading capacities of three different barge types that are operational on the White Nile River is provided (Table 20). The following assumptions are made in the report: *'Large Flat Barge with heavy machines on deck is assumed at 500t. Cargo Barge with full of goods is assumed at 425t per barge. Flat Barge is assumed at 300t diesel in the tank and 100t goods on deck.'*

Table 20: Estimates of Cargo/Barge Capacities[71]

Type of Barge	Capacity
Cargo Barge	425t
Flat Barge	400t
Large Flat Barge	500t
Average	**442t**

[71] World Food Programme, 2010. Logistics Capacity Assessment Report.

This is in line with values of barge capacities reported to the consultant to range between 400 and 500t. However, it must be noted that at present barges are not fully loaded due to shallow sections in the river and respective draft limitations. Dredging the river would be beneficial to enable barge operators to utilise the full potential of their vessels.

Pushers

These boats are designed for pushing barges. They have a flat bow designed to push multiple barges (Figure 57). The boats can also have crew accommodation depending on size. For the sake of minimising total fuel consumption and hence maximising cost-effectiveness, the pushers have traditionally pushed two to four barges at a time.[72]

The pushers' average pushing capacity was reported to range between 1,200 and 1,400t. As can be seen in Figure 6 and Figure 7 in Section 2, during very high water levels, flow velocities at specific locations may exceed 4m/s. This equates to around nine knots. The graph in Figure 6 and Figure 7 is marked in red, where computed flow velocities exceed a threshold value of 4m/s. However, it should be noted that these computed values present the upper limits for flow velocities on the river's navigation channel. The likelihood of associated navigation constraints is relatively low. Despite this, an assumption was made that a safe threshold value for maximum travel speed of river transport units should be around 8-9 knots. This would allow safe navigation even during higher water levels. Still, during very large flood events, navigation constrains must be anticipated. This should be considered, if new vessels are to be procured.

Figure 57: Small pusher, rehabilitated by TRISTAR as seen during port inspection of Juba port in 2017, (© HYDROC).

[72] Consultations of the consultant with local operators confirm that the setup is modified for different river reaches. From Mangalla / Bor to Adok the barges are pushed in a 2x2 setup with two pairs of barges aligned and one pusher behind. This helps to increase manoeuvrability on this reach, where sharp bends make turning difficult. After Adok, the barges are pushed in a 4x1 setup with one pusher pushing four barges in a row to optimise fuel consumption and increase speed due to reduced drag.

5.5.1. Current Operational Fleet in South Sudan

Vessels Based in Juba, Mangalla and Bor

The UNMISS Riverine Project Capacity Assessment in South Sudan[16] contains an assessment of the 2013 fleet capacity. It is further stated that a very large part of the initial fleet is now stuck in Kosti, Sudan and not accessible for any river transport operations in South Sudan. As per the report, in 2013, around 13 pushers and 40 barges (different loading types) were left in South Sudan, not all based in the Juba area but a larger share also serving the area between Renk and Malakal (Figure 58). The reported 2013 fleet sizes per main operator was compared with reported fleet sizes in 2017 (Table 21).

Table 21: 2013 and 2017 (operational) fleet capacity based in Juba area, 2013 numbers adapted from UNMISS Riverine Project Capacity Assessment in South Sudan report[73]

Name of Company	Pushers (2013)	Pushers (2017)	Barges (2013)	Barges (2017)
Keer Marine Co	2	1	8 (3 fuel, 1 cargo and 3 flat top barges)	8 (3 fuel, 1 cargo and 3 flat top barges)
Nile Barges	3	2[74]	10 (2 flat top, 9 cargo, 1 fuel)	10 (2 flat top, 9 cargo, 1 fuel)
TRISTAR (fuel only)	Not reported	1	Not reported	3 (2 Fuel and 1 JET A1) all flat top.
ESCO	Not reported	1[75]	Not reported	Not reported
South Sudan Transnile Company (B&S Group)[76]	8	7[77]	40	48 barges, 10 fuel & equipment's, 32 cargo and 6 passenger barges
Total	**13**	**12**	**58**	**69**

Vessels Based in Renk

Fleet capacity in Renk has been reported to be around 8,000t.[78] However, only 1,600t have been reported to be operational. Assuming an average barge capacity of 400t, this would be one operational unit of one pusher and four barges to serve the increasing demand for river transport for humanitarian goods between Renk and Malakal[31,79].

[73] It must be noted that while as many independent sources as possible were consulted, the effective operational fleet capacity may vary.

[74] Each reported to have a capacity of pushing up to 1,400t.

[75] Reported to have a pushing capacity of 500t

[76] In the United Nations Joint Logistics Centre's 'River Cargo Transportation Assessment' (2009) it is stated that the *'SRTC (Sudan River Transport Company) and New River Transport Company (NRTC) are new companies that*
were created by the privatisation of the Sudan Government owned River Transport Company (RTC). […] The new companies also created an entity in Southern Sudan, the Southern Sudan Transnile Company (SSTC), which is located in Juba.'.

[77] Pushing capacity of 1,400t per pusher, information retrieved from correspondence with SSTC's Logistics Manager and from web: http://bsgcompanies.com/public_servicesdetails_view_2.html

[78] Which would match with the assessment on the satellite image, counting about 20 barges and assuming a capacity of 400t per barge.

Figure 58: Port of Renk as seen on satellite image in 29.03.2017. It can be seen that around 20 barges are moored at the port, (Source: Google Earth / Digital Globe).

Vessels Based in Kosti and North Sudan

It was reported that a large fraction of the former RTC's fleet remains in Kosti, Sudan. This can also be observed on satellite images (Figure 59). With the current plans of resuming cross-border river transport[79], this fleet could become available to be used for river transport operations in South Sudan. This would further reduce the need to procure additional vehicles as the available fleet that could be utilised for supply of humanitarian aid by using the northern corridor could be significantly upscaled. It remains to be determined, if the border will be reopened and if this proves to be a reliable way of transporting humanitarian aid into South Sudan.

Figure 59: Port of Kosti and nearby railway station, (Source: Google Earth / DigitalGlobe).

[79] Radio Dabanga, 2018. *River-based transport to resume between White Nile state and South Sudan.* Retrieved from: https://www.dabangasudan.org/en/all-news/article/river-based-transport-to-resume-between-white-nile-state-and-south-sudan

5.5.2. Required Capacity and Proposal for Purchasing New Barges and Pushers

Assuming these assessments are broadly correct, there appears to be adequate capacity to meet humanitarian demands. The consultant makes a simplifying assumption that 40,000t are to be supplied from Juba to Malakal, of which small tonnages, say 5,000t in all, are forwarded to other locations fairly local to Malakal (e.g. the Sobat and Old Fangak areas, as assumed in Table 6 under Section 4). One pusher with four barges can undertake nine return trips per year. Assuming each carries 1,500t and there is no backload, total tonnage delivered is 13,500. Thus to deliver 40,000t annually requires 3 pushers and 12 barges. To deliver 2,500t as a subsidiary operation over a haul distance of 100km would require one pusher making between two and four round trips per year, depending on the frequency required. The same pusher and barge set could also manage a second subsidiary operation. The total required operational fleet would amount to four pushers and 14 barges – well within existing capacity. It is hence not recommended to procure any additional barges or pushers.

6. Environmental Aspects

6.1. Introduction

The project's environmental impacts on each of the river stretches can be split into two timeframes:

- Direct impacts of project activities, such as dredging, upgrading of inland ports and widening of river sections, this will be discussed in Section 6.2.
- Longer-term impacts of opening navigation routes into a global priority wetland, as recognised by the Ramsar status of the Sudd wetlands, which will be discussed in detail in Section 6.4.14.

The Sudd is a pristine wetland area and Ramsar site that has so far been relatively undisturbed by human activities. The designation of the Sudd wetlands, along with its source, the White Nile River, as a Ramsar wetland in 2006 made its protection a prime task of international importance.

Figure 60 outlines the protected areas in South Sudan as per the World Database on Protected Areas. This international status *obligates* the Government of South Sudan to protect and manage the Sudd effectively.[80] The Ramsar Convention is an international treaty that prioritises wetlands of global importance and provides a framework for national action and international cooperation for the conservation and wise use of the wetlands.[81] Though the convention itself does not specify what 'wise use' complies, it recommends that any future use of the wetland will be addressed at the national level:

- *'At institutional level, establishing mechanisms and procedures for incorporating an integrated multidisciplinary approach into planning and executing projects concerning wetlands and their support systems;*

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[80] Ramsar Convention Secretariat, 2010. Laws and institutions: Reviewing laws and institutions to promote the conservation and wise use of wetlands. Ramsar handbooks for the wise use of wetlands, 4th edition, vol. 3.

[81] World Bank, 2013. The Rapid Water Sector Needs Assessment and a Way Forward.

- *At legislative and policy level, reviewing existing legislation and policies which affect wetland conservation and using development funds for projects for conservation and sustainable use of wetland resources;*
- *At site-specific level, integrating environmental impact assessment into planning of projects which might affect the wetland, regulating utilisation of natural wetland products to avoid overexploitation, involving local people in planning and restoring wetlands whose benefits and values have been degraded.'*[81]

At the moment the institutional setup for conservation in South Sudan is still developing, as Fernando and Garvey observed:

'Lack of appropriate enabling regulatory and policy framework has constrained effective environmental protection, natural resource management, and social safety in South Sudan. In moving forward South Sudan needs to develop transparent and open environmental governance systems and mechanisms that permit and facilitate the active participation of all stakeholders. A basic problem in South Sudan is the lack of accurate and reliable information on environmental and social safeguards and how well or badly the sectors are performing in terms of implementation, monitoring, and auditing of environmental and social protection. Environmental and social impact assessment work is also constrained because of the lack of institutional networks, collaboration, and partnerships among different stakeholder groups.'[80]

It is global best practice that for cases where a Ramsar site could be seriously affected by anthropogenic interventions, dedicated social and EIAs are being carried out. Within the scope of this feasibility study a respectively broad environmental assessment has been carried out that has screened the proposed activities for potential environmental conflicts and highlights potential impacts. For the majority of the proposed interventions it has been found that impacts may be expected. It is thus essential that detailed social and environmental assessments will be carried out as part of detailed project design for those option catalogue interventions presented in this report (Section 5) that eventually get picked up by the government and/or international organisations.

Considering the above, it is recommended that international donors only fund navigation projects in South Sudan if the results of a foregoing detailed EIA show that the negative impacts are outweighed by the social benefits, especially for local communities and people most affected by the negative environmental impacts.

The manual on Good Practices in Sustainable Waterway Planning[82] describes 'wise use' as follows:

'The wise use of wetlands is defined as 'the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development'. Wise use therefore has at its heart the conservation and sustainable use of wetlands and their resources, for the benefit of humankind.'

[82] PLATINA, 2010. Manual on Good Practices in Sustainable Waterway Planning, European Commission.

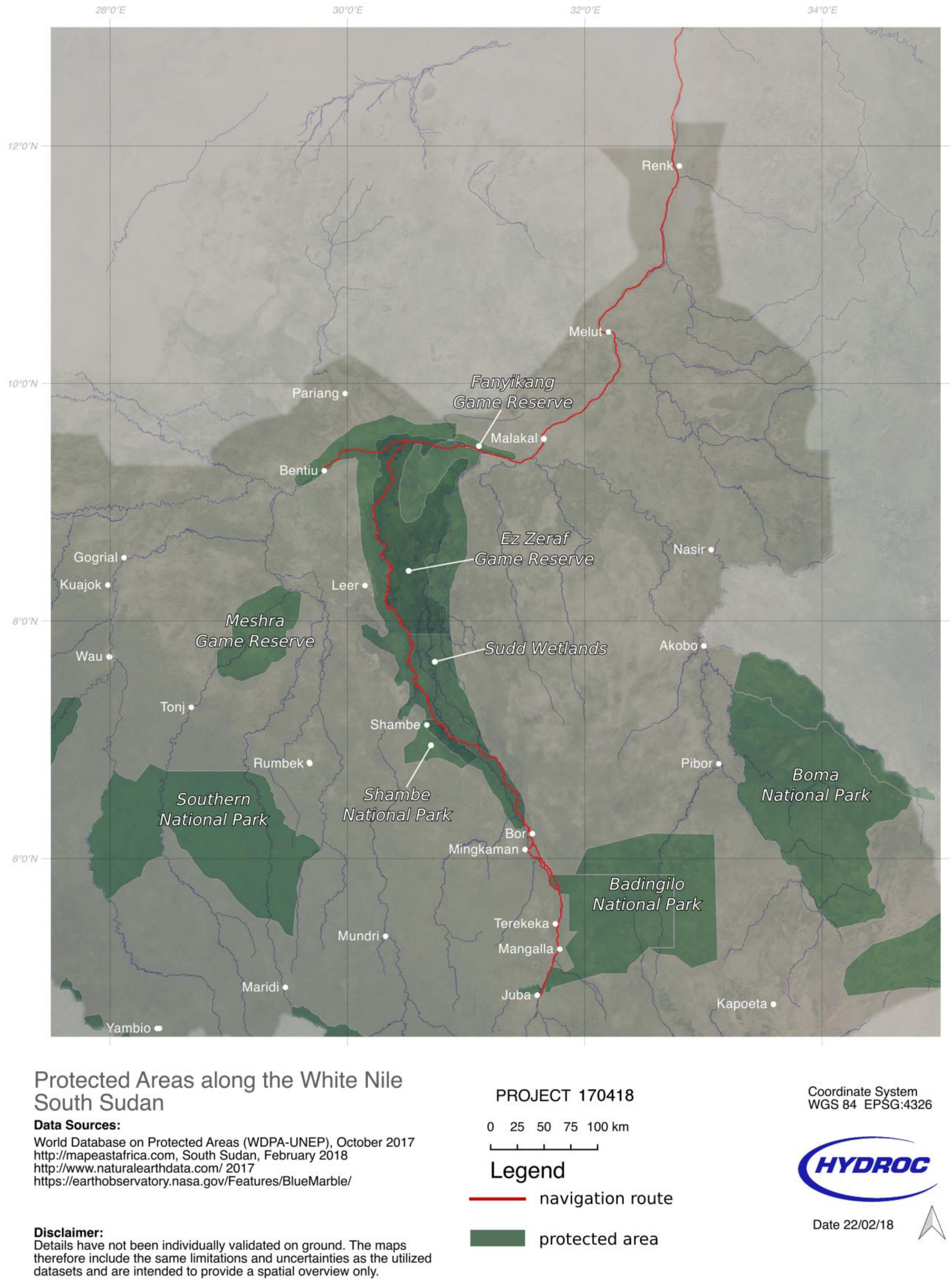

Figure 60: Protected areas along the White Nile River in South Sudan.

The project perception on this issue is that a revitalised navigation sector through the Sudd wetlands does constitute a 'wise use'. Human life in the Sudd wetlands will be better able to sustain the wetlands if navigational demands are met for the purpose of humanitarian and basic human development. As Fernando and Garwey observe: '*without improved connectivity and reduced transport costs, it would be difficult for the government to realise rural transformation'.* Which implies that in the end the wetlands would be better off in terms of sustainability if the current human relief and immediate human development requirements are being met.

1. Currently, some navigation is taking place, which shows that there is a demand, though the current navigation is limited due to the closed border and challenging security situation along the White Nile River.
2. On the short-term, an improved navigation sector would facilitate to support humanitarian demands for refugees and refugee camps such as the UNMISS PoC sites.
3. On the longer-term, an improved navigation sector will be able to support broader human development requirements.
4. In a future where the security situation has improved and stabilised, it is likely that an improved navigation sector will cater to commercial parties (e.g. the oil sector), national defence, or even ecotourism into the Sudd.
5. In the past, navigation was taking place, which seemingly left the Sudd without any lasting damage.

Yet, given the specific emergency demand to establish a strengthened river transport system in short time, there is a chance that projects are being implemented, which could leave lasting damage to the Sudd ecosystem:

- For instance, there is a chance that due to the emergency situation, a rushed decision is made to dredge specific river sections without first obtaining the detailed information required for an environmentally sustainable dredging plan. However, it must be emphasised that the development of such a dredging plan is not only required to assure environmentally sustainable programme implementation but furthermore also a crucial requirement for efficient dredging operations.
- Further, the project may be accused of taking advantage of the current lack of environmental enforcement, as an entry point to set up a navigation system that could lead to a potential destruction of the wetlands.

Both issues refer to a situation where the absence of adequate environmental controls leads to a situation where *either* an environmentally-aware project or its contractor drive the duration and costs of the activities '*in an overly cautious and irresponsibly manner*'[83] to limit their impacts, *or* in absence of any environmental considerations, the project activities could lead to lasting environmental degradation. Based on these considerations, the aim of an EA is to find a proper balance between (a) the improved navigation sector to support both humanitarian and human development and (b) environmental controls that secure sustainability of the White Nile River and the Sudd ecosystems.

In this context, it is important to state that any degradation of the Sudd would likely lead to increased desertification of South Sudan. The navigation project has therefore to be considered in perspective of future trends (e.g. climate change) and planned developments (on the river sections and in the upstream river, e.g. hydropower) to ensure that the combined activities do

[83] Bray N (ed.), 2010. Environmental Aspects of Dredging.

not trigger an ecological tipping point. As the main objective is to improve navigability of the river, the associated water level demands are however largely in line with the sustainability of the Sudd wetland's annual floods.[84]

Without proper environmental controls (for example on the allowed level of canalisation, sediment control, or dangerous goods risk management), there is a chance of the Sudd ecosystem functions changing, or retreating, which could possibly trigger an ecological disaster. In similar fashion, the disappearance or degradation of the Sudd would imply consequences which are likely to affect the entire sub-continent of the Eastern Sahel. This could lead to a situation that can e.g. be compared to the disappearance of the Mesopotamian Marshes in Iraq. The degradation of those marshes led to an international backlash[85] that is taking effect by large projects with the purpose to restore those ecosystems. Among other issues, these projects work on reverting the isolated national policies and impacts that led to the devastation of these ecosystems. A similar threat had previously existed when construction works for the Jonglei Canal started.[86]

6.2. Dredging and River Training

6.2.1. Environmental Performance of a Cutting Suction Dredger

Bray[83] evaluates the environmental effects of the CSD as follows:

'Cutter Suction Dredger

The Cutter Suction Dredger (CSD) dislodges the material with a rotating cutter equipped with cutting teeth. The loosened material is sucked into the suction mouth located in the cutterhead by means of a centrifugal pump installed on the pontoon or ladder of the dredger. Further transport of the material to the relocation site is achieved by hydraulic transport through a discharge pipeline (partly floating, partly land based). Occasionally the material can be pumped into transport barges for further transport […]

The CSD is used mainly for capital dredging in harder soils, which have to be removed in thick layers. The transport distance to the relocation or reclamation site should preferably be limited (max. 5 to 10km) to allow for an economical pipeline transport. In the case of environmentally sensitive projects, the dredging process must be controlled very carefully. The dislodging and hydraulic transport process must be carefully optimised such that dilution and spillage are minimized. To achieve this, the optimum setting should be found by carefully varying cutting face height, step length, cutter rotation speed, swing speed, pump engine power and pipeline resistance. The CSD is usually rated according to either the diameter of the discharge pipe, which may range from 150 millimetres to 1000 millimetres, or by the power driving the cutterhead, which may range from 15 kilowatts to 6000 kilowatts. The total installed power can be as much as 35,000 kilowatts (kW) or more. Regarding the environmental effects of the CSD, the following can be mentioned:

- ***Safety of the crew:*** *As with the SD, the transport process occurs within a completely closed circuit. The crew has no direct contact with the material. Consequently, their*

[84] As opposed to a dam, which could have significant adverse impact on downstream water availability for ecosystems.

[85] National Geographic, 2015. *Iraq's Famed Marshes Are Disappearing – Again.* Retrieved from: https://news.nationalgeographic.com/2015/07/150709-iraq-marsh-arabs-middle-east-water-environment-world/

[86] United Nations Environment Programme (UNEP), 2017. The Economic, Cultural and Ecosystem Values of the Sudd Wetland in South Sudan: An Evolutionary Approach to Environment and Development.

safety in relation to the dredging process, is guaranteed to a large extent, except when a blockage in the cutter or pump has to be removed.

- ***Accuracy of the excavated profile:*** *Good accuracy can be obtained because the movement of the dredging head is controlled from a fixed point (the working spud). Accuracies down to 10 cm are feasible, although at full productivity the accuracy level is approximately 25 cm.*
- ***Increase of suspended sediments:*** *Owing to the rotating cutter there is a potential risk of creating additional suspended sediments at the dredging site. The swing speed of the ladder and the rotating speed of the cutter are significant variables in this respect. For environmentally sensitive projects, careful selection of these values is important in order to reduce these effects. During vertical and horizontal transport, increases in suspended sediments do not occur because the pipeline is closed. If the dredged material is fine-grained the suspended sediment will remain in suspension for an extended period, which will increase the turbidity near the dredging site for a limited period.*
- ***Mixing of soil layers:*** *For optimal use of the CSD the complete height of the cutter should be utilised for cutting purposes. This means that the minimum layer thickness (1 to 3m depending on the size of the cutterhead) is often greater than the layer thickness which needs to be removed, especially in the case of selective dredging.*
- ***Creation of loose spill layers:*** *Most CSDs do not have an optimal combination of cutting capacity and suction capacity for all types of soil. In general the cutting capacity is over-dimensioned for softer soils; typically, therefore, a spill layer (25 to 45% of the cutting face, typically ranging between 0.25m and 1m) remains on the seabed after dredging if no special precautions are taken. An additional pass at the same dredging depth can remove most of this spill layer. The type of cutterhead may make a significant difference in the amount of spill left.*
- ***Dilution:*** *Owing to the hydraulic character of the transport, water is added to the soil for transportation purposes. Depending upon the soil type and the attainable layer thickness, the amount of added water varies significantly. It should be noted that dilution can be reduced by an under-dimensioned cutting power compared to the pumping power, but this will increase the spill layer effect. An optimum has to be searched for each project.*
- ***Noise generation:*** *Generally the CSD has a powerful engine, which generates a high level of noise. Given that the CSD is a stationary vessel, which often works in populated areas, the dredger can be a continuous source of significant noise levels, reaching 100 to 115 dB in the immediate vicinity of the dredger. This noise level diminishes to acceptable levels (50–70 dB) a few hundred metres from the dredging site. Precautions, such as low-noise engines, noise-tempering covers and procedures to keep the engine room closed under any circumstance, are possible but are not implemented on a routine basis. Underwater noise caused by the cutting action and the presence of underwater engines on many of the larger cutter suction dredgers will be higher compared to the SD.*
- ***Output rate:*** *CSD output rates vary widely from 50 to 7000m^3/hr depending upon the size of the CSD and the soil characteristics. The challenge is to select the best size for a particular project. For a given soil type the cost per cubic metre of the dredging operation with a CSD generally decreases with an increase in the size of the dredger.*

The most critical issue of the CSD in this respect is the creation of a spill layer. This is because the suction mouth is located inside the cutter approx. 0.5 to 1m above the actual cutting level. As such it is impossible to avoid the creation of a spill layer unless one accepts an important impact on the output of the dredger. This spill layer is easily erodible and will be a long-lasting source for an increased suspended sediment content or turbidity.'

In general comparison with six other dredgers[87], the CSD scores:

- *High* on: safety, accuracy and noise
- *Medium-high* on: turbidity and mixing
- *Medium* on: spill and dilution
- *Low* on: none of the characteristics

Of the six dredger types, the CSD is the only dredger that does not score low on any of the aspects, though it needs to be pointed out that the performance of the dredgers is very case-specific.

As Bray points out, the main concern of the CSD is the creation of a spill layer that remains on the *seabed* after the dredging. The layers material would be swirled up every time a ship passes through and settle again thereafter. This is unless special precautions are taken (such as second level dredging of the spill layer) and the issue also depends on the type of cutterhead used for different soiltypes. In the ocean, the existence of this spill layers could be important, but in a riverine setting it is likely that this sediment layer will be transported downstream. Still in the White Nile River - Sudd ecosystem this implies that this layer could be a serious impact during the flood season (when sediment plumes can travel widely into the wetlands), but it will be less of a concern in the season when the water returns to the river channel.
It is important to make a distinction here between natural sediment materials that settle in the wetlands annually and provide fertile soils, and the dredged material, which might be of another physical and chemical composition. The dredged material might enhance soil fertility in the wetlands but might as well cause unnatural levels of turbidity that would cause the loss of habitat and aquatic life (Table 22). Therefore a detailed analysis of to be dredged material is important.

It is also specifically mentioned that in environmentally sensitive projects, the dredging process must be controlled very carefully, and an optimum setting must be achieved by continuously adjusting the dredging process to minimise adverse environmental impacts. Without this, the activities would lead to issues of turbidity and sedimentation. Before implementing any dredging activities on the ground, it would be of crucial importance to understand beforehand what the different variables are to achieve this dredging optimum. As mentioned, an environmentally sustainable dredging plan is recommended to be developed. This may include the use of different types of cutterheads, or different sizes of discharge pipes to achieve the most sustainable dredging operation possible.

Bray[83] introduces different innovative dredging equipment, which is innovative in terms of improved environmental considerations and reduced impact. These new types of dredgers and dredging methods are better equipped to tackle negative environmental impacts, such as decreased turbidity. Yet they are much more sophisticated, often relying on computerised systems, and are therefore are less robust and more difficult to operate. This makes them less suitable in the South Sudanese context. Due to the remoteness of the dredging operations and the distance and time required to mobilise professional backup in any case of malfunctioning, it is recommended to employ robust and less failure prone equipment. This makes the preceding development of an environmentally sustainable dredging plan even more important.

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[87] The seven dredgers that are compared: suction-, cutter suction-, trailing suction hopper-, bucket ladder-, backhoe-, grab- and hydrodynamic dredgers.

6.2.2. Environmental Impacts of River Dredging

Along the White Nile River and in the main ports, the material to be dredged is *fine silt*, as well as *sandy black cotton soil*. Though this material is not suitable as building or construction material due to its shrinking and swelling properties, it is highly fertile. Due to the low level of population densities and industrial development along the White Nile River, the dredged material would on most locations classify as clean sediment. Around population centres, especially the ports, it is likely that the sediments are more polluted, due to the activities at the ports, and sometimes, the presence of shipwrecks in front of the ports (Juba, Bor; as confirmed from photo surveys). It is therefore recommended to perform foregoing physical, chemical and biological sediment analysis on the locations to be dredged. The outcomes of such an analysis will determine the usability of the dredged materials and identify risks if polluted sediments are to be dredged, which can be problematic in finding a solution to stabilise the placement of the dredged material. Stabilisation here refers to finding a sustainable placement for the material that makes sure that under no condition (e.g. seasonal floods) the contaminated material pollutes groundwater resources or returns into the streams.

The book 'Environmental aspects of dredging' presents a table that provides an environmental checklist for capital river dredging[88], which proves to be useful in the context of this assessment (Table 22).

The timing of the dredging and material disposition must be considered in detail. During the flood season, most sediment comes down the river as increased rainfall in the upstream catchments leads to erosion. Also, flow velocities are higher, keeping sediment in suspension. The advantage of dredging during this time is that the dredger can move easier (higher water levels), split barges can also get closer to the riverbank to dump dredged materials. A disadvantage would be that moving against the currents takes more energy and that floating vegetation can cause problems during dredging.

It will need to be decided where the dredged material from the river stretches will be disposed to make best use of it. In general, it must be assumed that the maximum distance that dredged material can be transported from the location is about 5-10 kilometres, unless a more sophisticated dredging disposal approach is employed, using a system of barges and pushers that would be able to transport the material over longer distances. This would be a challenging setup for the White Nile River as every dredger would need to be backed up by a 'train of barges' in order to retain dredging-capacity. Given the remoteness of some of the dredging activities, operating on this high level of logistics will be challenging and expensive.

[88] Capital river dredging refers to the kind of dredging that involves the creation of new or improved facilities, such as navigation channels.

Table 22: Environmental checklist for river dredging[83]

Parameter	Possible effects after dredging	Assessments to be made
Water levels	Increased cross-section → increased flow capacity	Flooding risk downstream Reduced water level upstream
Water surface slope and current conditions	Increased cross-section → decrease of current velocity in dredged area	Assess future current pattern and possible effects on navigation, river banks and sediment transport (erosion and sedimentation)
Sediment transport	Changes in current velocities → changes in transport capacity and river bank stability	Assess future sedimentation and erosion pattern Assess river bank stability
Sediment spill	Increased downstream turbidity during and after dredging → shading and burial of flora and fauna → loss of habitat	Assess sediment spill and dispersion including background turbidity. Check for vulnerability of local environment. Check for content of pollutants
Removal of existing riverbed	Temporary or permanent loss of habitat → increased erosion → increased turbidity	Check significance of habitat to be removed Assess possible recolonisation of species, rate, and extent
Changes in current and river morphology contamination	Temporary or permanent loss of habitat → reduction of flora and fauna	Check possible changes in riverbed morphology. Assess mitigation actions.

Potential options to dispose dredged materials include:

- In-stream, and carried downstream, though this will create sedimentation problems downstream, including in navigation channels.
- On the river banks during the dry season, there is a high risk that the material will be washed back into the river and moved downstream into the channels during and after the wet season.
- In the natural lagoons along the White Nile River, which would function as stabilised sedimentation ponds.
- To create stabilised islands (during flood season) that would provide ecological infrastructure that enhances overall wetland biodiversity.[89]

All these options will have different environmental impacts and different costs associated with them. Yet selecting one of these options would be essential for determining the full environmental impacts of the project. Figure 61 presents a detailed flowchart that describes how the selection of sediment disposal options is an interactive and iterative process including

[89] A similar project is currently undertaken in the Netherlands, where artificial islands are created in the Ijsselmeer wetlands: https://www.natuurmonumenten.nl/projecten/marker-wadden/english-version.

various feedbacks. In the South Sudan context, where dredging is taking place in and around different inland ports, as well as along a 1,300-kilometre-long stretch of the White Nile River, it is likely that optimum disposal options will differ between different geographic river sections. It is therefore recommended to further research the different disposal options, analysing cost, hydraulics, and environmental impacts, before a final and locally specified option for sediment disposal is selected.

At this stage, two types of disposal are considered:

- The preferred option is to dispose dredged sediment by pipelines onto preselected riverbanks, as this would be much cheaper than using split barges.
- Another option would be to operate using split barges and preselect disposal locations such as lagoons.

For environmental concerns, the selection of the placement sites is a critical aspect of the project. First, for both options the dredged material should not cover or threaten critical habitats. Second, it should be placed on a site where the material is stabilised, so that it will not create future sedimentation problems downstream.

For the dredged materials that are placed on preselected riverbanks, there are different considerations on the characteristics of the materials. It should be placed on such locations where it does not block the seasonal inundation patterns. It needs to be considered if the material makes fertile soil, and whether there could be agricultural uses planned for the placement sites. If that would be the case, it should be considered what the environmental impacts would be of these new agricultural uses.

For the option that considers placement of dredged material in the lagoons along the White Nile River, it would important to also assess the ecological functions which are provided by the lagoons, and how these will be affected. It must be assessed to which extent the selected lagoons perform an essential buffer during the dry season flows and if they are critical habitats to migratory birds or provide an ecosystem service for local fisheries. It should also be monitored to which extent the disposed material will be stabilised inside the lagoons, to prevent that they become sources of non-natural sediment transport.

In *Dredging for Development*[90], Bray and Cohen specifically stress:
'*It is always important to have a pre-project assessment of the characteristics of the materials to be dredged and the likely placement sites. Such characterisations permit:*

- *The definition of placement options;*
- *Quantities of materials to be suitably placed in each of the options;*
- *The dredging equipment to be used, not only considering the placement requirements, but also considering the transportation to the placement options and minimising sediment re-suspension and loss during dredging;*
- *Monitoring programmes at both dredging and placement sites;*
- *Mitigation measures that may be required at the dredging or placement sites.*

Effective environmental monitoring of the dredging and placement sites is likely to be a requirement either under permit or consistency with international conventions. Furthermore, post-construction monitoring of placement sites, both open water and upland, are essential to

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[90] International Association of Ports and Harbors, 2010. Dredging for Development, International Association of Dredging Companies, International Association of Ports and Harbors.

determining if the mitigation measures are adequate to prevent serious environmental harm. This is particularly true where contaminated dredged materials are involved. Such monitoring is also useful in establishing a database for future work in the area where either more or less stringent controls may be appropriate. It should be noted … that monitoring periods may need to be prolonged to enable adequate data sets to be obtained.'[83]

Also, in terms of international obligations, the Government of South Sudan's participation in the Nile Basin Initiative (NBI), and any (future) roles in basin wide treaties, it is of importance to assure downstream nations that the dredged sediments will not be simply dumped into the White Nile River, to let it be transported downstream. This would directly impact downstream water uses such as navigation, water supply systems, pumping systems, and reservoir storage. Of importance here is the NBI's precautionary principle, as stated in its Environmental and Social Policy:

'The precautionary principle puts forward the necessity to take preventive measures regarding uncertain future developments to avoid possible harm to the public or the environment. This principle requires member countries not to carry out activities that risk causing possible harm, even in the face of lacking full scientific certainty regarding the nature and extent of the risk.'[91]

[91] Nile Basin Initiative, 2013. Environmental and Social Policy.

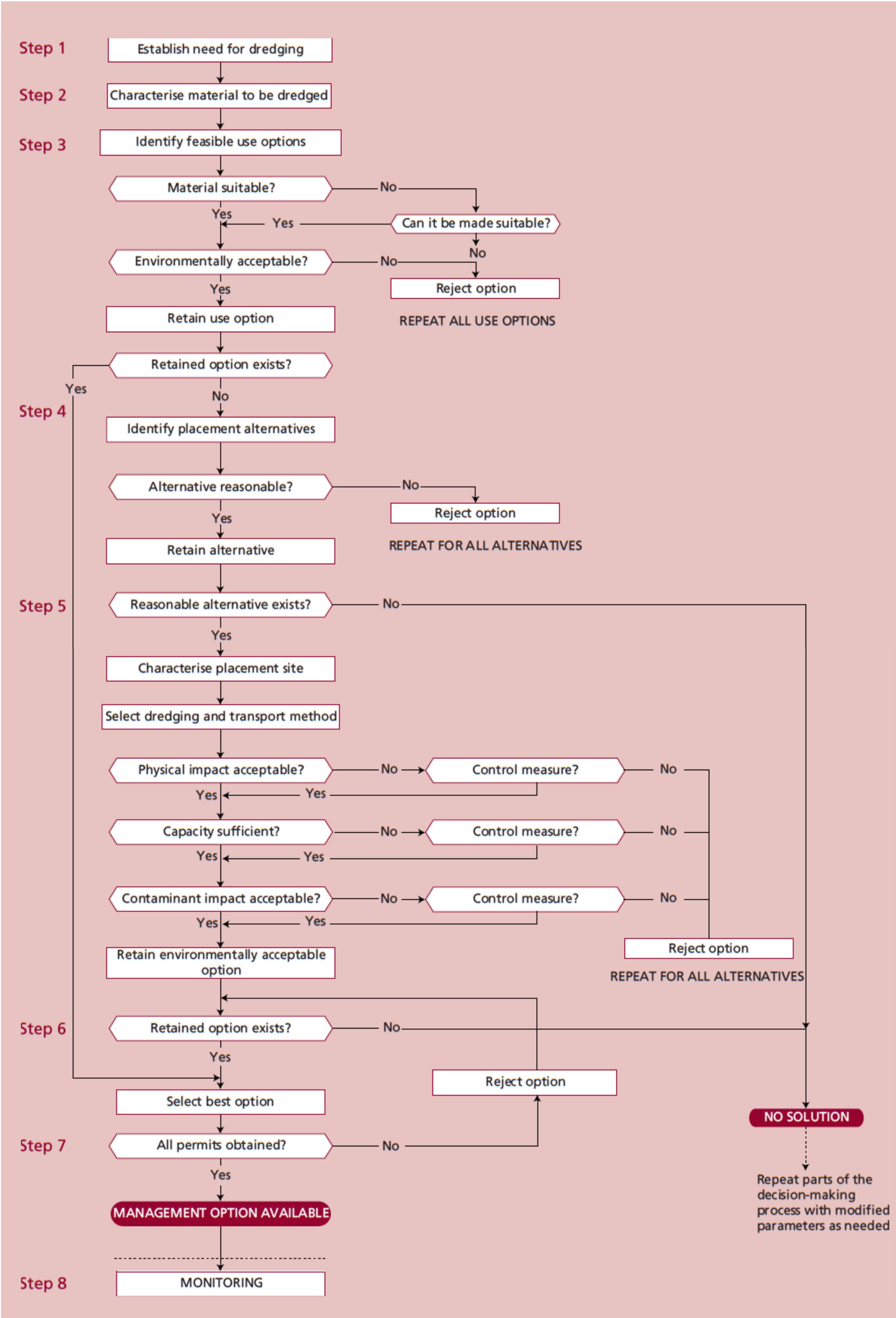

Figure 61: Flow chart for selecting the best sediment disposal options[83].

Canalisation

Canalisation, or cutting through meanders, has the advantage that shipping routes become shorter, resulting in less maintenance requirements, and reducing the overall travel time of flows in a river, which would result in a drop of water levels (Figure 62). These slowed travel times are behind the seasonal inundation of the Sudd wetlands, which implies that systematic canalisation will lead to a reduction in the extent of the Sudd. This would also leave more water available to downstream water uses, the same reason why the Jonglei bypass canal was conceived.

The project proposes, as much as possible, to make use of the existing river channels to do minimal damage to the ecological functions of the White Nile River in relation the Sudd annual flooding	Though it might make sense for purposes of navigation routing and channel maintenance (shorter river channels) to cut through meanders, for ecological purposes this would be a no-go. Any systematic change to shorten the White Nile River would impact the Sudd's annual flood cycle and trigger a possible collapse of the ecosystem.

Figure 62: Explanation on canalisation of meanders on the White Nile River, (Source: Google Earth / Digital Globe).

There are powerful water use demands in the downstream countries that would prefer the full canalisation of the White Nile River, as it would improve flow velocities and allow more water to pass through the Sudd wetlands, water which would otherwise considered 'lost' through evapotranspiration. In environmental terms, this evapotranspiration is what feeds the seasonality of the Sudd wetlands and its grazing lands, and without it the wetlands and seasonal grazing lands would disappear.

Improved navigation and the canalisation of the White Nile River are also considered to be part of a larger effort to connect North-Eastern Africa by the construction of a shipping lane connecting South Sudan's upstream neighbours with its downstream neighbours:

'A 2,500-mile navigational shipping line connecting Lake Victoria and the Mediterranean Sea via the Nile River should be up and flowing in 2024, 11 years after it was first approved.
The African Union Steering Committee, headed by Egypt, is directing construction of the project, which is part of the Presidential Infrastructure Champion Initiative. The enterprise is being carried out under the umbrella of the New Partnership for Africa's Development.

The project entails building a shipping lane along the Nile River for small- and medium-size commercial vessels to boost bilateral trade among nine countries: Tanzania, Kenya, Uganda, Rwanda, Burundi, Democratic Republic of Congo, South Sudan, Sudan and Egypt.'[92]

It is therefore very likely that the issue of canalisation of the White Nile River can become a pertinent issue to the navigation sector. The canalisation of rivers has historically been an effective practice for facilitating river transportation, yet in many places over the world, rivers are being reverted to their natural channels due to the experienced detrimental environmental concerns. In a manual on Good Practices in Sustainable Waterway Planning, it is specifically identified that:

'Navigation requirements can result in a stabilised, single thread, ecologically uniform river channel (i.e. a waterway or canal), lacking both natural in-stream structures with their gentle gradients and connectivity with the adjacent floodplains, which leads in the long run to ecosystem degradation (such as for the main river channel and the floodplain) and a loss of species.'[82]

Some of their recommendations on this are to update the navigation fleet to environmental standards, or to restore and make best use of the existing ecological infrastructure.

For the Government of South Sudan, the issue would be to weigh the benefits of canalisation with the impacts. It is recommended to plan this cross-sectoral with representation of relevant ministries and other stakeholders. In environmental concerns, the canalisation of the White Nile River would be a no-go as it would affect ecosystem functions critical to the sustenance of the Sudd.

6.3. Navigation Aid Systems

In general, improved safety of river traffic would be to the direct advantage of the local environment. Navigation aids will help to consolidate river traffic, and possibly prioritise those routes that are of least environmental concern. The installation and presence of navigations aids is not likely to be an environmental concern, since the to be installed equipment will, at the minimum, be hundreds of metres apart, which would not pose any restrictions to aquatic connectivity. The handling of the construction material and disposal of to-be-replaced material needs to fulfil specific requirements on waste disposal, to prevent any of the materials ending up in the White Nile River.

6.4. Rehabilitation and Expansion of Existing Ports

6.4.1. Juba

Environmental concerns: high

The port would need significant updates to function according to the requirements. An upgraded port would support local industries. The transportation of fuel (DG), does require special consideration for management guidelines and calamity protocols. It would therefore be recommended to elaborate to which extent the current mode of fuel transportation is taking

[92] Hussein W, 2017. *Nile River project seeks 'Africa without borders'.* Retrieved from: http://www.al-monitor.com/pulse/originals/2017/02/africa-egypt-nile-navigational-line-economic-development.html#ixzz56aPpbmcP

place according to international standards for DG. If under the project, barge traffic on the White Nile River will increase, so will the likelihood of accidents. In this case it is important to mention that it is not the (low) amounts or (low) frequency of dangerous goods that require a DG management protocol, but the fact that dangerous goods are being transported. Accidents do happen unexpectedly, and if that would involve a fuel vessel, there will be serious environmental impacts, both on location and downstream.
Some shipwrecks are located around the port area, removing these would disturb sediment profiles, while it is currently unknown what the level of pollution of these sediments would be. This would pose a significant risk locally and downstream of the wrecks locations.

Environmental Highlights from Images (Surveyed and Online)

Figure 63: In general, Juba port is in a bad condition. This photo shows trash is being dumped along the port side along the river channel. The survey team reports occurrence of floating plastic waste all along the White Nile River, (© HYDROC).

Figure 64: This image shows an accidental fire with a barge in front of Juba port in 2013. On the left it also shows a shipwreck in front of the port.[93]

[93] Retrieved from: https://www.youtube.com/watch?v=6hv-ldDdC9Y

Figure 65: This photo shows some open storage of barrels labelled as dangerous goods, though the actual contents are unknown. The photo in not taken at the port itself but at the shipyard; it illustrates a situation occurring along the White Nile River where dangerous goods are stored in the open, quite near the river channel, (© HYDROC).

6.4.2. Mangalla

Environmental concerns: medium

Due to the current functioning conditions of the port, the project is unlikely to make changes to the physical environmental context. As the port is located inside the town, there is some chance of environmental impacts (noise, air quality, waste) trickling down to the local community, especially if navigation will increase.

Highlights from Images (Surveyed)

Figure 66: This is a part just upstream of the port where boats are berthed, and some activities take place outside of the official port. A truck parked, some plastic and erosion on the river bank. In the background some smoke and air pollution.

Figure 67: This photo illustrates the well maintained Mingkaman port, fenced-off and secured, (© HYDROC).

Figure 68: Some fuel barrels are stored in the open on the water front, this indicates some general environmental concern, as this would be prone to barrel tipping or rolling into the river, (© HYDROC).

6.4.3. Terekeka

Environmental concerns: low

The port is located on the outskirts of Terekeka village, it will therefore be unlikely that the recommended upgrades will have significant direct impacts on the local community. Though it is important that the planned upgrades do fulfil local environmental regulations (e.g. for fuel storage), it is unlikely that they affect critical ecological processes or habitats, also because some basic port activities have been existing on location already.

Environmental Highlights from Images

Figure 69: Rural setting of the port, which is currently only accessible by smaller boats. (© by Louis Susairaj)[94]

Figure 70: Vegetated patches, or islands in front of the port. A passage must be cut or dredged to make the port accessible for larger barges. These patches are reoccurring along this stretch of the White Nile River, and are therefore not to considered as a fragile habitat feature. (© by Louis Susairaj)[94]

[94] http://ss.geoview.info/village_by_the_river,84694365p

6.4.4. Mingkaman

Environmental concerns: low

The upgrades that are proposed need to fulfil local environmental regulations. The Safety Net and Sills Development Project is currently working on the definitions and institutional enforcement aspects of kind of the local environmental regulations.[95] The port management needs to be strengthened to enforce environmental regulations with reference to overall increased navigation in the White Nile River. Without strengthened port authorities, it is unlikely that any form of environmental regulation will be observed en route.

Highlights from Images (Surveyed)

Figure 71: The port is operational and provides a maintained impression, (© HYDROC).

Figure 72: The quay wall does not allow the loading and unloading of cattle, which is done on the natural, eroded, river bank, (© HYDROC).

[95] Ministry of Agriculture, Forestry, Cooperatives and Rural Development, 2016. Safety net and skills development project, Environmental and Social Management Framework.

Figure 73: The presence of a warehouse allows for protected storage, (© HYDROC).

6.4.5. Bor

Environmental concerns: high

Though it is important that the planned upgrades do fulfil local environmental regulations (e.g. for a fuel station), it is unlikely that they affect critical ecological processes or habitats. As the port is located inside the town, there is some chance of environmental impacts (noise, air quality, waste) trickling down to the local community, especially if navigation will increase. Also, the visits show some shipwrecks near the port, cleaning these up does raise environmental concerns about the management of polluted sediments.

Environmental Highlights from Images (Surveyed)

Figure 74: This shows that there are no advanced port facilities in Bor. This leads to an instable river bank, (© Francois Henepin).

Figure 75: With the absence of more advanced port facilities, handling of goods is inefficient, and environmental controls on the handling and storage of goods more difficult to be enforced, (© Francois Henepin).

Figure 76: This shows a shipwreck near the port, which raises some concerns on the level of pollution around the port, (© Francois Henepin).

6.4.6. Shambe

Environmental concerns: low

The upgrades that are proposed need to fulfil local environmental regulations. The port management needs to be strengthened to enforce environmental regulations with reference to overall increased navigation in the White Nile River; without strengthened capacities of port authorities, it is unlikely that any form environmental regulation will be observed en route.

Environmental Highlights from Images (Surveyed)

Figure 77: The port is located away from the White Nile River main stem on Shambe Lagoon, (© HYDROC).

Figure 78: Some waste and a boat can be found inside the overgrown side of the jetty, (© HYDROC).

Figure 79: One side of the jetty is overgrown with water hyacinth and can no longer be used, (© HYDROC).

6.4.7. Adok

Environmental concerns: low

From satellite imagery it can be observed that Adok port is located outside of town, which means that it is unlikely that any upgrades to the port will have direct detrimental impact on the local community, though this has to be verified on-ground. Still, the recommended upgrades will need to fulfil to local requirements for impact assessments. An important environmental concern is the limited width of the White Nile River at Adok; this would make adjustments to the hydraulic profile of the river (such as the construction of a quay) much more sensitive to upstream and downstream impacts.

6.4.8. Bentiu

Environmental concerns: high

The port has to be reconstructed entirely from its former use. Roads have to be rebuilt and buildings have to be erected. The tens of kilometres of access waterways and port have to be cleared and maintained. Currently, the Bahr el-Ghazal from Bentiu to the White Nile River provides a kilometres-long bottleneck. Clearing this will change flow velocities and upstream and downstream inundation patterns. This might all fall within the natural variability of the wetlands but needs to be closer assessed on environmental impacts. Also, part of this clogging might not have happened if it were for the invasive species of water hyacinth; clearing the Bahr el-Ghazal will therefore be costly and have certain environmental impacts but could as well be considered as ecological restoration.

Figure 80: Not much is left of what used to be Bentiu port, (© HYDROC).

Figure 81: These are some shipping containers in the middle of a field, (© HYDROC).


Figure 82: All access channels to the old port have been overgrown, (© HYDROC).

6.4.9. Malakal Town Port

Environmental concerns: medium

The upgrades that are proposed need to fulfil local environmental regulations. There needs to be a continuous port management to enforce environmental regulations with reference to overall increased navigation in the White Nile River; without strengthened capacities of port authorities, it is unlikely that any form environmental regulation will be observed en route. As the port is located inside the town, there is some chance of environmental impacts (noise, air quality, waste) trickling down to the local community, especially if navigation will increase.

Figure 83: The port shows signs of deterioration where scrap metal from boats is lying around on the quay, (© Francois Henepin).

Figure 84: The port itself extents to eroded river banks, (© Francois Henepin).

Figure 85: Equipment and goods are stored higher on the riverbank in town as there are currently no designated areas for handling and storage, (© HYDROC).

6.4.10. Malakal UN/WFP Port

Environmental concerns: low

The upgrades that are proposed need to fulfil local environmental regulations. There might need to be a continuous port management to enforce environmental regulations with reference to overall increased navigation in the White Nile River. As the port is located near to the camp, there might possibly be some trickle down of environmental impacts to the camp residents, this would concern the management of the impacts from the construction activities, such as noise, dust, safety, and waste.

Environmental Highlights from Images (Surveyed)

Figure 86: Overview of Malakal UN/WFP port, (© Francois Henepin).

Figure 87: Vegetable gardening near the port, (© Francois Henepin).

6.4.11. Melut

Environmental concerns: low

The upgrades that are proposed need to fulfil local environmental regulations. There might need to be a continuous port management as the starting point to enforce environmental regulations with reference to overall increased navigation in the White Nile River.

Environmental Highlights from Images (Surveyed)

Figure 88: The port is located along a road in a rural setting, (© HYDROC).

Figure 89: There are some remnants of past activities at this location, but no direct indications of environmental concern, (© HYDROC).

6.4.12. Renk

Environmental concerns: medium

The upgrades that are proposed need to fulfil local environmental regulations. There might need to be a continuous port management as the starting point to enforce environmental regulations with reference to overall increased navigation in the White Nile River. Some environmental concerns exist if the retired ships will be removed with regard to polluted sediments and soils.

Environmental Highlights from Images (Surveyed)

Figure 90: Some retired ships are resting on the river banks around the port, (© HYDROC).

Figure 91: The port shows signs of deterioration where scrap metal from boats is lying around as well as other waste (plastics), it is more likely that the proposed project activities are considered to be a local clean-up rather than an environmental concern, (© HYDROC).

Figure 92: The current situation of the port shows some issues with the low-lying and overgrown riverbanks around the port, (© HYDROC).

6.4.13. Summary and Recommendations on Environmental Concerns of Upgrading Individual Ports

The ranking of environmental concerns is as follows:

- **High**: Some issues were assessed that need better understanding before activities can go ahead. In most of the cases this concerns polluted sediments, when there are shipwrecks to be removed or (light) industrial activities surrounding the port. It is therefore necessary that to be dredged material must be analysed for pollutants.
- **Medium**: Some issues were assessed that would require active management of environmental factors during the project activities. In most of the cases this concerns ports that are located inside towns, any of the proposed activities should put controls in place to limit direct impacts on the surrounding population, such as more active noise, dust, safety, and waste control.
- **Low**: No specific issues were assessed that were of environmental concern. Project activities should fulfil to requirements to minimise environmental impacts.

For each of the ports, the concerns are combined for issues as described in the assessments (Table 23). There are some gaps in environmental details concerning the distribution of critical habitats or the occurrence of threatened species. These issues would require more-detailed ecological knowledge at a resolution which is currently not available. But since many of the ports are already existing, and since the ports occupy small localities along the 1300 kilometres of the White Nile River, it is unlikely that the proposed activities will affect critical habitats or species.

Table 23: Assessed environmental concerns for port upgrades

Port:	Environmental Concerns:
Juba	high
Mangalla	medium
Terekeka	low
Mingkaman	low
Bor	high
Shambe	low
Adok	probably: low
Bentiu	high
Malakal Town Port	medium
Malakal UN/WFP Port	low
Melut	low
Renk	medium

From the surveys, a general observation relates to the management of fuels and other dangerous goods at the port. The storage of these goods needs to be enforced in such a way that these are secured in locations as far away as conveniently possible from the waterside. From the observation and the photos, it becomes evident that currently some of these goods are stored along the riverbank, close to the places where ships are berthing. In many of the ports it is suggested to upgrade the storage of goods in the port, yet even with such improved stores, the issue of ‘no dangerous goods stored near the river channel’ needs to be consistently addressed. The next section will go into detail on the improved environmental operation of the inland ports.

6.4.14. Environmental Concerns on the Operation of Inland Ports

Here a short introduction is given on the environmental concerns on the operational side of ports, which comes *after* the proposed construction phase. It concerns the lasting changes that the project would bring in revitalising port operations along the White Nile River and in the Sudd wetlands, the continuous environmental impacts.
Given the layout and relatively low density of the port network, compared to the total river network length and the overall size of the Sudd, it is assumed that the environmental impacts of ports will be very isolated, and therefore local. For each of the ports, the proposed construction work will be considered separately and was added to each port description (Section 5.4.1).

In a recent survey for port operators, Seguí et al[96] rank the following ten priority environmental concerns associated with inland ports:

1. The port's relationship with the local community
2. Air quality
3. Water quality
4. Port expansion (land related)
5. Garbage/port waste
6. Soil contamination
7. Dangerous goods
8. Noise
9. Energy consumption
10. Ship waste

Most of the items on this list will also become an environmental concern in the South Sudan context, though the ranking might be different. The inland ports in South Sudan are geographically very isolated and environmental legislation and enforcement, both surrounding and between the ports, will become a major challenge in this context. It is therefore recommended to include detailed environmental impact studies before the commencement of actual works for the recommended project activities at each port. Such assessments would also identify if any critical habitat or vulnerable species would be affected.

6.5. Environmental Impact of Barges and Pushers for Supply of Humanitarian Aid

The PLATINA manual[82] on Good Practices in Sustainable Waterway Planning provides a detailed insight in the environmental concerns for planning navigation in the European context. While considering that the manual has been written for a European setting, many of the described issues are of relevance to the White Nile River. The manual describes the environmental needs of river transport projects as follows:

'The river transport project developer is advised to identify early on the basic environmental needs of the particular river stretch. These include protected areas, valuable habitats and species, as well as nature management needs (according to national, international and European Union law), which usually demand ***no deterioration of the current status or restoration towards a better status.*** *In this early phase it is also important to assess the*

[96] Seguí, X., Puig, M., Quintieri, E., Wooldridge, C. & Darbra, R.M., 2016. New environmental performance baseline for inland ports: A benchmark for the European inland port sector.

required scope for an SEA/EIA. […] This scope also includes the potential wider impacts of the planned infrastructure project beyond the actual river transport project area, i.e. up- and downstream the river as well as laterally into the floodplain (e.g. in terms of hydromorphology, fish migration).'[82]

Evident from this quote seems that navigable rivers in Europe already have undergone a certain level of development, hence the project's purpose of restoration is raised. The White Nile River and Sudd, in contrast, can be considered to be in natural condition, so any new development would be a deterioration of the current status. The environmental needs of this project could therefore be better defined as identifying the most sustainable and least harmful interventions, with the purpose to respect essential functions of the White Nile River and Sudd ecosystems.

The current intact status of the Sudd wetlands is attributed to its inaccessibility[97,98], which is the main characteristic that revitalising the transport by navigation is about to change. Yet, this must be put in perspective. If transportation on the White Nile River would not be increased in capacity, the bulk of the required goods have to come from (improved) road transportation, which would imply a much higher density, less-centralised, transport system through the Sudd. Next to this, the current status also needs to be understood in light of the past navigation, which either did not leave a lasting negative impact, or took place such a long time ago that the Sudd has recovered from its impacts.

6.5.1. Overnight Berthing

Currently, and in the near future, it is unlikely that river navigation is to take place during night time. Not all ports are within daytime reach of each other, which implies that barges are anchored somewhere in between. It would make sense to assign specific anchoring places. The designation of out-of-port anchoring locations would help to keep the impacts more concentrated, and less incidental, allowing monitoring of environmental conditions and enforcement of regulations. These locations should be identified in coordination with the current navigation sector and can be assigned as part of the Navigation Aid Systems.

6.5.2. Waste

Training must be provided, and regulations have to be enforced to limit (domestic) waste being dumped into the river from the barges. With an increased number of barges on the river, it is likely that the amount of waste will increase. Any pollution in the White Nile River will also be transported by the annual floods and deposited into the Sudd. It is therefore recommended that there is a standard protocol introduced where ships handle their 'on-board' waste at each of the ports.

6.5.3. Hunting/poaching/wildlife

One issue that is to be prevented is that opening up navigation will increase hunting and poaching along the White Nile River, resulting in the decimation of Sudd wildlife. As South

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[97] Gowdy J, Lang H, 2017. The Economic, Cultural and Ecosystem Values of the Sudd Wetland in South Sudan: An Evolutionary Approach to Environment and Development, UNEP, The Evolution Institute

[98] UNEP, Ministry of Environment, Government of South Sudan, 2015. *Fifth national report to the convention on biological diversity.*

Sudan is recovering post-conflict, weapons are ready available, also for security purposes in protecting the barges. It is not that a strengthened navigation system could be blamed for the introduction of poaching. During the conflict, poaching took place to get food[99] by the different parties. Recently, there seems to be a trend towards of professionalism in poaching, connected to international wildlife trafficking.[100] It is therefore recommended that regulations and enforcement are in place to prevent navigation of becoming a driver to poaching or more professional wildlife trafficking by providing improved access into the Sudd wetlands.

The Sudd is famous for its mass migrations of white-eared Kob and hosts an abundance of Mangalla gazelle, Tiang antelope and elephants.[97,101] There will be little interaction between the increased capacity in navigation and these migrations as these take place on the Jonglei plains, Africa's largest savannah. The Jonglei plains are part of the Sudd, the migrations follow the flood patterns that originates from the White Nile River, but do not cross or get near the White Nile River navigation channel itself.

Of more concern to poaching are the animals that live in the White Nile River channel, who will be in direct contact with the shipping routes and dredging activities (crocodiles, hippopotamus, birds, aquatic life). Yet, there should be only one developed shipping route, and often there are many branches, pools, and lagoons along the White Nile River. It is likely that these would offer refuge of wildlife to the project activities. It is recommended to map such different locations in detail, related to the dredging plans, as there will certainly also be single channel bottlenecks. Of special concern here are those (fish) species that migrate from the river channels and pools into the seasonal wetlands. For them the issue is to maintain connectivity between those seasonal- and permanent wetlands.

Dangerous goods (DG)

DGs are defined as solids, liquids, or gases that can harm people, other life, property or the environment. The United Nations Sub-committee on the Transportation of Dangerous Goods assigned nine classes according to the type of hazard they pose in transportation (Figure 93). In the figure, the examples provide insights in some common goods that are considered dangerous. Consultations with different transport agents in South Sudan indicated some amounts of DG being presently transported:

- Fuel (diesel, jet fuel)
- Crude oil
- Some chemicals for oil fields
- Aluminium sulphate (for water purification)
- Small construction material (paint solvents, cement, etc.)
- Some ammunition

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[99] The Guardian, 2014. *South Sudan's wildlife becomes a casualty of war.* Retrieved from: https://www.theguardian.com/global-development/2014/jun/19/south-sudan-wildlife-casualty-of-war

[100] WCS Newsroom, 2017. *South Sudan Wildlife Surviving Civil War, but Poaching and Trafficking Threats Increase*. Retrieved from: https://newsroom.wcs.org/News-Releases/articleType/ArticleView/articleId/10089/South-Sudan-Wildlife-Surviving-Civil-War-but-Poaching-and-Trafficking-Threats-Increase.aspx

[101] CEEEPA, 2006. Environmental Impact Assessment of the Bor counties' dyke rehabilitation project, South Sudan: Integrated assessment report.

The Dangerous Goods Manual by the Mekong River Commission[102] provides excellent guidelines how to set up DG guidelines in a setting similar to the White Nile River (with existing inland ports). It is recommended to make use of this manual on DGs and adjust it to make the content more suitable to the White Nile River context.

6.5.4. Institutional Capacities

In this context, it is recommended that the Department of River Transport, under the Ministry of Transport, should be strengthened with capacity on environmental assessment, regulation and enforcement. Under this initiative, each individual port would require a port manager that is to ensure environmental regulations are met at each port. This would concern both, the project activities, and post-project activities. An important role of the port manager would be to maintain an open relation with the local communities and keep them involved and updated of the project activities.

In such a way, the Port Managers at different ports are likely to form the initial authority to enforce environmental regulation. It is therefore of importance that there is consistent cooperation among the different ports and that, as a regulator, the ports operate independently from the shipping operators. They would also need to be up to date on the requirements to transport, handle, and store DGs.

But, capacity on environmental regulations and enforcement should also be built for the barge boatmasters, to ensure environmental concerns are addressed en route. It is important that this does not become a bureaucratic target, yet it might be worthwhile to introduce a boatmaster certificate with the requirement to be trained as a captain on a vessel, and this capacity building should include environmental regulations. The Economic Commission of Europe provides an elaborate checklist in their recommendations of the knowledge to be mastered by a certified boatmaster.[103]

An important precondition for the success of the project would therefore be to which extent the different sectoral ministries are able to coordinate and enforce environmental legislation and provisions associated regarding port operation in feedback to environmental controls and monitoring. The Department of River Transport should therefore include representation of the different sectoral ministries and have the authority to monitor and provide feedback to the development of the navigation sector.

Another important aspect of these regulations would be the (re-)instatement of the River Police. The task of the police would be the guarantee security of the barges, the crews, and the passengers along the White Nile River. Monitoring and enforcing environmental regulations should also become part of their mandate, they would be an independent party in law enforcement. It is very important to stress that their mandate should be to facilitate safe and sustainable navigation, and not mainly to regulate it. The challenge would be how to consistently roll this out for the (1400 kilometres of) navigation routes. The technical centres for

[102] Mekong River Commission, 2013. Dangerous Goods Management Manual, Prepared for Chiang Saen Commercial Port Area.

[103] Economic Commission of Europe, 2017. Recommendations on Minimum Requirements for the Issuance of Boatmaster's certificates in Inland Navigation with a view to their Reciprocal Recognition for International Traffic – Resolution No. 31

aids to navigation maintenance, as proposed in Section 5, could be a possible starting point to enforcing an improvingly consistent environmental regulations regime.

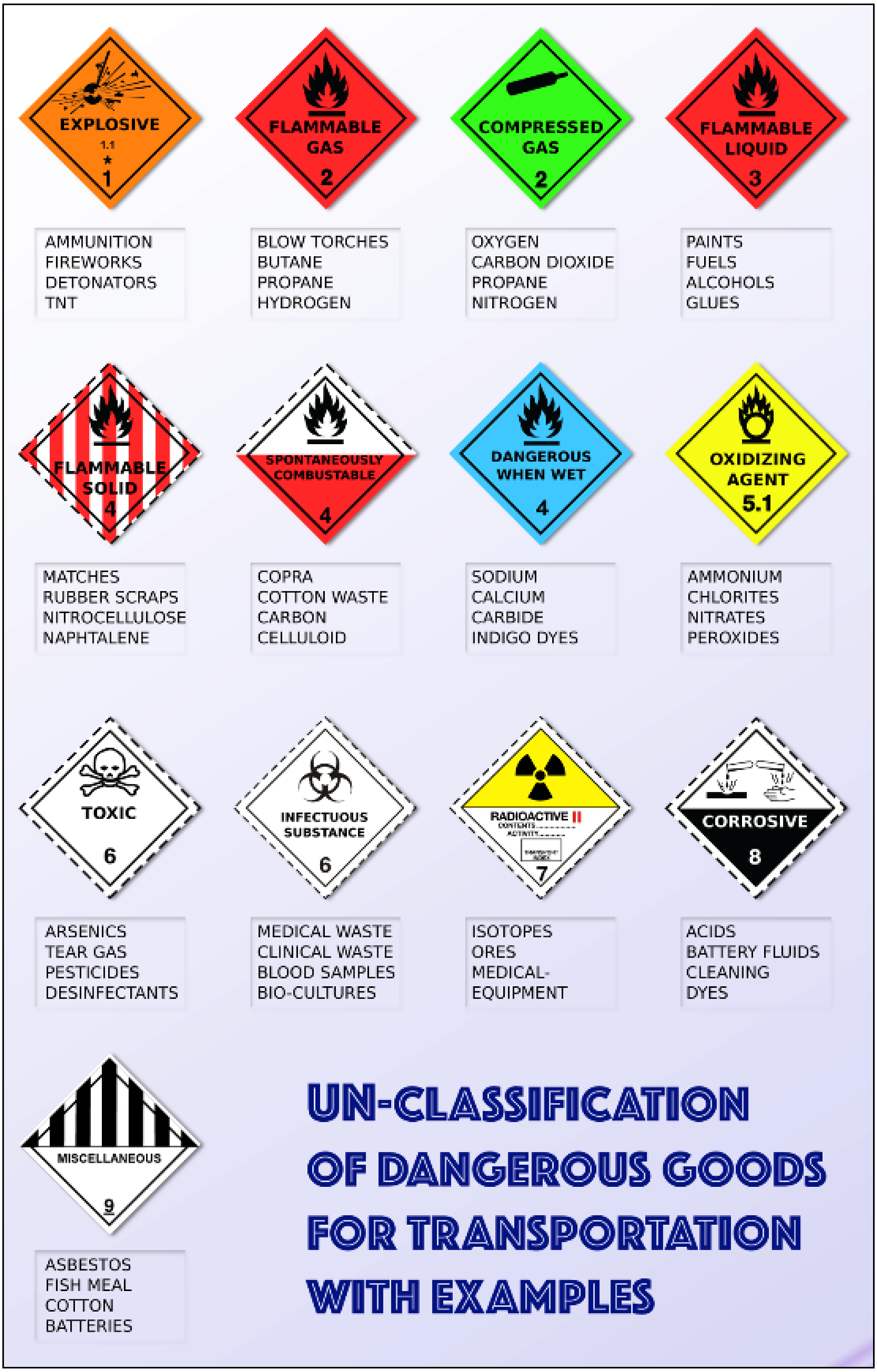


Figure 93: UN classification of DGs, (Source: United Nations).

7. River Transport System Operation and Management

River transport in South Sudan is currently overseen by the Ministry of Transport of the Government of South Sudan. Considering the security situation and limited capacity of the ministry, river transport operation and management is currently at a limited state, with only few barges operating. In comparison to international standards, river transport is at a low level. Nevertheless, given the present socio-economic situation in South Sudan, it may be argued that international standards for river transport may be difficult to be achieved for operation on the White Nile River and that the system may rather grow over time based on actual needs and in line with the countries general development.

With the river transport system being proposed in this study, a level of operation and management will anyhow be necessary for the safe and sustainable operation of the system and to achieve the desired targets, i.e. in the first place to cater for humanitarian needs and to support long-term economic development. Four main building blocks are described to achieve the river transport system, this being river dredging, ports, barge fleet and navigation aids. Developing these building blocks will need to be done in a coordinated approach with priority given as follows:

1. Dredging where barge movements are currently not possible
2. Installation of navigation aids to ensure safe passage
3. Improving the ports for increasing handling capacity
4. Developing the barge fleet to provide more transport capacity

The prioritisation may be substantiated as follows:

- The main bottleneck for the existing river transport in South Sudan is navigability of the stretch between Juba and Bor, as with the current water depth Juba cannot be reached. Barges are available in sufficient numbers and with potential to increase transported tonnage. Ports can handle the current barge numbers even with their limited facilities. Based on narrative evidence captains on barges are currently sufficiently experienced to navigate the White Nile River also without navigation aids.
- With traffic increasing and over time the number of inexperienced sailors going up, navigation aids will be necessary to ensure safe passage through the meandering river channels.
- With increased barge numbers and transport frequencies, ports capacities for handling cargo may become a limiting factor. At this point the port capacity and efficiency will need to be increased through extension of quay walls, introduction of cargo lifting equipment, etc. to allow for more berthing capacity and faster turnaround times.
- With the White Nile River being opened up, interest in river transport may increase and respectively the need for more transport capacity will rise, resulting in the need for an increasing barge fleet.

The above is a general characterisation of a vision. It is expected that different ports may develop differently and that rehabilitation and improvement of some ports that develop to be major hubs may need to start earlier. This in particularly also holds true for selected important port installations like workshops and shipyards that will be required to maintain the growing barge fleet and maintain its performance.

For developing all the above, an essential requirement will be that security on the river will improve as currently safe passage is not guaranteed, and significant security risks exist for barge operations. Without this problem being solved, a river transport system will seriously suffer and maintain throttled.

It is expected that the river transport system will develop gradually and that the management and operation will become increasingly complex. The following sections respectively describe proposed ways for handling this situation.

7.1. Management of New Mobile Assets (Dredgers, Barges, Pushers)

New mobile assets that are proposed in this river transport feasibility study include dredgers, barges and pushers. While the private sector may quickly react once the possibilities for efficient barge transport are established through necessary river dredging and increasing demands, the study suggests that at a later stage procurement of barges may be beneficial to provide the necessary capacity to enable efficient barge transport and meet the needs of humanitarian organisations. Considering historic records about barge transport in South Sudan, river transport has significant room to grow. It is suggested that an increased barge and pusher fleet could initially be managed by an international organisation with logistical experience, leasing out the barges to private enterprises who could eventually take over and the Ministry of Transport assuming a regulatory role to ensure required standards are met and fees are paid by the barge users that will eventually ensure the financial sustainability of the transport system.

Dredging should be considered to be a state responsibility to open and keep open waterways for the benefit of various users. The Ministry of Transport would be a natural owner in this regard and it is suggested that a respective department in this ministry would be in charge for managing the dredging activities. The dredging itself may be conducted through government owned dredgers or through commercial contracts with the latter often being more sustainable. It is suggested that for the case of the White Nile River an international organisation could provide initial guidance and management of the dredging operations building capacity of the ministry and gradually handing over responsibilities. The dredgers could be taken over and operated in a company setup with the government as the owner. Very successful examples in this regards are available e.g. in Egypt where a government owned holding company is managing water and wastewater construction works. The setup allows for a clear reporting structure and ensures financial sustainability which of course needs to be enabled through a respective charge system.

7.2. Management of Fixed Assets (Ports, Navigation Aids)

Fixed assets mainly include ports and navigation aids. Both may be handled by the Ministry of Transport considering the respective needs for financing the growing asset base as well as the need for increasing the ministries capacity to handle and maintain the assets. It is recommended to conduct a detailed institutional and economic capacity assessment to define needs for successful operation.

South Sudan owns different ports that are currently operational with different management regimes in place. Best practice should be evaluated here to draw on lessons learned and make use of setups where functionality is proven in practice. Ports may be government or privately operated under government licence and regulations. Mangalla port, leased out and managed by TRISTAR, is a good example in this regard.

Navigation aids will be new to South Sudan and a specific department under the River Transport Directorate should be in charge for operating and maintaining the navigation aids. It is recommended that the respective government body is already involved in the installation of the navigation aids in order to obtain full knowledge and ownership of the system and to gradually take over responsibility.

7.3. Financial Sustainability

The proposed river transportation system can only be successful when financially sustainable in the long-term, i.e. after the initial involvement of international organisations has seized. The transportation system, including its maintenance needs for the port infrastructure, navigation aids, maintenance dredging and covering administration overhead costs need to be financed through a tax/fee system for barge operators to use the facilities, i.e. the navigation channels and ports. It is important that not only recurring maintenance is included in the necessary calculations but also capital replacement costs where applicable.

A key success factor given the limited capacity of the Ministry of Transport is to outsource the commercially viable activities to private companies and respectively reduce the necessary management efforts. This in particular holds for dredging activities that can be outsourced to private government owned companies as compared to operating an own dredger fleet. Such government owned companies are successfully implemented e.g. in Egypt.

7.4. Government Involvement

Government involvement from the onset of any activities is a key element of the proposed actions in this feasibility study to ensure ownership and long-term sustainability of the proposed measures. The Government of South Sudan is the regulating body for all proposed activities and needs to be directly involved. Next to the direct involvement in decision making it is suggested to provide significant training and capacity development to relevant government bodies and to coach the Ministry of Transport in setting up relevant departments for overseeing and managing the activities. Streamlining of approaches will be necessary as e.g. there are currently different systems of port management in place that may lead to conflicting situations and complications in management. Also, inter-governmental activities need to be promoted e.g. for setting up tax/fee systems and channelling collected funds, developing budgets and ensuring inter-sectoral activities. For the latter a main focus should be on security aspects as only with secure shipping routes in place a growing river transport system will be successful.

7.5. Final Handover to Government

With activities currently being promoted by UNOPS, it is expected that various international stakeholders will get on board for implementing the river transport system on the White Nile River. While this will lead to the necessary kickstarting of activities it is imperative to keep in mind that the system shall eventually be taken over by the Government of South Sudan and that for this to be successful, training and capacity building, ownership and overseeing the development of respective governmental departments for managing the system will be necessary. With the capacity of government departments being assessed as sufficient, the river transport system including its asset may then be handed over to the government, keeping in mind that privatisation of management and operation through private or state-owned companies is a strong option to reduce workload for government entities. The private management option may be used for leasing government assets, e.g. by leasing out port operations or through hiring contractors for e.g. dredging operations instead of operating an own dredger fleet. The exact way forward may be developed over time with ongoing capacity development and arising opportunities.

7.6. River Transport Administration.

Until the independence of South Sudan, the Inland River Navigation Department (IRND), based in Khartoum was the Federal Unit which had the overall responsibility on river transport. the main objectives assigned to IRND were to:

1. Promote river transport
2. Assume an overall control of river transport
3. Encourage the private sector to invest in river transport
4. Ensure safety of navigation on all the river routes in Sudan

Its functions include registration of vessels, vessel inspection, vessel licences and crews' licences. GoRSS, through MoT, has claimed progressive delegation of the development, management and operation of the river transport system in Southern Sudan.

7.6.1. Directorate of River Transport. (Input from GoRSS)

Some of the ports operating in South Sudan are managed by Port Managers. The Port Managers report to the Port Department Director. In the case of Juba port, the port manager is supported by a team of eight technicians; three of them in charge of maintenance of equipment, three of them maintaining infrastructure and cargo handling and two of them handling security matters. The security function is reinforced by the River Transport Police and other security organisations.

8. Implementation Roadmap

The roadmap described in this section outlines the steps necessary and identifies the concrete activities for the establishment of an enhanced river barge transportation system in South Sudan. In that regard the roadmap builds on the existing situation and available assets in South Sudan and highlights necessary actions from a holistic perspective including security, institutional, technical and economic considerations aiming towards a sustainable system. All activities will need to be closely coordinated with the government to ensure ownership, capacity transfer and smooth handover.

Further to the aspects directly related to implementation, the roadmap is considering shorter term as well as longer-term targets with the former aiming at supporting humanitarian operations and the latter aiming at economic growth.

The main elements for successful implementation are identified as follows:

- Agreement of overall implementation concept with the government. While setting out a detailed way forward, the concept will need to be held flexible to be able to adjust to budget availability as well as to security aspects and the ability of the involved stakeholders to perform their roles along growing responsibility and the need for increasing capacity.
- Securing budget: It must be noted that all proposed projects are subject to the availability of funding. The mobilisation process to obtain funding for selected activities can be time consuming and will likely have an impact on the timeline.
- Solving the security situation along the transport route is of utmost importance to facilitate unhindered transport.
- Considering the planned role of stakeholders, capacity building and institutional strengthening plays a major role in the implementation.
- Detailed implementation planning of the individual building blocks of the system prior to mobilisation and under involvement of all stakeholders will be essential.
- Cooperation with the private sector should be endeavoured.
- The implementation of the roadmap to establish the river transport system requires an integrated approach with a clear understanding of required actions, risks, interrelations, policies, procedures and critical factors for success. The actions required to establish and enhance the river transport system are:

1. Dredging: Transportation capacity on the White Nile River is limited due to limited water depth. Dredging for deepening and widening a navigation channel is required. Initial dredging to open the required shipping channel and maintenance dredging to keep it open are required.
2. Ports: All ports identified in the study require various levels of rehabilitation and construction to improve and develop docking, cargo and passenger-handling ability.
3. Navigation Aids: Installing navigational aids to ensure the safe and efficient movement of river traffic.
4. Boats, Pushers and Barges: The river transport fleet may require additional boats, pushers and barges in the future. To ensure efficiency, the acquisition and/or operation could be in partnership with the private sector.

Critical Factors for Success

To ensure the projects sustainability, critical success factors include the requirement for continuing donor support and government commitment to mobilise and invest financial resources. Government commitment to efficient practices and management is critical, as is buy-in from the local communities living near the port areas. It is considered critically important for the private sector to be convinced that river transport services are good business which to utilise. This can be promoted through respective transport sector taxation schemes. Finally, a regulatory environment which is conducive to fair competition among service providers, and protection of private property and assets is essential for creating the conditions required for long-term investment in the transport system. Commercial viability can only be achieved if the border to Kosti opens, thereby enabling cross-border trade with Sudanese markets. The access to Sudanese markets will lower the price of fuel, increase trade in commodities and permit more cost-effective fleet operations.

Expected Benefits/Impacts

The establishment of a river barge transportation system will provide access and development possibilities to regions in South Sudan that would otherwise have limited development opportunities. The access would provide not only economic opportunities to the isolated communities, but also access to essential medical and other social services. A lower cost and dependable river transport system for moving trade and passengers could drive a growth in agricultural production as well as bulk good required for construction works, which would have a synergistic effect on the broad development of the entire region through market access and price reduction.

Areas of High Risk

An area of high risk is the armed conflict destroying the transport system infrastructure and assets or stopping operations for a protracted period – and driving away support by donors. It is important for the future health and operation of the river transport system that private enterprises are involved in a significant way. They bring cost-efficiencies that are difficult for a government-controlled operation to achieve.

8.1. Implementation Phases

Phase 1 - Budget Approval and Establishment of the Project Management

Once the budget is established, respective project management organs will be determined and implemented. Following this start, an Integrated Action Plan (IAP) will be prepared including procurement, mobilisation and operations of the transportation system as well as including the necessary institutional development steps on government side. A budget plan, based on committed donor resources, will be prepared to support the approved IAP.

Phase 2 - Integrated Action Plan for Institutional development, Procurement and Operations

The IAP will have the following major components:

- Institutional development
- Procurement
- Operations

The government as the future owner of the system will be essentially involved in the IAP development.

Phase 3 - Implementation

Implementation will be based on the IAP and will include the major components listed above for the technical actions including dredging, ports, navigation aid and fleet extensions.

- Institutional development. The Ministry of Transport as the identified main stakeholder for the dredging operations will need to strengthen its River Transportation Department to deal with the dredging operations, port management, navigation aids and regulating barge transport. It is recommended to establish individual organisational units under the department, which are responsible for dredging, navigation aid systems, river ports and river transport fleet respectively. In general, responsibilities will include management, finances, operation and maintenance of the teams, works and transport activities, including ensuring financial sustainability of the system. While it is assumed that in the beginning activities will be mainly led by an implementing international organisation it is essential that institutional development to set up the respective management structures is agreed and implemented.
- Procurement and mobilisation of dredgers and supporting equipment. A competitive bidding process based on technical specifications will be required for implementing dredging operations. Procurement shall include the dredgers, their transport, assembly in South Sudan, testing, and training of operation staff as well as a period of technical support including maintenance. Staff recruitment for the dredging teams will need to go in parallel with procurement to ensure teams are ready to be trained.
- Dredging operations. Both production dredging as well as maintenance dredging will need to be planned and performed. With the dredgers procured and commissioned, responsibility will be with the executing agency.
- Procurement for port rehabilitation and construction. Both engineering and construction services will be needed for port rehabilitation and construction. Depending on timing requirements, the works may be tendered out in one or more lots with the most cost-effective and efficient way being to have one contractor in charge of all the work. The contract works will need to include a detailed engineering assessment of all nine ports to produce a detailed engineering project plan. The companies will require a mobilisation period and space for offices and facilities in the port assembly area.
- Construction supervision. Port rehabilitation work will need to be supervised by respective engineering firms to ensure adequate implementation.
- Procurement and Installation of navigation aids. Based on the current estimate tenders with detailed requirements need to be launched. It is recommended that for uniformity reasons equipment from only one supplier will be procured. Installation shall be done with local staff who at the same time will be trained.
- Procurement and mobilisation of barges and pushers. Needs assessments have shown that for the first years of developing the river barge transportation system existing transport capacity on the White Nile River will suffice. The situation should anyhow be reviewed periodically, and potential fleet increases be considered in coordination with the private sector.

Phase 4 – Handover

Already during implementation, phasing out and handover will have to be carefully planned and started, especially considering private sector ability and capabilities of the government. Developing the required government structures as will be essential for the system to function sustainably.

8.2. Summary of Proposed Activities and Cost

Table 24 below provides an overview of the identified projects for funding. More details are provided in Section 5 (proposed activities for the establishment of the river barge transportation system) and Annex VI (cost of proposed activities). It must be noted that each dredging project has been calculated as a stand-alone project. The capital investment cost are added for each separate project. When implementing multiple of the dredging projects listed below, the total project sum will be reduced, because the dredgers only need to be procured once.

Table 24: Summary of Proposed Activities and Cost

Project	**Estimated cost ($US)**
Dredging Juba – Bor (233 days)	15,930,000 (Box 1)
Dredging Bor – Malakal (48 days)	14,560,000
Dredging Bahr el-Ghazal between Lake No and Bentiu (233 days)	15,930,000 (Box 1)
Dredging Malakal – Renk (22 days)	14,360,000
Navigation aid system Juba to Renk	15,600,000
Mangalla port rehabilitation	620,500
Terekeka port rehabilitation	2,141,550
Mingkaman port rehabilitation	62,600
Bor port rehabilitation	5,742,222
Shambe port rehabilitation	1,527,757.50
Adok port rehabilitation	2,141,550.50
Bentiu port rehabilitation	2,731,543.50
Malakal (town) port rehabilitation	3,050,815
Malakal UN/WFP port rehabilitation	2,031,865.50
Melut port rehabilitation	2,521,458
Renk port rehabilitation	3,571,765
Fleet	No investments are recommended at this stage.

Box 1 provides an overview of how the budgets for dredging were derived.

The volume of to be dredged between Juba and Bor as well as between Lake No and Bentiu (Bahr el-Ghazal) are each estimated roughly at 7 million m^3 (Section 5.2.1, Table 19). It is assumed that two dredgers are procured, each being capable of a production volume of 3,000 m^3/h. It is further assumed that due to manoeuvring (re-setting spuds and anchors) the operational time per day is only around 5 hours. This leads to a maximum daily production of 3,000m^3/h x 2 dredgers x 5h = 30,000m^3. For dredging the entire stretch between Juba and Bor, it is hence estimated that around 233 days of operation are required. Time required for maintenance has not been included.

The capital cost are estimated at $14,200,000 (refer to Annex VI, Table 29). In addition, operation and maintenance cost will need to be considered. Operating cost are assumed at $1,500 per day and dredger, which leads to approx. $700,000 for the operation of 233 days. Maintenance cost for the two dredgers are estimated at $770,000. The two self-propelled pontoons + hydraulic excavators are estimated at $65,000 respectively for operation and maintenance. This leads to:

Capital cost:	$14,200,000
2x dredgers operation:	$700,000
2x dredgers maintenance:	$770,000
2x self-prop. + excav. operation:	$130,000
2x self-prop. + excav. maintenance:	$130,000
Total:	**$15,930,000**

It must be noted that this estimation is subject to many variables and exact parameters will have to be determined based on actual conditions.

Box 1: Cost estimates for dredging operation between Juba and Bor

9. Conclusion

The assessment of river barge transportation on the White Nile River in South Sudan was carried out by HYDROC GmbH between August 2017 and March 2018 working with the Ministry of Transport of the Government of South Sudan as the main stakeholder and UNOPS as the client. Works included fieldworks, stakeholder interviews as well as desk studies and resulted in a series of findings including the technical and financial details for proposed project implementation as well as recommendations regarding sustainable project implementation. The study is clearly showing the potential of river transport on the White Nile River, also evident by historical shipping records, transported tonnage and barge numbers.

Analysis works were based on a needs assessment as well as bathymetric surveys on the White Nile River between Juba and Bor, i.e. the least navigable stretch that is currently impassable for loaded barges, and port assessment in all accessible ports. Analysis covered the need for dredging, navigation aids, port improvement works and investments into the barge fleet. Recommendations further cover necessary institutional development.

Concluding the assessment it was found that improving the security situation is a major pre-requirement for any investments into the river barge transportation system as uncertain security conditions form a major hindrance for economic development. Further, the responsible institution on government level that will have to deal with the different elements of the river barge transportation system will need to be built up and developed in line with the recommended construction works.

With regards to the works themselves it was found that dredging is the top priority for both opening up the southern stretch of river between Juba and Bor as well as for improving passage further downstream of Bor. In addition the approach channel to Bentiu at the Bahr el-Ghazal will need significant vegetation clearing and dredging along its entire length. Considering the quantities to be dredged it is recommended to work with two dredgers. The dredging operations may be conducted by government owned dredgers with government teams, by government owned dredgers leased to local companies or the works may be outsourced completely. Given that maintenance dredging will be required in the future, the first two options are preferable.

The setup of navigation aids was set as the second priority. Based on narrative evidence, today there is only a limited number of people who have sufficient knowledge to navigate the entire White Nile River between Juba and Renk. Assuming more barges will be required for facilitating increasing river transport needs, this may lead to staffing the barges and pushers with less experienced staff resulting in the risk for accidents and losses. Responsibility for the navigation aids system is seen with the government who would be expected to develop respective capacity with the necessary support.

The ports in South Sudan currently are fulfilling their main role as loading / offloading locations quite well given the actual number of barges calling at the ports. With no pressure to load/offload fast because of limited barge traffic there is currently not much incentive for port rehabilitation. With the navigation channel being dredged it is foreseen that ship movements and respectively moorings and loading activities will increase. Respectively ports will need to be upgraded to be able to handle the increasing volumes. It is suggested that the respective upgrading should be planned and executed demand driven. In addition health and safety as well as environmental aspects will be improved with port improvements.
In line with port upgrading activities management of the facilities will need to be streamlined. Different models are again possible, including government operated ports, port management through government owned companies or outsourcing to the private sector.

It was assessed that further barges are currently not necessary for developing a river barge transportation system as enough transport capacity is lying idle in the different ports. Only once the existing fleet is back in working condition and demand increases, additional barges may be required though this could be covered by the business owners as well who are expected to react to market demands and opportunities. If it is finally assessed that bringing in additional barges is beneficial, it is recommended to consider private sector loans or leasing arrangements for this undertaking

The governments capacity to handle the tasks of managing / overseeing a river barge transportation system is seen as crucial for the long-term success and sustainability of the interventions. Respectively much effort should be spent on institutional development and capacity building in line with the physical infrastructure investments. It is essential that the respective government institutions are enabled to keep pace with the development to avoid collapse of the system. Respectively it is recommended that the government institutions concentrate on their core responsibility, the regulation of the sector, while actual activities are being outsourced. Good practice examples for this are available in Egypt where activities are being carried out by government owned companies that ensure financial sustainability and limiting management requirements.

The success of the system will further depend on its financial sustainability that will need to be ensured through a fee system to cover operational costs of the system as well as in the long-term the replacement of capital assets. Fees may be collected for port usage as well as for rover operations and will need to cover for maintenance dredging operations, maintaining the navigation aids system and port operations. Again it is emphasised that it will be highly beneficial for the system to grow so that sustainability is maintained at all times and White Elephants are being avoided. This should be in the utmost interest of the government in order to make best use of the available resources.

Environmental aspects will be an important consideration for any developments in the Sudd. The area being a Ramsar site, interventions need to be scrutinised and designed to limit environmental impacts.

A news that became available at the end of the assessment is that there is a probability of the border between South Sudan and Sudan reopening for commercial activities. Such border opening may lead to significant opportunities for the river transportation system by opening new markets, and also increasing access to availability equipment and construction materials as well as opening international import routes. Actual opportunities will need to be established once details of the development become available.

Annex I Technical Methodology River Survey – Data Collection

For the bathymetric survey an echo sounder survey method was decided to be the most suitable for this application. The requirements for the surveying were to have a reliable method which is able to gather high resolution information from a boat with highest possible speed to ensure fast surveying of large areas within a limited time. The depth information should be easy to read and handle, meaning that each depth value should automatically come with the corresponding position from which it was measured. The total amount of data was expected to be quite large, so the data should also be easy to handle and easy to post-process with standard tools utilising standard GIS software. Finally, the hardware should be easy to mount on a boat temporally, dismount in the evening to prevent stealing and be easy to use in case local staff needed to be trained for handling the equipment.

Survey Equipment and Mount

For the bathymetric survey a Lowrance Elite T 7 echo sounder with down scan, side scan and structure scan was used. The echo sounder uses multiple frequencies (83/200/455/800 kilohertz (kHz)) and adjusts the best frequency automatically. The transduce is connected to a 7'' touchscreen control panel, which is equipped with a 10kHz internal high-sensitivity WAAS/EGNOS/MSAS GPS antenna for positioning. The echo sounder can store around 2 hours of continues scan data in a single file, saved on an external storage card. For each depth signal, the corresponding position is stored in the dataset. The transducer is permanently mounted to a stainless-steel mount, that comes with a screw clamp and a 45° moveable hinge. The screw clamp was required for fast mounting and dismounting to the boat. During the survey, the transducer was in the water, facing downwards to the ground. In case of faster driving of the boat (max. speed for surveying is approx. 16km/h), the 45° hinge was used to swing the transducer out of the water. This prevented damage in case of high speed drives in the evening back to the port and in the morning back to the survey site.

Surveying

The surveying was conducted between Juba and Bor, from 16th to 22nd December 2017. During that time, the equipment was mounted every morning and taken back to the hotel in the evening. The touch panel, which included the GPS, was mounted 1m ahead of the transducer and 40cm on the port side of the vessel. The GPS coordinates were later corrected for this distance. The transducer was 40cm below the water surface, which was also corrected later during data post processing. The area between Juba and Bor (and the side channel to Mingkaman) were survey in that period, using a zick-zack course. This method should ensure to get information on the development on the river bottom all the way downstream, but also on the changing bathymetry between both riversides and if there were any changes in that, as depth in rivers may vary from one side to another significantly. The data were stored in files containing around 2 hours of data and later checked for plausibility on a field computer, directly on the boat. Using the GPS, it was also ensured that no gaps in between data sets could occur. In addition to the bathymetric surveying, photos with GPS information were taken all the way. Furthermore, several surface velocity measurements were taken. A simplified approach was used to measure surface water flow velocity: The boat was placed in the middle of the river and the engines were turned off. After a waiting period, which should ensure that the boat is drifting approximately with surface velocity, a GPS speed measurement and position log was started for around 10 minutes. This average value is supposed to be the surface velocity. For these measurements a time slot with low or no wind was selected, to ensure boat drift speed is not affected by wind.

Figure 94: Transducer mounted beside motor, facing downwards, during surveying (left). Transducer head used for the surveying (right), (© HYDROC).

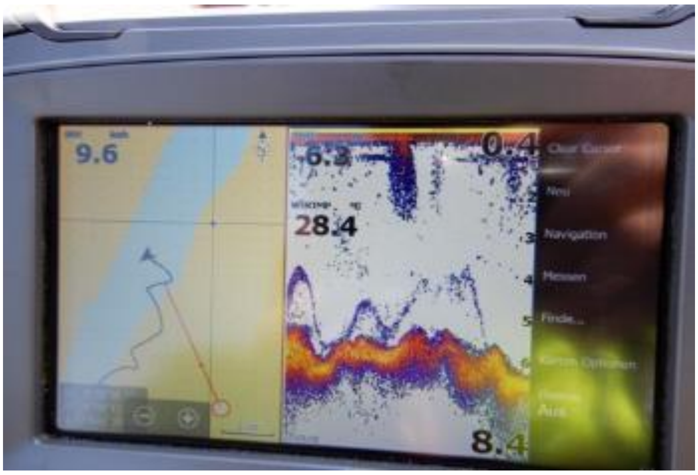


Figure 95: Touch screen panel of the echo sounder during surveying, showing the actual course and the course log on the left side and the depth and further bottom information on the left side, (© HYDROC).

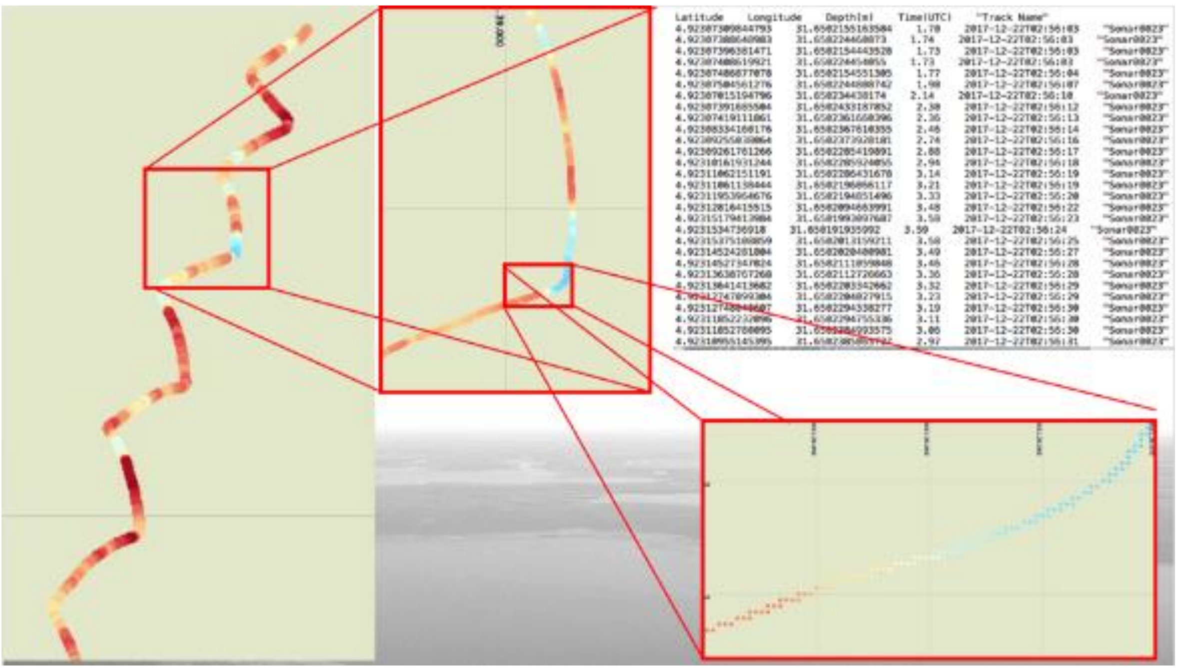


Figure 96: Excerpt of the surveying course, showing colour-coded depth information. Data are derived from local, single point measurements. The table shows raw data from that surveying, were each depth information is also assigned a GPS position, as well as a date and time.

Annex II Technical Methodology – Data Post Processing and Interpolation

In order to utilise the limited time and budgetary resources as efficiently as possible, the consultant interpolated the measured depth values of the bathymetrical survey on the White Nile River between Juba and Bor including Mingkaman. This was needed to derive an interpolated bathymetry for the modelling of river flow velocities and seasonal fluctuations of the river's bathymetry. The following steps were implemented as illustrated in Figure 97 below.

1. Before the survey took place, a domain was defined. All opened waters of the White Nile River between Juba and Bor were delineated based on satellite imagery from 2013-2015. The delineated coastlines were subsequently assigned value 0m of water depth.
2. All available results of echosounder from December campaign were plotted over the domain and connected with each other using a Triangular Irregular Network (TIN). The TIN is a representation of the surface, where every measured depth point was converted into a vertex of triangles, so that triangular facets do not overlap with each other. This feature allows creating triangle over both short- and long distances, which allows interpolating inside elongated domains, such as river valleys. Note that the application of this method did not influence any value of the true echosounder soundings. If some river sections, such as sharp meander bends, were not measured, they were removed from bathymetry charting at this stage.
3. To avoid sharp edges produced by TIN algorithm, the surface was simplified into a rectangular grid. A grid of regularly spaced 1x1m points was drawn over the investigated White Nile River domain. These points were assigned the exact values of the TIN surface laying beneath. A rectangular grid became thus a smooth representation of the TIN surface.
4. Based on the rectangular grid, water depth contours were automatically delineated and labelled (in blue). Note that the depth contours are reliable only close to the real measurements, which were shown in black. Due to small scale of charts (1:10,000) and therefore limited space on charts, only every 50th value was plotted on the final chart.
5. In addition, harbours and landing places recognised on satellite imagery were marked in the charts.
6. In total, the domain was divided into 16 sheets and numbers northwards from Juba towards Bor. Sheet 14 contains additionally an approach to Mingkaman.

It must be noted that while this approach yields a sufficient level of accuracy for the modelling, the accuracy is insufficient to utilise the interpolated bathymetrical charts for navigation purposes on the river. For instance, shipwrecks and other local shoals have not been mapped.

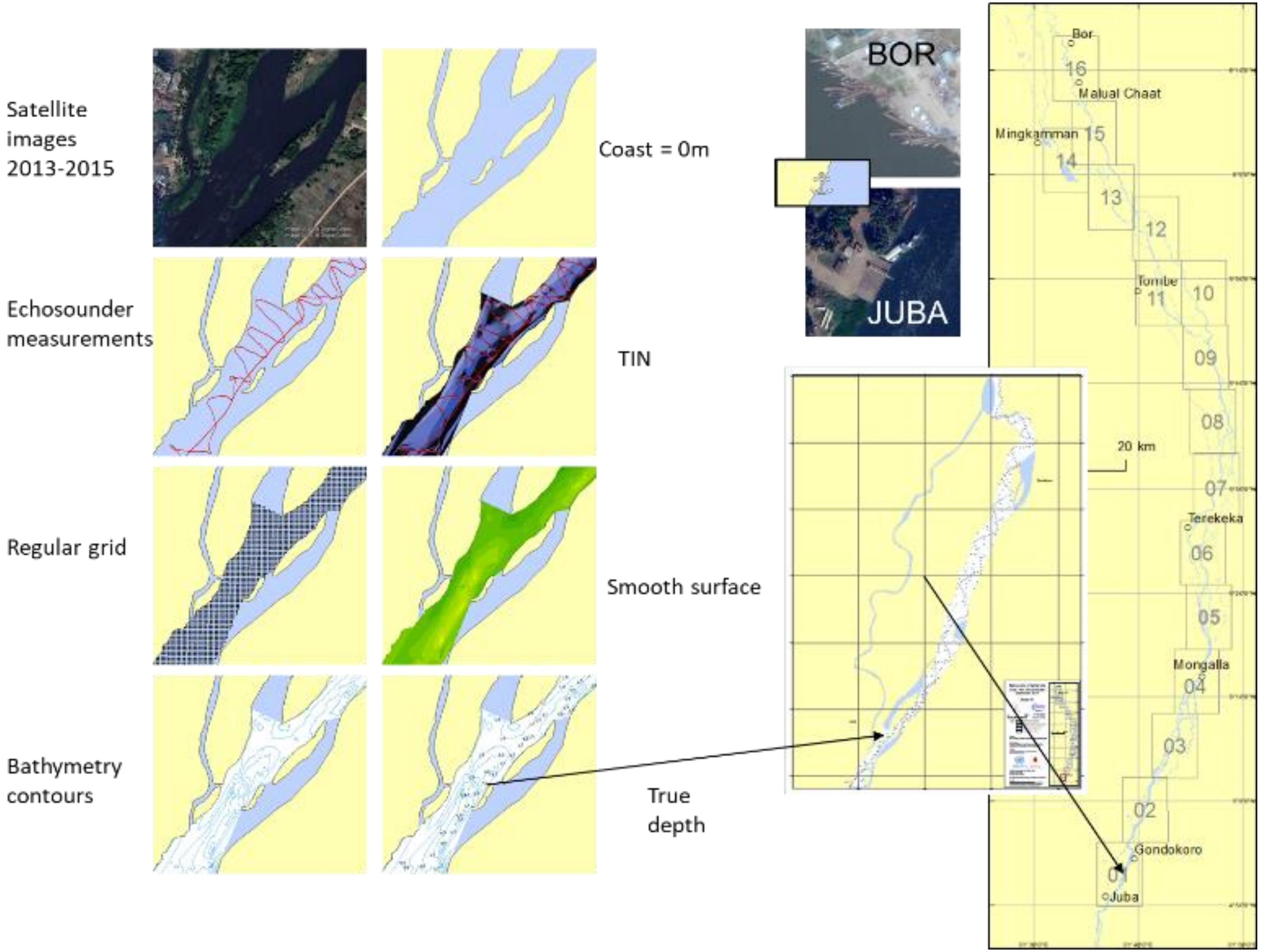


Figure 97: Illustration of bathymetric data interpolation.

Annex III Technical Methodology – River Modelling

Navigability of the White Nile River has been assessed using both, on-site surveys as well as in the areas not accessible due to security reasons through modelling approaches. Modelling has been conducted using historical data, which has been the best available at the time of the study, nevertheless, this results in a high level of uncertainty in the model results and the recommendation that it is imperative to set up water level monitoring stations along the White Nile River to obtain better data for any future study.

Channel properties for the navigation assessment are calculated using two different approaches. Most important parameters of interest for the shipping assessment are channel width, curvature, required shipping channel width, water depths and flow velocities. The geometric properties regarding width and curvature of the channel are relatively stable over time, while water depths and flow velocities are highly variable depending on the river discharge and therefore need to be calculated for defined design discharges.

Two different approaches have been developed to calculate the required parameters. First, spatial programming in Python is used to calculate width, curvature and required shipping channel width to find width bottlenecks along the whole Juba to Renk stretch based on remote sensing data only.

Second, a hydraulic assessment was planned to calculate in-stream flow velocities and water depths to find depth- and velocity constraints from Juba to Bor where the bathymetric survey was carried out but was extended to the whole region of interest. For the region downstream of Bor, initially a simplified hydraulic calculation and data analysis at old river gauges was used. The approach was improved by applying a detailed hydraulic approach to the full region of interest. For this, the hydraulic modelling approach was split into two different methods which enabled the detailed hydraulic model to be extended from the Juba to Bor stretch to the full Juba to Renk section, utilising additional algorithms and data. See Figure 100 and Figure 101 and descriptions therein for details.

Calculating width bottlenecks based on channel geometry

The shipping channel analysed in this study is defined as the channel with the largest consecutive width and least curvature from Juba to Renk. Google Earth satellite images have been used to digitise banks and obstacles (e.g. islands) within the main channel to obtain the maximum surface width of the shipping channel. Based on the left and right bank, the centreline is calculated. The centreline contains more vertices the higher the curvature of the channel. Along the centreline, for each vertex the following parameters have been calculated using Python scripting:

- **Id**: consecutive number, counted from upstream (Juba) to downstream (Bor)
- **Distance**: the distance between the points [m]
- **Cumulative distance**: the distance to the most downstream point of the river (Juba) [m, km]
- **Width**: the water surface width of the river
- **Radius**: the radius between current and last point calculated from intersection point of perpendicular lines of each polyline pair, cut-off radius is set to 10km
- **Navigation width**: the required navigation width of the ship, increased by a defined buffer

- **Width reserve**: the remaining width of the channel, if zero or negative, this location has to be dredged

The required **navigation width** depends on the ship properties and barges setup as well as the curvature (radius) of the shipping channel and recommended buffers. The smaller the radius (the higher the curvature) the higher is the drift of the ship and hence, the larger is the required navigation width. This relationship is empirically described by the following equation:[104]

$$W_{Nav,bend} = \sqrt{(R+b)^2 + (Cf \cdot L)^2} - R$$

where $W_{Nav,bend}$ is the navigation width in bends, R is the radius of the channel section, b is the ship width, Cf is a coefficient that can be set to 0.95 and L is the ship length. A single barge used on the Bahr el-Jebel and the White Nile River is 11m wide and 35m long. The pusher is 10m wide and 25m long.
The barge setup of 2x2 barges (2 barges next to each other and behind each other, so 4 barges in total) then yields a geometry of L =95m and b =22m

The equation is valid for locations where radius > shiplength and if turning point lies between ship middle point and bow of ship. This is not the case for all locations with very high curvature along the Bahr el-Jebel, therefore results can be used to remotely identify existing bottlenecks, but for the final shipping channel design, the navigation width, especially in sharp bends, should be assessed on the ground.

At straight sections, the minimum required width is not equal to the ship width, but should be ship width is increased due to possible ‘wiggling’ of the ship with an angle of 3 degrees:[105]

$$W_{Nav.straight} = b + L \cdot \sin(\theta)$$

where $W_{Nav,bend}$ is the navigation width in straight sections and θ is the wiggling angle of 3 degrees.
Final navigation width W_{Nav} is then calculated as:

$$W_{Nav} = \min\left(W_{Nav,bend}, W_{Nav,straight}\right) + Buff$$

where $Buff$ is the recommended buffer to define the final navigation width, defined as 12m left and 12m right, so 24m in total.[106]

By subtracting the actual channel width from the required navigation width, the width reserve is obtained, which shows the remaining channel width. If this value is smaller zero, the river width should be widened in order to obtain the recommended navigation width.

Calculating depth and velocity distribution
The hydraulic model HEC-RAS 5.03 is used to calculate water depths and flow velocities. The application is limited to one-dimensional (1D) calculations. Though the Bahr el-Jebel and White Nile River from Juba to Renk contain braided sections and flow through the Sudd wetland

[104] Lecher, Luehr, Zanke, 2001. Taschenbuch der Wasserwirtschaft. Binnenverkehrswasserbau.
[105] Wiegleb, 1997. Wassertechnik, Band 4.
[106] USACE, 1997. Engineering and Design, Inland Navigation and Canalisation.

where horizontal flow processes outside the channel banks play a significant role, especially during high discharge events, a fully 2D or coupled 1D-2D approach is not possible for this assessment. To resolve the in-stream channel geometry of 100s of kilometres in a 2D surface mesh in a resolution required to assess the shipping channel is technically not feasible. Instead, the consultant is using a 1D approach and consider only the in-stream processes. This is made possible by forcing the hydraulic model with in-stream discharge observations only, additionally considering flow splits in braided river sections and channel islands in the cross-section geometry.

1D depth and velocity distributions represent average values across a given cross-section. Regarding water depths, it is assumed that the ship channel to be established is located in the deeper-than-average parts of the cross-section. Therefore, presenting average water depths is conservative. Maximum flow velocities on the other hand occur in the centre of the channel and near the surface where ships sail. Therefore, the empirical factor of 2.13 is used to translate average flow velocities to maximum flow velocity.[107]

The following procedure and data sources are used to setup HEC-RAS.

Model Domain and Channel Definition

The left and right banks of the main channel and in-stream islands were digitised based on Google Earth images. The flow centreline was calculated from the left and right bank line. These datasets were used to derive perpendicular cross-sections on the flow centreline and to define channel and island intersection points (Figure 98). Intersecting cross-sections (can occur in extreme bends and wide river sections) have been removed, and the total model domain consists of 14,327 cross-sections and covers a distance of 1437km from Juba to about 100km downstream of Renk. The model domain is extended further downstream to avoid influence of the downstream boundary condition on calculated water depths and flow velocities.

[107] Moramarco, Saltalippi, Singh, 2004. Estimation of Mean Velocity in Natural Channels Based on Chiu's Velocity Distribution Equation.

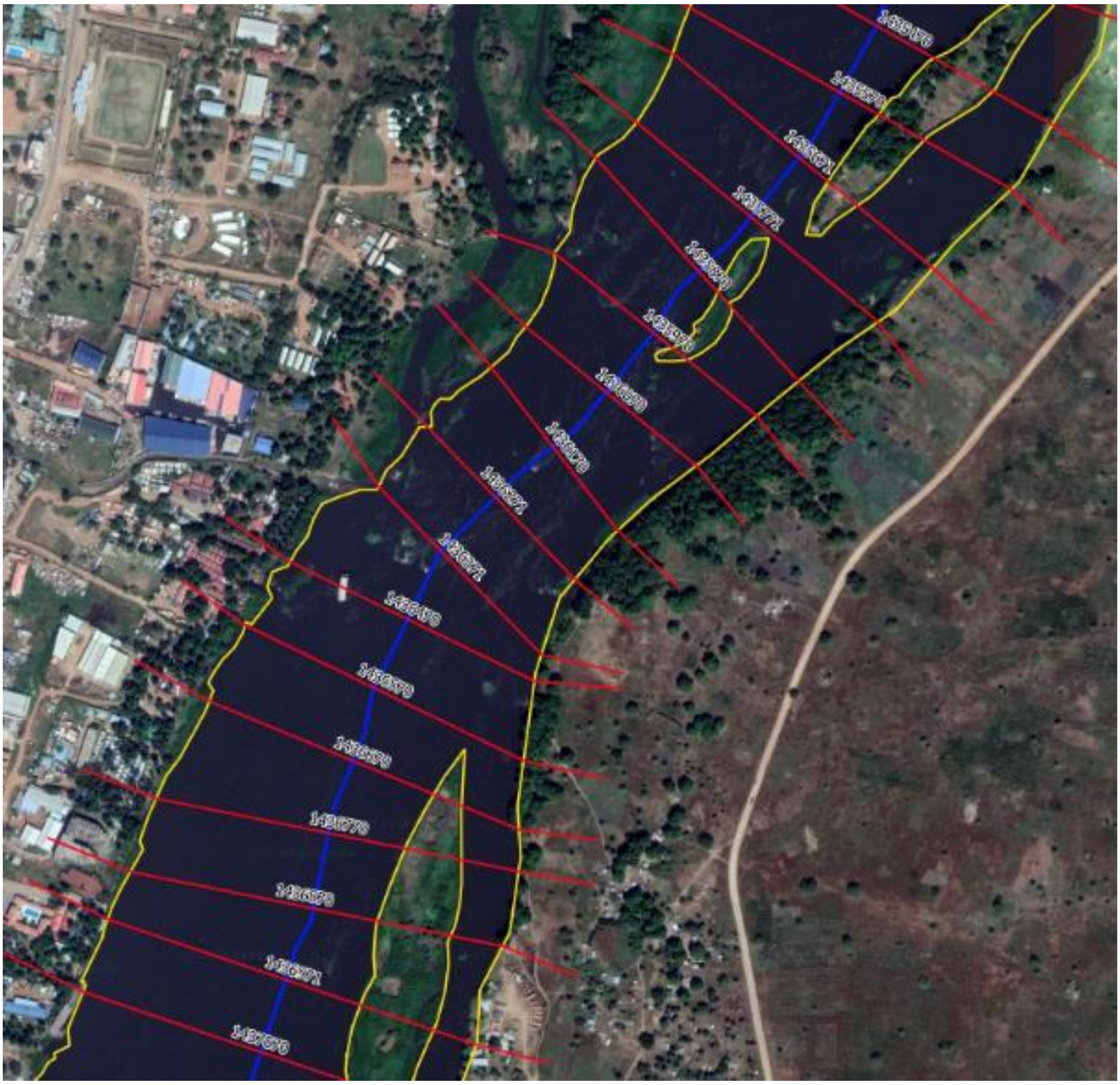


Figure 98: Model components at Juba on the Google Earth images, yellow: digitised banks and islands, blue: flow centreline, red: derived cross-sections in 100m interval with distance from downstream end of model domain in metres.

Topographic Data and Channel Bathymetry

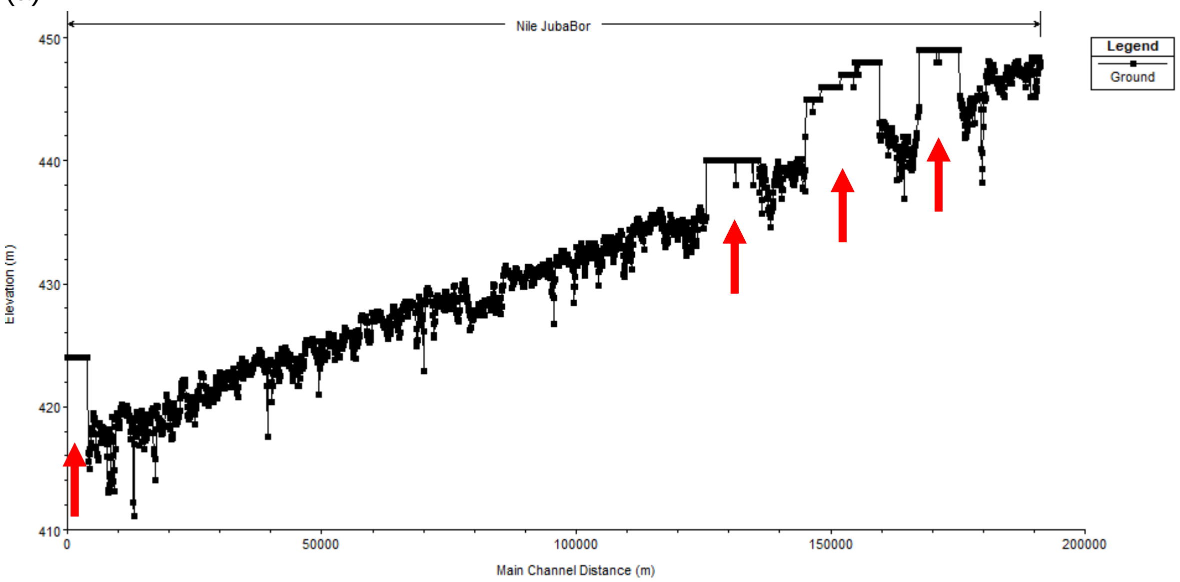
The Shuttle Radar Topography Mission (SRTM) 30m Digital Elevation Model (DEM) was acquired for the model domain[108], the individual tiles were merged, clipped to the region of interest, projected and resampled using bilinear interpolation to a cellsize of 15m in order to keep a smoothed representation of the river banks. The SRTM elevation depicts the water surface elevation and therefore does not allow direct extraction of channel bathymetry and longitudinal profile of channel bed slopes.

Bed slopes and channel depths for the HEC-RAS geometry are derived using two approaches. The first approach is used between Juba to Bor. There, the bathymetric data from the river survey was merged in the SRTM30m and used to derive an initial HEC-RAS geometry file. Figure 99a shows the initial longitudinal channel bed profile. The locations where the survey vessel left the main channel due to lack of water depth are clearly visible as the four stepwise increases of bed elevation (arrows in Figure 99a). To estimate these channel depths, a linear

108 https://earthexplorer.usgs.gov/

width-depth relationship has been derived from the data where the survey took place. Therefore, at each cross-section, the depths distribution has been sampled for each cell and the average depth has been recorded alongside with the width between the banks. The resulting relationship (Figure 100, where x is the river width and y the depth) has a goodness of fit of r^2 = 0.3 and a standard deviation of 0.6m. For river width higher 1000m, depths of 1.5m are assumed. The shown equation is used to extrapolate observed depths to locations where no survey was carried out. The interpolated depth profile between Juba and Bor is shown in Figure 99b, as can be seen, the locations where no survey could have been carried out due to too shallow water levels, bed elevations are still visibly higher.

(a)



(b)

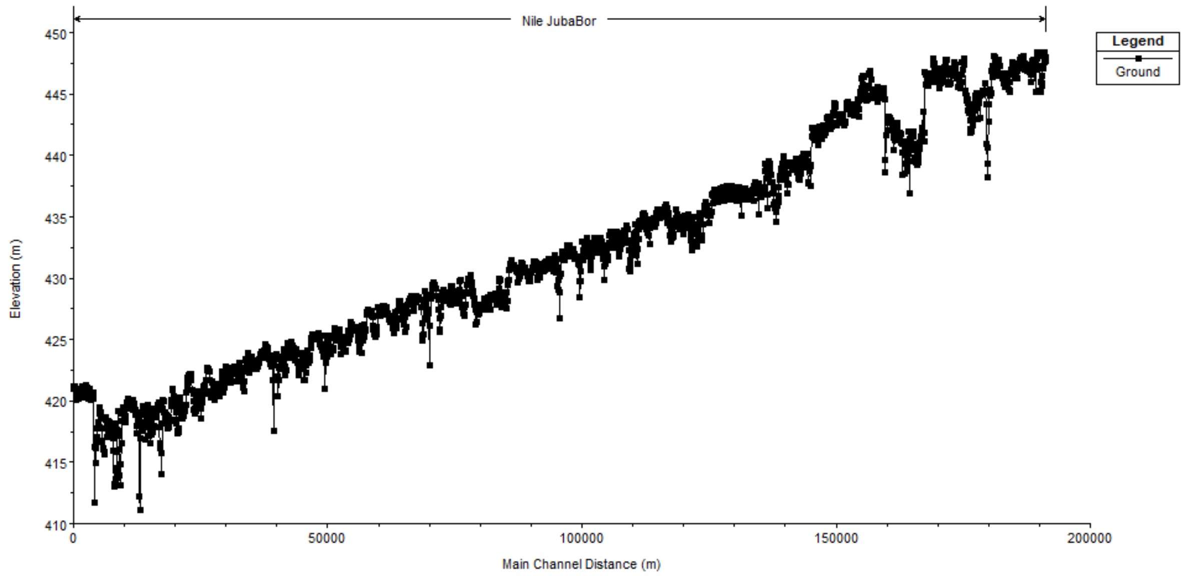


Figure 99: Channel bed slope from Juba to Bor (a) surveyed sections only and (b) surveyed section with interpolated water depths using the relationship shown in Figure 100. Shallower sections where the survey could not be carried out are marked by red arrows.

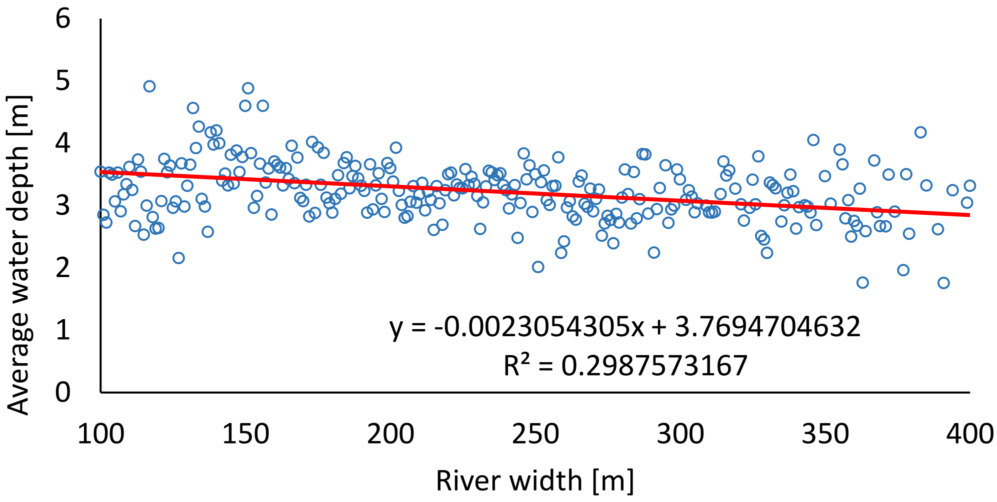


Figure 100: Width-depth relationship and fitted equation with goodness of fit measure ($r^2 = 0.3$), derived from the survey between Juba to Bor.

A second approach is used to estimate river bed bottom outside the surveyed Juba – Bor stretch up to Renk. Bathymetry is derived through the established width-depth formula (Figure 100), the SRTM30m and recently published data about the morphology and elevations of the Bahr el-Jebel and Sudd region. Problematic sections of the raw SRTM data include the Sudd swamps. Figure 101a shows the profile based on the SRTM. The SRTM elevation is implausible and arises from erroneous radar return signals in the papyrus vegetation of the Sudd, with a published average correction factor of -4.66m.[109] Therefore, the jump in the bottom profile occurring at 1250000 Main Channel Distance in Figure 101a is corrected by reducing bed elevation of the downstream cross-sections by 4.66m. The noise in the longitudinal elevation profile in the Sudd swamps is filtered through a digital filter (Savitzky-Golay, which effectively filters data without distorting the original signal). The filter is calibrated on the survey data from Juba to Bor, where the 90 percentile of bed elevation-change within a 2km distance is 6m. Since the bed elevation is becoming consecutively smoother downstream of Bor[110], the filter is set to yield a 99% bed elevation-change of 6m, which results in a smoother longitudinal bed profile (Figure 101b). This final longitudinal elevation profile is used in HEC-RAS hydraulic modelling software and is the basis for populating the cross-sectional geometry (see Figure 102 for an example).

[109] Petersen, Lebed, Fohrer, 2009. SRTM DEM levels over papyrus swamp vegetation – a correction approach.

[110] Petersen, Sutcliffe, Fohrer, 2008. Morphological analysis of the Sudd region using land survey and remote sensing data.

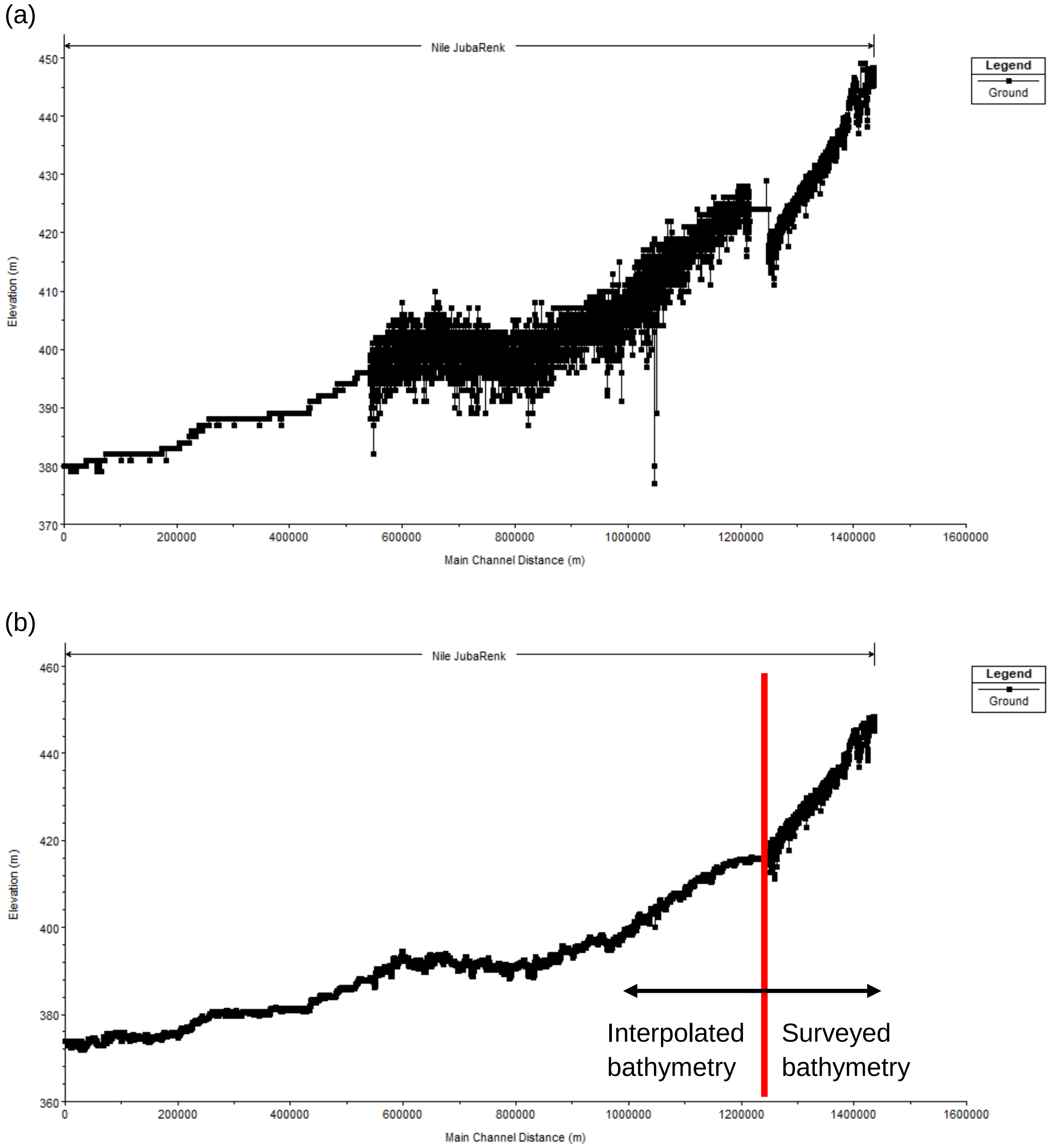


Figure 101: Elevation profile from Juba (right) to Renk (left) of (a) raw SRTM30m with the highly fluctuating region of the Sudd swamps in the centre which is unusable for hydraulic simulations and (b) corrected elevation profile based on correction factors[109], longitudinal noise filtering and adjusting bed level using the equation presented in Figure 100, vertical red line shows the transition from the surveyed bathymetry (Juba to Bor) to the interpolated bathymetry based on the SRTM (Bor to Renk).

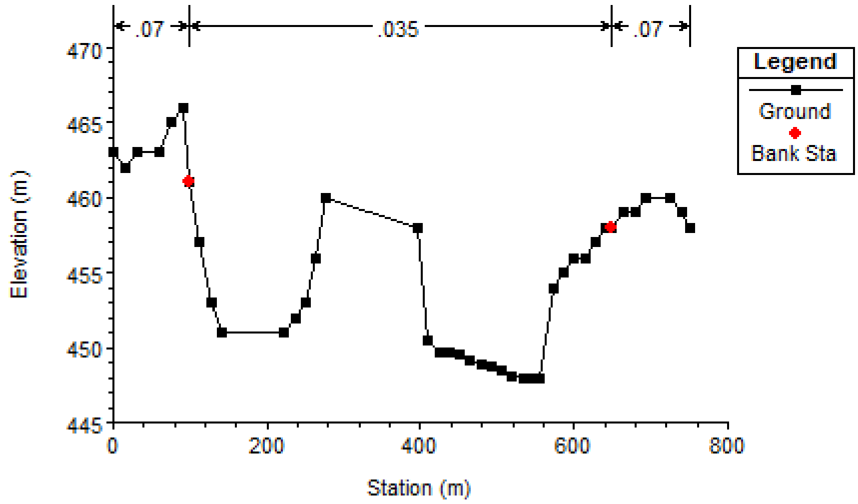


Figure 102: Example cross-section in HEC-RAS with a channel island.

Roughness Data and Upstream-downstream Boundary Conditions

Channel roughness information in HEC-RAS is depicted by the Manning's n value and is required to calculate hydraulic losses. Generally, smaller roughness values lead to lower water depths and higher flow velocities, while higher roughness values lead to higher water depths and lower flow velocities. The roughness values are used as a calibration parameter and initial Manning's n roughness values are set to 0.035 in the channel and 0.07 outside the channel based on established literature[111] and experience.

For computing a mixed flow regime of subcritical and supercritical flow, boundary conditions at the upstream and downstream model domain are required. Therefore, the water surface slope upstream of Juba (4.136km for 1m elevation difference = 0.00024m/m) and downstream of Renk (33.3km for 1m elevation difference = 0.00003m/m) was taken from the SRTM.

Flow Data and Design Flow

The flow system from Juba to Renk was analysed for deriving discharges and flow changes along the model domain. The Bahr el-Jebel and White Nile River branches with the highest discharges are considered to be the main shipping channels. All available flow data was screened, assessed gaps and plausibility (clarity of assignment to a single channel, extreme jumps, up-downstream losses and confluences). The data useful for the study is shown in Figure 103, including the flow connections within the Bahr el-Jebel and White Nile River system. The black boxes show gauges along the main channel. Red and green arrows show flow splits and confluences respectively, where observed values were used to modify the main channel discharges. The grey circles indicate locations where flow splits within the main channel occur, but where no observations are available. At these locations, flows have been estimated by the ratio of the main channel width to the side channel width. Between each flow change location shown in Figure 103, flow values are linearly interpolated between all cross-sections to account for the constant losses that the Bahr el-Jebel is subject to, which occurs especially in the Sudd.

[111] Chow, 1959. Open Channel Hydraulics.

Figure 103: Flow schematics for the model domain from Juba to Malakal (no additional major flow changes occur up to Renk). Background image: OpenStreetMap.

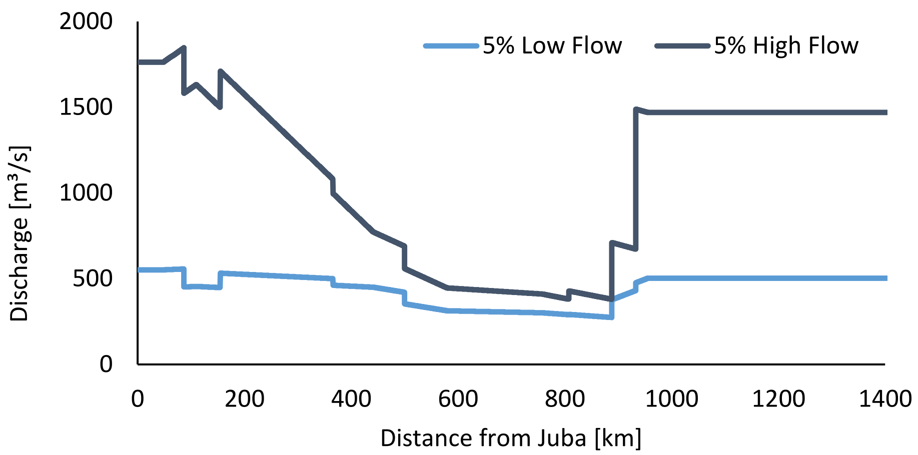


Figure 104. Longitudinal changes in discharge from Juba to Renk based on the flow schematics shown in Figure 103 and the linear interpolation between the flow change locations. Note the significant decrease of discharge in the Sudd, especially for the high flow scenario.

The consultant considers two design scenarios in the hydraulic model: First, minimum flow, which eventually causes such low water depths that ships with a certain draft cannot pass the channel. Second, maximum flow, which causes high flow velocities up to the point where sailing ships becomes too dangerous or the velocities are beyond the ships design velocities it is able to handle. For both minimum and maximum flow, the consultant defines the 5% lowest and 5% highest flows observed in the historical flow data. This means, that ships designed for these conditions should be able to operate 90% of the time. Table 25 lists the flow gauges and derived flows used for the simulations and the distribution of the low and high flow values along the model domain is shown in Figure 104, which is based on the flow schematic shown in Figure 103.

Table 25. Used gauges along the hydraulic model domain with selected period of record and location

Station	Time Period	Longitude	Latitude
WN Malakal	1936 - 83	31.651	9.529
Sobat Mouth	1936 - 83	31.617	9.35
WN US Zeraf	1936 - 83	31.117	9.433
BeZ Mouth	1940 - 73	31.133	9.417
BeZ MeshraKwatch	1940 - 73	30.7	8.317
BeG ExitLakeNo	1923 - 40	30.467	9.517
BeJ BuffaloCape	1936 - 83	30.383	9.217
BeJ HilletNuer	1936 - 83	30.3	8.15
BeJ BeZ CutAtHead	1936 - 83	30.55	7.783
BeJ DS LakeNyong	1937 - 83	30.6	7.45
BeJ Gigging	1936 - 67	31.75	5.65
BeJ Gemeiza	1936 - 83	31.783	5.683
BeJ Mangalla	1936 - 83	31.767	5.2
BeZ = Bahr el-Zeraf	WN = White Nile River	BeJ = Bahr el-Jebel	
US = Upstream	DS = Downstream		

Table 26: Used gauges with data for the 5% low and 5% highest flows: Discharge, average velocities, average flow depths in the gauges cross-section. Source: Nile Basin Volumes.[112]

Station	5% Low Flows			5% High Flows		
	Q [m³/s]	D [m]	V [m/s]	Q [m³/s]	D [m]	V [m/s]
WN Malakal	502	3.6	0.4	1470	6.4	0.6
Sobat Mouth	44	--	--	816	--	--
WN US Zeraf	274	4.5	0.4	380	6.3	0.6
BeZ Mouth	103	--	--	331	--	--
BeZ MeshraKwatch	106	--	--	212	--	--
BeG ExitLakeNo	2	--	--	48	--	--
BeJ BuffaloCape	301	5.0	0.7	411	5.6	0.8
BeJ HilletNuer	313	4.9	0.6	446	5.8	0.8
BeJ BeZ CutAtHead	67	--	--	130	--	--
BeJ DS LakeNyong	450	4.3	0.6	773	6.1	0.8
BeJ Gigging	105	--	--	264	--	--
BeJ Gemeiza	455	3.4	0.8	1632	7.1	1.4
BeJ Mangalla	552	2.5	0.9	1764	4.8	1.4

Hydraulic Model Plausibility Assessment

Plausibility of the hydraulic model results can be checked at the gauge locations where the old data on discharge, average flow velocities and average water depth are available for the simulated scenarios Figure 105 shows the comparison of the simulated water depth and flow velocities with the historical observations listed in Table 26. Since at Gemeiza for the high scenario water depths match, but flow velocities show a high deviation, the cross-sectional profile for high water levels is not exact. This can either be due to changes over time or the location of the gauge is not accurate.

It must be stressed that, currently, there is no working gauge along the White Nile River and the calibration of the model on the decades-old data is not ideal. Therefore, water level data was compared to the data observed during the survey carried out within this study. This yielded a correction factor of 1.43m, by which modelled water levels needed to be reduced to match the observations. The consultant strongly suggests establishing working flow gauges along the White Nile River to reduce uncertainties in future studies.

[112] The Nile Basin, Volume II. Measured Discharges of the Nile and its Tributaries.

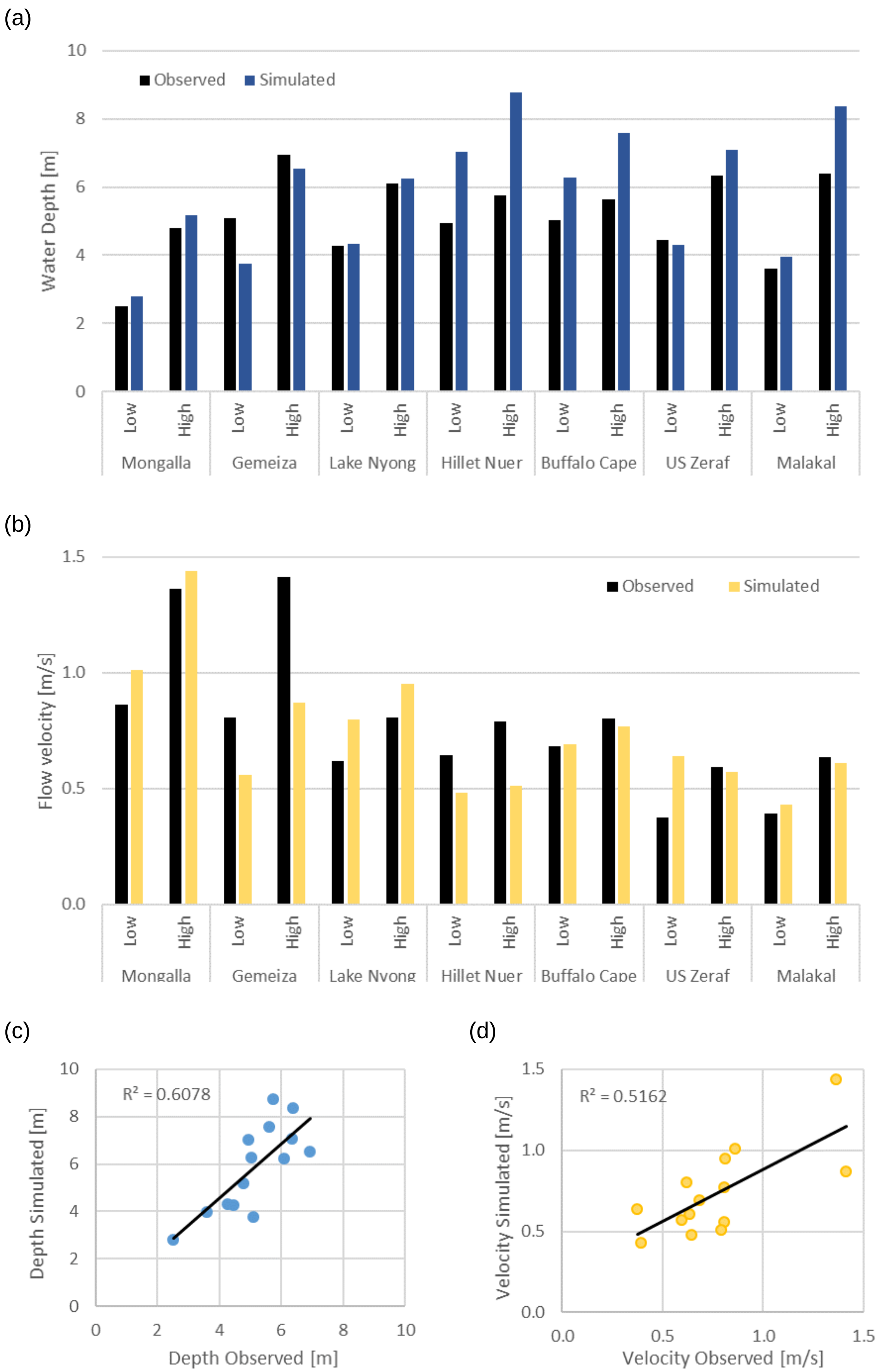


Figure 105: Hydraulic model results compared to observations at the available gauges for the 5% low and 5% high flow scenarios (a) water depths, (b) flow velocities. Scatter plots with goodness of fit for (c) water depths in [m] ($r^2 = 0.63$) and (d) flow velocities in [m/s] ($r^2=0.52$).

Annex IV Port Assessment Sheets

Juba

Name of Port	Juba Port
Location coordinates	N. 04^0 49’50,09’ E. 31^0 36’51.44’
Approximate port area	600 x 250m = 150,000m^2 = 15 ha
Geological condition of port area (soil type, slopes, river bank height)	• Black cotton soil with clay pockets • Slopes of river bank 1:3 • Level difference between river water and general port surface 1.50m
Port roads	Length: 750m
	Width: 6m
	Surface type: gravel
	Condition: poor
Goods handling area/ cargo handling	Area l x w: 35 x 10 = 350m^2
	Pavement type: un-compacted gravel
	Surface condition (Raw soil, gravel, paved) poor
Bulk goods storage area	Area: No designated area for bulk goods storage, however sufficient space available Surface condition: (Paved, gravel, raw soil)
River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 3.50m Narrative difference between high and low water level. Top of quay wall to river level: 2.10m
Quay walls	Length: 35m Width: 12m
	Type of structure (concrete, sheet): Steel structure with I-Beams and steel plates
	piles, wooden planks
	Condition: Serviceable
	Equipment: Fender Bollards:2
Jetty N/A	Length: Width:
	Type of structure (concrete, sheet)
	piles, wooden planks
	Condition
	Equipment: Fender Bollards
Equipment	
Lifting equipment	Number of cranes: 1

	Type of cranes: Portal crane on steel tracks
	Lifting capacity: 300kg
	Condition: Serviceable
	Other handling equipment: (forklift, loaders) N/A
Firefighting equipment	Available equipment and staff: N/A
Electric power generating sets	Type:
	Output:
	Condition:
	No. of units
Workshop facilities	Available: N/A Operating:
	Power tools:
	Welding equipment
Ship recovery installation	Concrete ramp: N/A Winch:
Refuelling installation	Fuel storage capacity Fuelling system (fixed pipes, on demand hose)
Storm water drainage system N/A	N/A
Water oil separator N/A	N/A
Structures	
Offices	No. of offices: 1
	Type of structure: Pre-fab. wooden structure
	Floor area: 48m^2
	Condition: serviceable and in use
Warehouses	No. of warehouse buildings: N/A
	Type of structure:
	Floor area:
	Condition:
	Cold chain, storage volume
Workshop sheds	Type of structure: N/A
	Floor area:
	Condition:
Staff accommodation	No. of units: N/A
	Type of structure:
	Total floor area:
	Condition:
Water supply and sanitation	Number/type of toilet facility: N/A
	Sewage disposal: (VIP latrines available)

	Water source:
	Pumping equipment:
	Water treatment:
	Elevated storage tank:
	Reticulation system:
Security installation	
	Gates: 1 steel gate
	Guard houses: N/A
	Fence: Type: Chain-link with angle iron posts, length: 1900m, partly demolished
	Security lighting: N/A

General observations / questionnaire

Is the port in use?	Not frequently, 3-4 calls per month
Which department is managing the port? Who manages the port locally, chain of command?	Ministry of Transport Port Manager Harbour Master
How many staff are employed? Admin, cargo handling, workshop, security, etc.	Accountant 2 Crane operator 2 Mechanics 3 Clerks 2 Loaders 10 temporary engaged Security guards 4
Number of vessels berthing per month: Average duration of stay Vessel capacities:	3-4 4-10 days < 300t
What kind of services are provided to port users (Loading, offloading, refuelling, maintenance, repairs, storage, cold chain, etc.)	Loading and offloading
Estimated volume of transshipped goods per month/year in t:	No info available
Distance of access road from port to national road network:	600m
Condition of access road:	dilapidated
Which construction material can be obtained from within the vicinity of the port?	All material basic construction material available in Juba
Distance for sourcing of the following construction material: • Cement • Crushed aggregate • Building sand • Reinforcement steel • Timber • General building hardware	 All material available in Juba ditto ditto ditto ditto ditto

Main problems and breakdowns including their causes	Port is actually not in use; No basic facilities available, fuel supply, repair shops etc.
List of priority investments as identified by port management	Priorities from port manager: • Container crane for 20' container • Extension of quay wall by 50m • Construction of bulk storage area (10,000 m^2) • Construction of ware house (2,500m^2)
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	Not found

Mangalla

Name of port	Mangalla
Location coordinates	N.05º12'09.72' E. 31º46'6.67'
Approximate ort area	4,900m^2
Geological condition of port area (soil type, slopes, river bank height)	Black cotton soil/sandy soil
Port roads: Whole yard is gravelled	Length/width:
	Surface type: Gravel
	Condition: Good
Goods handling area / cargo handling yard	Area: 600m^2 Soil condition: Gravel Surface: Paved, gravel, untreated
Bulk goods storage area	240m^2 Surface condition: Gravel Soil condition: Good
River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 3.0 Narrative difference between high and low water level (top of quay wall to water surface)
Quay walls	Length x width: 80m long
	Type of structure (concrete, sheetpiles, wooden planks): Sheet piles
	Equipment (fenders, bollards): bollards
	Condition: Good
Jetty None	Length x width:
	Type of structure (concrete, sheet piling, wooden planks)
	Equipment (fenders, bollards):
	Condition:

Equipment	
Lifting equipment	Number of cranes: None, hired when needed
	Type of cranes:
	Lifting capacity:
	Condition:
	Other handling equipment (e.g. forklifts, tractors, trailers, loaders): None
Electric power generating sets	Type: Perkins
	Output:44KV-1 no., 22KV – 3 no.
	Condition: Serviceable
	No. of units: 4
Workshop facilities	Available: None Operating:
	Power tools: None
	Welding equipment: None
Refuelling installations	Fuel storage capacity fuelling system (e.g. fixed pipes, on demand hoses): None
Ship recovery installation	Concrete ramp: None Winch: None
Stormwater drainage system? Water oil separator?	Yes, 2No.storm water drains
Structures	
Offices	No. Of offices: 1
	Type of structure: Container
	Floor area: 20m^2
	Condition: Fair
Warehouses	No. Of warehouse buildings: 5
	Type of structure: Steel structure and 4No.containers
	Floor area: 336m^2
	Coldchain? storage volume? None
	Condition: Good
Workshop sheds	Type of structure: None
	Floor area:
	Condition:
Staff accommodation	No. Of units: 5
	Type of structure: Containers
	Total plinth area: 100m^2
	Condition: Fair
Water supply	

	Water source: White Nile River
	Pumping equipment: 1No.
	Water treatment: Yes
	Elevated storage tank: Yes
	Toilet facilities & sewage disposal: Yes
	Reticulation system: To shower and toilet only
Security installation	
	Gates: 2No.big 2No.small
	Guard houses: Yes, 1 no.
	Fence type: Chain-link/iron sheets, length: 280m
	Security lighting: 9 no. flood lights

General observations / questionnaire

Is the port in use?	Yes
Which department is managing the port? Who manages the port locally, chain of command?	River Transport Department has rented it to 'Tristar' Company
How many staff are employed? (admin, cargo handling, workshop, other)	No fixed number. They come from Juba when required
Number of vessels berthing per month, average duration of stay (days)	4 no. fuel barges connected to a pusher berth once in two months
What services are provided to port users (loading, offloading, refuelling, maintenance, repairs, storage, coldchain, etc.)	There are no other port users
What are the major type of goods being loaded / offloaded at the port	Jet fuel and diesel
Estimated volume of loaded / offloaded goods in t per month/year	1,700,000Lt in 2 months
Berthing fees? how are finances administrated / accounted for? (system of record keeping and reporting obligations)	-
Main users (e.g. private, UN, non-government organisations (NGO), government)	Private (Tristar Transport Ltd)
Distance of access road from port to national road network	5kM
Condition of access road type of pavement	Fair, gravel
Which construction material can be obtained from within the vicinity of the port?	

Distance for sourcing of the following construction material: • Cement	Juba, 40kM
• Crushed aggregate	Juba, 40kM
• Building sand	Mangalla
• Reinforcement steel	Juba, 40kM
• Timber	Juba, 40kM
• General building hardware	Juba, 40kM
Main problems and breakdowns including their causes,	-
List of priority investments as identified by port management	-
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	No

There is a passenger shed that is in good condition. This port was constructed in 2010

Bor

Name of port	**Bor**
Location coordinates	N.06º12'13.9' E. 31º33'12.5'
Approximate port area	m^2 75,000
Geological condition of port area (soil type, slopes, river bank height)	Black cotton soil/sandy soil
Port roads:	Length/width:
	Surface type: untreated
	Condition: Worn out
Goods handling area / cargo handling yard	Area: 4,000m^2 Soil condition: Untreated Surface: Paved, gravel, untreated
Bulk goods storage area	None Surface condition: Soil condition:

River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 2.0 Narrative difference between high and low water level (top of quay wall to water surface)
Quay walls: None	Length x width:
	Type of structure (concrete, sheetpiles, wooden planks):
	Equipment (fenders, bollards): bollards
	Condition: Fair
Jetty: None	Length x width: None
	Type of structure (concrete, sheet piling, wooden planks)
	Equipment (fenders, bollards):
	Condition:
Equipment	
Lifting equipment	Number of cranes: None
	Type of cranes:
	Lifting capacity:
	Condition:
	Other handling equipment (e.g. forklifts, tractors, trailers, loaders): None
Electric power generating sets: None	Type:
	Output:
	Condition:
	No. of units:
Workshop facilities	Available: None Operating:
	Power tools: None
	Welding equipment: None
Refuelling installations	Fuel storage capacity fuelling system (e.g. fixed pipes, on demand hoses): None
Ship recovery installation	Concrete ramp: None Winch: None
Stormwater drainage system? Water oil separator?	None
Structures	
Offices	No. Of offices: 1block with 2rooms
	Type of structure: Brick walled, iron sheet roof
	Floor area: 40m^2
	Condition: Poor
Warehouses	No. Of warehouse buildings: 1

	Type of structure: None
	Floor area: -
	Cold chain? storage volume? None
	Condition:
Workshop sheds	Type of structure: None
	Floor area:
	Condition:
Staff accommodation	No. Of units: None
	Type of structure: -
	Total plinth area: -
	Condition: -
Water supply	
	Water source: None
	Pumping equipment: None
	Water treatment: None
	Elevated storage tank: None
	Toilet facilities & sewage disposal: None
	Reticulation system: None
Security installation	
	Gates: None
	Guard houses: None
	Fence type: Length:
	Security lighting: None

General observations / questionnaire

Is the port in use?	Yes
Which department is managing the port? Who manages the port locally, chain of command?	Stake holders: Union of Boat Operators, municipality, Revenue Authority and Port Security
How many staff are employed? (admin, cargo handling, workshop, other)	-
Number of vessels berthing per month, average duration of stay (days)	120 boats
What services are provided to port users (loading, offloading, refuelling, maintenance, repairs, storage, coldchain, etc.)	Freelance porters do the loading and offloading
What are the major type of goods being loaded / offloaded at the port.	Foodstuff, cattle, fish, charcoal, building materials, also passengers.
Estimated volume of loaded / offloaded	150t per day

goods in t per month/year	
Berthing fees? how are finances administrated / accounted for? (system of record keeping and reporting obligations)	Berthing fees charged per departure by Revenue Authority 100SSP
Main users (e.g. private, UN, NGO, government)	Private (Union of Boat Operators)
Distance of access road from port to national road network	800m
Condition of access road type of pavement	Earthroad in poor state
Which construction material can be obtained from within the vicinity of the port?	
Distance for sourcing of the following construction material: • Cement • Crushed aggregate • Building sand • Reinforcement steel • Timber • General building hardware	 Bor Juba, 160kM Juba, 160kM Bor Bor Bor
Main problems and breakdowns including their causes,	There is no proper port
List of priority investments as identified by port management	Construction of a new modern port
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	No

Mingkaman

Name of port	Mingkaman
Location coordinates	N.06º03’38.8’ E. 31º30’57.6’
Approximate port area	10,000m^2
Geological condition of port area (soil type, slopes, river bank height)	Black cotton soil/sandy soil
Port roads: Whole yard is gravelled	Length/width:
	Surface type: Gravel
	Condition: Good
Goods handling area / cargo handling yard	Area: 4,000m^2 Soil condition: Gravel Surface: Paved, gravel, untreated
Bulk goods storage area	650m^2 Surface condition: Paved

	Soil condition:
River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 3.0 Narrative difference between high and low water level (top of quay wall to water surface)
Quay walls	Length x width: 105m long
	Type of structure (concrete, sheetpiles, wooden planks): Sheet piles
	Equipment (fenders, bollards): bollards
	Condition: Good
Jetty	Length x width: None
	Type of structure (concrete, sheet piling, wooden planks)
	Equipment (fenders, bollards):
	Condition:
Equipment	
Lifting equipment	Number of cranes: One
	Type of cranes: Tower, rotating
	Lifting capacity: 1.2t
	Condition: Broken down
	Other handling equipment (e.g. forklifts, tractors, trailers, loaders): Forklift, crane truck-both broken down
Electric power generating sets	Type: Staunch
	Output:-
	Condition: Broken down
	No. of units: 1
Workshop facilities	Available: None Operating:
	Power tools: None
	Welding equipment: None
Refuelling installations	Fuel storage capacity fuelling system (e.g. fixed pipes, on demand hoses): None
Ship recovery installation	Concrete ramp: None Winch: None
Stormwater drainage system? Water oil separator?	No
Structures	
Offices	No. Of offices: 1block with 2rooms
	Type of structure: Brick walled, iron sheet roof
	Floor area: $40m^2$

	Condition: Poor
Warehouses	No. Of warehouse buildings: 1
	Type of structure: Steel structure with iron sheets
	Floor area: $650m^2$
	Coldchain? storage volume? None
	Condition: Good
Workshop sheds	Type of structure: None
	Floor area:
	Condition:
Staff accommodation	No. Of units: None
	Type of structure: -
	Total plinth area: -
	Condition: -
Water supply	
	Water source: Borehole
	Pumping equipment: Yes, broken
	Water treatment: No
	Elevated storage tank: Yes
	Toilet facilities & sewage disposal: Yes
	Reticulation system: To shower and toilets only
Security installation	
	Gates: 1No. big 2 no. small
	Guard houses: No
	Fence type: Chain-link, length: 320m
	Security lighting: 9 no. flood lights

General observations / questionnaire

Is the port in use?	Yes
Which department is managing the port? Who manages the port locally, chain of command?	Stake holders: Union of Boat Operators, Revenue Authority and Port Security
How many staff are employed? (admin, cargo handling, workshop, other)	-
Number of vessels berthing per month, average duration of stay (days)	300 boats
What services are provided to port users (loading, offloading, refuelling, maintenance, repairs, storage, coldchain, etc.)	Freelance porters do the loading and offloading
What are the major type of goods being loaded / offloaded at the port	Cattle, fish, charcoal, groundnuts timber, firewood. Also passengers

Estimated volume of loaded / offloaded goods in t per month/year	150t per day
Berthing fees? how are finances administrated / accounted for? (system of record keeping and reporting obligations)	Berthing fees charged per departure by Revenue Authority
Main users (e.g. private, UN, NGO, government)	Private (Union of Boat Operators)
Distance of access road from port to national road network	1kM
Condition of access road type of pavement	Gravelled but is narrow and has potholes
Which construction material can be obtained from within the vicinity of the port?	
Distance for sourcing of the following construction material: • Cement	Mingkaman market
• Crushed aggregate	Juba, 140kM
• Building sand	Mingkaman
• Reinforcement steel	Juba, 140kM
• Timber	Mingkaman
• General building hardware	Bor 40kM
Main problems and breakdowns including their causes,	Misuse of facilities – there is no proper management of the port
List of priority investments as identified by port management	Expansion of port, establishment of strong management, security lights, bigger office, repair of water supply, staff accommodation
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	No

There is a passenger shed that requires expansion. This port was constructed in 2015

Shambe

Name of port	Shambe
Location coordinates	N.07º06’24.0’ E. 30º46’27.7’
Approximate port area	4,900m^2
Geological condition of port area (soil type, slopes, river bank height)	Black cotton soil/sandy soil

Port roads: Whole yard is gravelled	Length/width:
	Surface type: Gravel
	Condition: Good
Goods handling area / cargo handling yard	Area: 600m^2 Soil condition: Gravel Surface: Paved, gravel, untreated
Bulk goods storage area	240m^2 Surface condition: Gravel Soil condition: Good
River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 3.3 Narrative difference between high and low water level (top of quay wall to water surface)
Quay walls	Length x width: 80m long
	Type of structure (concrete, sheetpiles, wooden planks):
	Equipment (fenders, bollards):
	Condition:
Jetty	Length x width:40m x15m
	Type of structure (concrete, sheet piling, wooden planks sheet piles)
	Equipment (fenders, bollards): bollards
	Condition: Good
Equipment	
Lifting equipment	Number of cranes: None,
	Type of cranes:
	Lifting capacity: -
	Condition: -
	Other handling equipment (e.g. forklifts, tractors, trailers, loaders) None
Electric power generating sets	Type: -
	Output:-
	Condition: Minor mechanical problems
	No. of units: 2
Workshop facilities	Available: None Operating:
	Power tools: None
	Welding equipment: None
Refuelling installations	Fuel storage capacity fuelling system (e.g. fixed pipes, on demand hoses): None
Ship recovery installation	Concrete ramp: None

	Winch: None
Stormwater drainage system? Water oil separator?	No
Structures	
Offices	No. Of offices: 4
	Type of structure: Container
	Floor area: 80m^2
	Condition: Poor
Warehouses	No. Of warehouse buildings: 5
	Type of structure: Steel structure and 4No.containers
	Floor area: 336m^2
	Coldchain? storage volume? None
	Condition: Good
Workshop sheds	Type of structure: None
	Floor area:
	Condition:
Staff accommodation	No. Of units: None
	Type of structure: -
	Total plinth area: -
	Condition: -
Water supply	
	Water source: Borehole
	Pumping equipment: Yes, but no power.
	Water treatment: Yes
	Elevated storage tank: Yes
	Toilet facilities & sewage disposal: Yes
	Reticulation system: To shower and toilet only
Security installation	
	Gates: 2No.big 1No.small
	Guard houses: 1 no
	Fence type: Chain-link/iron sheets, length: 215m
	Security lighting: No

General observations / questionnaire

Is the port in use?	Yes, by fishing boats only
Which department is managing the port? Who manages the port locally, chain of command?	Local government
How many staff are employed? (admin, cargo handling, workshop, other)	2 No
Number of vessels berthing per month,	5 No.

average duration of stay (days)	
What services are provided to port users (loading, offloading, refuelling, maintenance, repairs, storage, coldchain, etc.)	Docking only
What are the major type of goods being loaded / offloaded at the port	Fish
Estimated volume of loaded / offloaded goods in t per month/year	15t per month
Berthing fees? how are finances administrated / accounted for? (system of record keeping and reporting obligations)	Berthing fees per departure 450SSP
Main users (e.g. private, UN, NGO, government)	Private (Boat operators)
Distance of access road from port to national road network	2.5kM
Condition of access road type of pavement	Good, gravel
Which construction material can be obtained from within the vicinity of the port?	
Distance for sourcing of the following construction material: • Cement	Bor, 120kM
• Crushed aggregate	Yirol, 60kM
• Building sand	Yirol, 60kM
• Reinforcement steel	Bor, 120kM
• Timber	Yirol, 60kM
• General building hardware	Yirol, 60kM
Main problems and breakdowns including their causes	Lack of maintenance
List of priority investments as identified by port management	Renovation of the port facilities
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	No

There is a passenger shed that is in good condition. Port constructed in 2010

Bentiu

Name of port	Bentiu
Location coordinates	N. 9°17'11'' E. 29°48'48''
Approximate port area	24,000m^2 only estimated. Former port area cannot be seen anymore today
Geological condition of port area (soil type, slopes, river bank height)	Partly grass, partly reed, partly bare soil. River is complete overgrown. River bank has no slope. Good access to the river possible.
Port roads	Length:
	Width: 5m
	Surface type: soil
	Condition: very bad
Goods handling area/ cargo handling	Area l x w: N/A
	Pavement type N/A
	Surface condition (Raw soil, gravel, paved) N/A
Bulk goods storage area	Area: N/A Surface condition: (Paved, gravel, raw soil) N/A
River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 1m Narrative difference between high and low water level. Top of quay wall to river level: N/A
Quay walls	Length: N/A, width: N/A
	Type of structure (concrete, sheet)
	piles, wooden planks N/A
	Condition N/A
	Equipment: N/A Fender N/A Bollards N/A
Jetty	Length: N/A, width: N/A
	Type of structure (concrete, sheet)
	piles, wooden planks N/A
	Condition N/A
	Equipment: N/A Fender N/A Bollards N/A
Equipment	No equipment availably
Lifting equipment	Number of cranes:
	Type of cranes:
	Lifting capacity:
	Condition:
	Other handling equipment: (forklift, loaders)

Firefighting equipment	Available equipment and staff
Electric power generating sets	Type:
	Output:
	Condition:
	No. of units
Workshop facilities	Available: Operating:
	Power tools:
	Welding equipment
Ship recovery installation	Concrete ramp: Winch:
Refuelling installation	Fuel storage capacity Fuelling system(fixed pipes, on demand hose)
Storm water drainage system	N/A
Water oil separator	N/A
Structures	No structures
Offices	No. of offices:
	Type of structure:
	Floor area
	Condition
Warehouses	No. of warehouse buildings:
	Type of structure:
	Floor area:
	Condition:
	Cold chain, storage volume
Workshop sheds	Type of structure:
	Floor area:
	Condition:
Staff accommodation	No. of units:
	Type of structure:
	Total floor area:
	Condition:
Water supply and sanitation	Number/type of toilet facility: N/A
	Sewage disposal N/A
	Water source: N/A
	Pumping equipment: N/A
	Water treatment: N/A
	Elevated storage tank: N/A
	Reticulation system: N/A
Security installation	N/A

	Gates:
	Guard houses:
	Fence: Type: Length:
	Security lighting:

General observations / questionnaire

Is the Port in use?	No. Port has not been in use since 1989 (according to interview of a local)
Which department is managing the port? Who manages the port locally, chain of command?	N/A
How many staff are employed? Admin, cargo handling, workshop, security, etc. Provide organigram	0
Number of vessels berthing per month Average duration of stay Vessel capacities	0
What kind of services are provided to port users (loading, offloading, refuelling, maintenance, repairs, storage, cold chain, etc.)	N/A
Estimated volume of transshipped goods per month/year in t	N/A
Distance of access road from port to national road net work	100m
Condition of access road	Ok. Just dust road. Tarred road close.
Which construction material can be obtained from within the vicinity of the port?	N/A
Distance for sourcing of the following construction material: • Cement	N/A
• Crushed aggregate	N/A
• Building sand	N/A
• Reinforcement steel	N/A
• Timber	N/A
• General building hardware	N/A
Main problems and breakdowns including their causes,	N/A
List of priority investments as identified by port management	N/A
Find old elevation benchmarks (reference to	N/A

Khartoum level), typically a bronze plug at an old building	

Further comments:
Today (Dec 2017) there is almost nothing to find, indicating that there was a port many years ago. The port area itself was pointed to me by UNMISS security officer and he said, that the area to him was *'pointed out by one of the humanitarians who was working in Bentiu when the port was in operation'*. Even the former port area is hard to estimate. There is nothing except the water and two old boats indicating a port today. The information about the port area, including the information that the port is not in use since 1989, was from a local met during the port assessment. Part of the port area is used today for growing plants. Shells and bones from the war can be found all over the port area. The river was fully overgrown during the time of the port assessment. An old fence can be still seen around some parts of the port area.

Malakal

Name of port	Malakal
Location coordinates	N. 09^{0} 31'36.70' E: 31^{0} 39'02.31'
Approximate port area	300 x150m = 45,000m^{2} = 4.5 ha
Geological condition of port area (soil type, slopes, river bank height)	Organic black cotton soil with minimal sand content Part of river bank covered with thick vegetation Approx. 30m river bank natural slope in 1:2.5
Port roads	Length: 80m
	Width: 5m
	Surface type: Black cotton soil, partly mixed with gravel
	Condition: poor
Goods handling area/ cargo handling	Area l x w: no distinguished area identified
	Pavement type
	Surface condition (Raw soil, gravel, paved)
Bulk goods storage area	Area: Surface condition: (Paved, gravel, raw soil): N/A
	Roofed
River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 3m Narrative difference between high and low water level. Top of quay wall to river level: 0.60m
Quay walls	Length: 20m, width: 0.4m
	Type of structure: Reinforced concrete
	Condition: Serviceable
	Equipment: N/A Fender: N/A

	Bollards:2
Jetty	Length: 15m, width: 8m
	Type of structure:
	Steel structure, consisting of I-Beams and steel plates
	Condition: fair
	Equipment: N/A Fender: N/A Bollards: 2
Equipment	
Lifting equipment	Number of cranes: N/A
	Type of cranes:
	Lifting capacity:
	Condition:
	Other handling equipment: (forklift, loaders)
Firefighting equipment	Available equipment and staff: N/A
Electric power generating sets	Type:
	Output:
	Condition:
	No. of units
Workshop facilities	Available: N/A Operating:
	Power tools:
	Welding equipment
Ship recovery installation	Concrete ramp: N/A Winch: N/A
Refuelling installation	Fuel storage capacity: N/A Fuelling system (fixed pipes, on demand hose): N/A
Storm water drainage system	N/A
Water oil separator	N/A
Structures	
Offices	No. of offices: 1
	Type of structure: Permanent stone building
	Floor area: 185m^2
	Condition: Poor, partly abandoned
Warehouses	No. of warehouse buildings: 2
	Type of structure: Permanent stone building
	Floor area: 210m^2
	Condition: Poor, partly abandoned

	Cold chain, storage volume: N/A
Workshop sheds	Type of structure: N/A
	Floor area:
	Condition:
Staff accommodation	No. of units: 1 (MoT guest house)
	Type of structure: Permanent stone building
	Total floor area: 145m^2
	Condition: Serviceable, but requires refurbishment
Water supply and sanitation	Number/type of toilet facility: 2 – abandoned
	Sewage disposal: N/A
	Water source: N/A
	Pumping equipment: N/A
	Water treatment: Portable unit available but requires refurbishment: N/A
	Elevated storage tank: N/A
	Reticulation system: N/A
	Gates: 1 steel gate
	Guard houses: N/A
	Fence: Type: Chain-link with steel angle iron posts Length: 600m
	Security lighting: N/A

General observations / questionnaire

Is the port in use?	Occasionally in use
Which department is managing the port? Who manages the port locally, chain of command?	County administration
How many staff are employed? Admin, cargo handling, workshop, security, etc. Provide organigram	No info available
Number of vessels berthing per month Average duration of stay Vessel capacities	No info available 150 – 200t
What kind of services are provided to port users (Loading, offloading, refuelling, maintenance, repairs, storage, cold chain, etc.)	Manual offloading
Estimated volume of transshipped goods per month/year in t	No info available
Distance of access road from port to national road net work	500m
Condition of access road	dilapidated

Which construction material can be obtained from within the vicinity of the port?	Building sand
Distance for sourcing of the following construction material: • Cement • Crushed aggregate • Building sand • Reinforcement steel • Timber • General building hardware	 Kosti, Sudan ditto local Kosti, Sudan Kosti, Sudan Kosti, Sudan
Main problems and breakdowns including their causes,	No info available
List of priority investments as identified by port management	No info available
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	Not found

Malakal UN/WFP Port – WFP Jetty

Name of port	**Improvement of WFP earth fill jetty in Malakal**
Location coordinates	N.09^0 34’56.62’ E.31^0 39’29.27’
Approximate port area	120 x 200= 24,000m^2 = 2.4 ha
Geological condition of port area (soil type, slopes, river bank height)	Organic black cotton soil with minimal sand content Part of river bank covered with thick vegetation
Port roads	Length:200m
	Width: 5
	Surface type: Compacted black cotton soil
	Condition: poor
Goods handling area/ cargo handling	Area I: N/A
	Pavement type
	Surface condition (raw soil, gravel, paved)
Bulk goods storage area	Area: N/A Surface condition (paved, gravel, raw soil): N/A
	Roofed
Water level	Depth in metre from top of quay wall/jetty or river bank to river bottom: 3m[113] Narrative difference between high and low water level.

[113] The depth varies between 1.5 – 3m as river bottom level raises towards the river bank.

	Top of jetty surface to river level: 0.60
Quay walls	Length: N/A Width: N/A
	Type of structure (concrete, sheet)
	piles, wooden planks
	Condition
	Equipment: Fender Bollards
Jetty	Length: 105m, width:10m, only 50m are suitable for docking
	Type of structure
	Compacted improved earth fill
	Condition: Serviceable (temporary solution)
	Equipment: N/A Fender Bollards
Equipment	
Lifting equipment	Number of cranes: N/A
	Type of cranes:
	Lifting capacity:
	Condition:
	Other handling equipment: (forklift, loaders)
Firefighting equipment	Available equipment and staff: N/A
Electric power generating sets	Type:
	Output:
	Condition:
	No. of units
Workshop facilities	Available: N/A Operating:
	Power tools:
	Welding equipment
Ship recovery installation	Concrete ramp: N/A Winch: N/A
Refuelling installation	Fuel storage capacity: N/A Fuelling system (fixed pipes, on demand hose): N/A
Storm water drainage system	N/A
Water oil separator	N/A
Structures	
Offices	No. of offices: N/A
	Type of structure:
	Floor area

	Condition
Warehouses	No. of warehouse buildings: N/A
	Type of structure:
	Floor area:
	Condition:
	Cold chain, storage volume
Workshop sheds	Type of structure: N/A
	Floor area:
	Condition:
Staff accommodation	No. of units: N/A
	Type of structure:
	Total floor area:
	Condition:
Water supply and sanitation	Number/type of toilet facility: N/A
	Sewage disposal
	Water source:
	Pumping equipment:
	Water treatment:
	Elevated storage tank:
	Reticulation system:
Security installation	N/A
	Gates:
	Guard houses:
	Fence: Type: Length:
	Security lighting:

General observations / questionnaire

Is the port in use?	Occasionally in use
Which department is managing the port? Who manages the port locally, chain of command?	UN humanitarian organisations, WFP
How many staff are employed? Admin, cargo handling, workshop, security, etc. Provide organigram	No info available Temporary staff is hired as barges dock
Number of vessels berthing per month Average duration of stay Vessel capacities	1-2, but not regularly 200t
What kind of services are provided to port users	Manual offloading

(Loading, offloading, refuelling, maintenance, repairs, storage, cold chain, etc.)	
Estimated volume of transshipped goods per month/year in t	No info available
Distance of access road from port to national road net work	2km
Condition of access road	Fair, only useable in dry season
Which construction material can be obtained from within the vicinity of the port?	Building sand
Distance for sourcing of the following construction material: • Cement • Crushed aggregate • Building sand • Reinforcement steel • Timber • General building hardware	 Kosti, Sudan Kosti, Sudan Kosti, Sudan Kosti, Sudan Kosti, Sudan
Main problems and breakdowns including their causes,	The earth fill structure of the jetty is not adequate for requirements of UN operations
List of priority investments as identified by port management (UN staff)	The jetty needs to be enlarged to provide berthing facility for at least two barges
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	N/A

Melut

Name of port	**Melut**
Location coordinates	N. 10^0 26'50.09' E. 32^0 12'19.42'
Approximate port area	60 x 200 =12,000m^2 30 x 80 = 2,400m^2 Total 14,400 = 14.4 ha
Geological condition of port area (soil type, slopes, river bank height)	Organic black cotton soil with minimal sand content River bank slope 1:2.5
Port roads	Length: 500m
	Width: 6m
	Surface type: Local black cotton soil
	Condition: poor
Goods handling area/ cargo handling	Area l x w: 80x30m = 2,400m^2
	Pavement type: Compacted gravel

	Surface condition: serviceable
Bulk goods storage area	Area: N/A Surface condition: (Paved, gravel, raw soil)
	Roofed
River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 2m Narrative difference between high and low water level. Top of quay wall to river level: N/A
Quay walls	Length: N/A Width: N/A
	Type of structure (concrete, sheet)
	piles, wooden planks
	Condition
	Equipment: N/A Fender Bollards
Jetty	Length: N/A Width: N/A
	Type of structure (concrete, sheet)
	piles, wooden planks
	Condition
	Equipment: Fender Bollards
Equipment	
Lifting equipment	Number of cranes: N/A
	Type of cranes:
	Lifting capacity:
	Condition:
	Other handling equipment: (forklift, loaders)
Firefighting equipment	Available equipment and staff: N/A
Electric power generating sets	Type:
	Output:
	Condition:
	No. of units
Workshop facilities	Available: Operating: Not operating
	Power tools:
	Welding equipment
Ship recovery installation	Concrete ramp: N/A Winch: N/A
Refuelling installation	Fuel storage capacity: N/A

	Fuelling system (fixed pipes, on demand hose): N/A
Storm water drainage system	N/A
Water oil separator	N/A
Structures	
Offices	No. of offices: 1
	Type of structure: Permanent stone building
	Floor area $80m^2$
	Condition: Unserviceable, not in use
Warehouses	No. of warehouse buildings: 1
	Type of structure: Timber structure, covered with corrugated iron sheets
	Floor area: $160m^2$
	Condition: Unserviceable, not in use
	Cold chain, storage volume: N/A
Workshop sheds	Type of structure: Timber structure, covered with corrugated iron sheets
	Floor area: $110m^2$
	Condition: dilapidated, unserviceable
Staff accommodation	No. of units: N/A
	Type of structure:
	Total floor area:
	Condition:
Water supply and sanitation	Number/type of toilet facility: N/A
	Sewage disposal
	Water source:
	Pumping equipment:
	Water treatment:
	Elevated storage tank:
	Reticulation system:
Security installation	N/A
	Gates:
	Guard houses:
	Fence: Type: Chain-link with angle iron posts, length: 340m partly uprooted
	Security lighting: N/A

General observations / questionnaire

Is the port in use?	Currently not in use
Which department is managing the port? Who manages the port locally, chain of command?	County administration
How many staff are employed? Admin, cargo handling, workshop, security, etc. Provide organigram	No info
Number of vessels berthing per month Average duration of stay Vessel capacities	None for some time
What kind of services are provided to port users (Loading, offloading, refuelling, maintenance, repairs, storage, cold chain, etc.)	No info
Estimated volume of transshipped goods per month/year in t	No info
Distance of access road from port to national road net work	2.5km
Condition of access road	Black cotton soil, not useable during rainy season
Which construction material can be obtained from within the vicinity of the port?	Building sand
Distance for sourcing of the following construction material: • Cement • Crushed aggregate • Building sand • Reinforcement steel • Timber • General building hardware	 Kosti, Sudan Kosti, Sudan Kosti, Sudan Kosti, Sudan Kosti, Sudan Kosti, Sudan
Main problems and breakdowns including their causes,	No info
List of priority investments as identified by port management	No info
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	Not found

Note:
During the inspection of the port the consultant was stopped taking photographs by county officials and was escorted to the commissioner's office for questioning. The commissioner informed the consultant that he was not aware of the port project and that the consultant must report to his office before inspection of any government installation. The consultant presented copies of official correspondence to various departments requesting assistance from the state and county government officers. The commissioner then allowed the consultant to proceed with his assessment, however insisted that the current port site should not be rehabilitated, and a

new port should be developed. The consultant could not return to the port, instead was shown a different site some 3km downstream. The proposed site appeared to be unsuitable for construction of a port due to the following observations:

- Slopes of riverbank too gentle >1:5
- Dense vegetation along the river banks
- Long distance to road network

It is therefore recommended to approach the county government with the view to re-consider their decision and agree on a rehabilitation of the existing port.

Renk

Name of port	**Renk**
Location coordinates	N. 11^{0}44’ 52.28’ E.32^{0} 47’19.41’
Approximate port area	350 x 150 = 52,500 = 5.24 ha
Geological condition of port area (soil type, slopes, river bank height)	Organic black cotton soil with minimal sand content < 1:5 slope riverbank, largely overgrown with Nubian grass
Port roads	Length: 200m
	Width: 5m
	Surface type: local black cotton soil
	Condition: poor, unserviceable Access road from main port area to quay wall and cargo handling area has been submerged, quay goods handling area is cut-off from main land
Goods handling area/ cargo handling	Area l x w: 17 x 60 = 1,020m^2
	Pavement type
	Surface condition 30 % concrete 70% compacted gravel
Bulk goods storage area	Area: Surface condition: (Paved, gravel, raw soil). No designated area identified.
River bank stabilisation system	
Water level	Depth in metre from top of quay wall or river bank to river bottom: 3.60 – 4m. Narrative difference between high and low water level:400 mm Top of quay wall to river level: 0.50m
Quay walls	Length: 60m, width:0.4m
	Type of structure: Reinforced concrete
	Condition: serviceable, but Some of the reinforcement steel bars are exposed
	Equipment: N/A Fender Bollards

Jetty	Length: N/A Width: N/A
	Type of structure (concrete, sheet)
	piles, wooden planks
	Condition
	Equipment: N/A Fender: Bollards:
Equipment	
Lifting equipment	Number of cranes: N/A
	Type of cranes:
	Lifting capacity:
	Condition:
	Other handling equipment: (forklift, loaders)
Firefighting equipment	Available equipment and staff: N/A
Electric power generating sets	Type: N/A
	Output:
	Condition:
	No. of units
Workshop facilities	Available: N/A Operating:
	Power tools:
	Welding equipment
Ship recovery installation	Concrete ramp: N/A Winch:
Refuelling installation	Fuel storage capacity: N/A Fuelling system (fixed pipes, on demand hose): N/A
Storm water drainage system	N/A
Water oil separator	N/A
Structures	
Offices	No. of offices: 1
	Type of structure: Semi-permanent (abandoned)
	Floor area 40m^2
	Condition
Warehouses	No. of warehouse buildings: N/A
	Type of structure:
	Floor area:
	Condition:
	Cold chain, storage volume: N/A
Workshop sheds	Type of structure: N/A
	Floor area:

	Condition:
Staff accommodation	No. of units: N/A
	Type of structure:
	Total floor area:
	Condition:
Water supply and sanitation	Number/type of toilet facility: N/A
	Sewage disposal
	Water source: River
	Pumping equipment: Portable pumps
	Water treatment: Composite treatment unit, unserviceable
	Elevated steel storage tank: 48m^3, unserviceable
	Reticulation system:
Security installation	N/A
	Gates:
	Guard houses:
	Fence: Type: Chain-link on steel angle iron posts, length: 550m, partly uprooted
	Security lighting:

General observations / questionnaire

Is the port in use?	Occasionally
Which department is managing the port? Who manages the port locally, chain of command?	No port management available
How many staff are employed? Admin, cargo handling, workshop, security, etc. Provide organigram	Loaders on temporary terms Port security provided by county administration and SPLA County collects port charges
Number of vessels berthing per month Average duration of stay Vessel capacities	1-2 per month
What kind of services are provided to port users (Loading, offloading, refuelling, maintenance, repairs, storage, cold chain, etc.)	Loading/offloading by manual labour
Estimated volume of transshipped goods per month/year in t	No information
Distance of access road from port to national road net work	2km
Condition of access road	Poor, not useable during rainy season
Which construction material can be obtained from within the vicinity of the port?	Building sand

Distance for sourcing of the following construction material: • Cement • Crushed aggregate • Building sand • Reinforcement steel • Timber • General building hardware	Kosti in Sudan Ditto Available Kosti, Sudan Kosti, Sudan ditto
Main problems and breakdowns including their causes	No info
List of priority investments as identified by port management	No info
Find old elevation benchmarks (reference to Khartoum level), typically a bronze plug at an old building	Not found

Annex V Detailed Information for Tender Docs

While above under Section 5 the proposed options are described in detail, down here in Annex VI detailed technical specifications to support the tendering process by donors are summarised.

This information is meant to enable UNOPS to prepare and finalise the technical specifications and tender documentation for the procurement.

On the following pages the consultant has outlined detailed information and specifications that will enable UNOPS or other potential financiers to develop tender documents for projects, containing works, goods and services. The individual options are presented in the same structure as Section 6:

1. Dredging
2. Navigation Aid Systems
3. Rehabilitation and expansion of existing ports
4. River transport fleet and supporting crafts

Please refer to the following sub-sections for details.

Dredging and River Training

River dredging will require the procurement of capital investments as well as the procurement of operational goods and services. An environmentally sustainable dredging plan will need to be developed before the commencement of any works on the ground.

Capital Investments

Dredger:

CSDs with a minimum working depth of 8m, a maximum draft of 1.5 m and a minimum production capacity of 3000 m^3/h. The dredger shall be equipped with four winches for anchor cables as well as two spuds for self-anchoring. The dredger shall be fit to work under conditions with currents up to 8m/s. The dredger shall be equipped with the necessary storage and equipment including tools for common repairs, service and maintenance equipment as well as health and safety equipment suitable for usual operational needs.

Dredger accessories:

Accessories shall include eight mobile anchor weights suitable for holding the dredger in place each by their own under currents of up to 8m/s, a floating discharge pipeline of 2000m length, and a docking platform including the necessary anchoring for docking two barges for filling with dredged material. Further the dredger shall be equipped with a small motorised vessel for transporting staff and light equipment. The dredger shall be equipped with the usual electronics including radio communication and depth measurement devices.

Working boat:

The working boat shall be motorised and equipped with a crane in a manner suitable to handle, place and move the dredgers anchor blocks as well as to move and lift the floating pipeline and to efficiently tow the dredger, i.e. to handle all required works related to the dredging operations

Spare part and maintenance set

The dredger shall be delivered with a multi-year set including spare parts and maintenance that are required based on manufacturers experience

Delivery, assembly, commissioning and testing:

All equipment shall be delivered, assembled, commissioned and tested in Juba. Assembly shall be done utilising supervised local staff, selected in coordination with MoT, that is employed with the intention to later form the maintenance team.

Training:

The operation team shall be trained on the dredger on-site to be enabled to carry out the dredging works and maintain the equipment sustainably. Training shall include operators, deck hands, and maintenance/workshop staff.

Operational Goods and Services

Fuels and lubricants:

Fuels and lubricants as per specification of the selected dredger and auxiliary equipment

Wearing parts:

Wearing parts as per specification of the selected dredger and auxiliary equipment

Staff:

Staff will need to be hired, trained and maintained throughout the dredging period

Navigation Aid Systems

Different planning and implementation steps will be required for setting up the navigation aid system.

Technical Survey and Navigation Inventory

Conduct technical survey over 1,400km to establish exact needs and quantities for navigation aids to be installed and summarise information in navigation inventory using a kilometric index.

Capital Investment

Navigation aids shall be manufactured on-site in Juba and in other ports. Contractors responsibilities shall include the procurement of sufficient equipment and tools. The contractor shall create nine technical centres in the river ports, each outfitted to handle setup and maintenance of the navigation aids. It is envisaged that the centres are housed in 20-foot containers or similar. The contractor shall train local staff, enabling them to select, design, install and maintain the equipment. A workboat with crane shall be supplied for each of the nine centres to install and maintain the equipment. The contractor shall be responsible for supplying all necessary equipment including spareparts for a period of several years of operational maintenance.

A rough estimate of the navigation aids includes

- 200 polyethylene buoys
- 700 fixed beacons, to be installed along the river banks on steel masts

- 200 plastic poles, when buoys cannot be deployed (shallow waters) and when the river bank panel installation is not possible
- 20% of the equipment shall be required for operational maintenance in a multi-year support package

The fixed beaconing river banks marking system shall be modular, easy to be transported on the workboats, suitable for remote areas, robust, with high resistance of the material, maintenance free, secured against vandalism (i.e. with no salvage value, inviolable bolts), and panels shall be coated with retro-reflective vinyl to enhance visibility at night.

The plastic poles shall be made of PVC, 5 metres high, fitted in a concrete block of 150kg, to be equipped with a lifting ring to facilitate handling and installation on-site. The poles shall further be equipped with retro-reflective tapes to enhance navigation by night.

The floating buoys shall have three mooring eyes and adjustable ballast to ensure high stability of the buoy according to current intensities. They shall have submersion and self-righting capabilities, capable do deal with debris flow. The float diameter shall be minimum 0.60m, the float volume minimum 0.4$\mathbf{m^3}$, the focal height 1.40m able to be deployed in currents of seven knots.

Following construction, the navigation aids shall be installed along the river as per the developed navigation aid inventory and staff trained in all duties required for the installations.

Operational Goods and Services

Fuel and lubricants:
Fuel and lubricants for work boats to operate.

Wearing parts:
Maintenance parts for operations in the nine technical centres including running the workboats.

Staff:
Staff will need to be hired, trained and maintained for continuous support and maintenance.

Rehabilitation and Expansion of Existing Ports

Earthwork

Generally, construction of earthworks structures in areas of South Sudan, north of Juba, and within the larger vicinity of the White Nile present great challenges due to unsuitable soil conditions and unavailability of improved material for roads or other earth structures. Soils found in the area can be described of organic clays of medium to high plasticity (black cotton) with poor shearing strength and poor workability as a construction material.
To keep construction costs within affordable limits it is recommended to construct subbase and base for roads, cargo handling - and bulk storage areas with locally available soils, for roads wearing course and other pavements, material will have to be imported from a distant source. It is suggested to import wearing course material for Renk, Melut and Malakal ports by barge transport from Kosti in Sudan. For the ports of Bor and Shambe, material may be obtained from near Mangalla and transported by barge to the respective ports.

Roads

Clearing and grubbing:

(a) Clearing

Shall consist of the removal of trees, bushes other vegetation rubbish and other objectionable material including the disposal of all material resulting from the clearing and grubbing.
It shall also include the removal and disposal of structures that obtrude, encroach upon or otherwise obstruct the work and which can be cleared by means of bulldozers. (270 KW flywheel power).

(b) Grubbing

Where directed by the supervisor all stumps and roots larger that 75mm in diameter shall be removed to a depth of not less that 600mm below the finished road level and a minimum of 75mm below original ground level. Where the existing ground level has to be compacted all stumps and roots shall be removed to a depth of at least 200mm below the cleared surface. Except at borrow areas the cavities resulting from the grubbing shall be backfilled with approved material and compacted to a density not less than the density of the surrounding ground.

(c) Disposal of material

Material obtained from clearing and/or grubbing shall be disposed of, as indicated by the supervisor, in borrow pits or other suitable places and covered with soil. Measurement in ha/m^2.

Treatment of Existing Ground of Road Bed and Cargo Handling Areas

(a) Removal of unsuitable material

Any material, occurring below the existing ground surface in fill areas or roadbed material in cut areas, which is considered by the supervisor to be of a quality that would detrimental to the performance of the completed road, shall be removed to such widths and depths as ordered by the supervisor and dispose of, as directed. The excavated spaces shall then be backfilled with approved, imported material, compacted to the required density.

(b) Three-pass roller compaction

Where the existing ground in fill sections, or the road bed in cut sections, by reason of its inadequate in-situ density is prescribed by the supervisor to be given three roller passes compaction, it shall be prepared by shaping if necessary and compacting with a heavy pneumatic tired, vibratory flat steel drum, consisting of pneumatic tired wheels mounted on a rigid frame. The vibratory flat steel drum roller shall be capable of exerting a combined static and dynamic load of not less than 120 kN/m at an operating frequency not exceeding 1500 rpm.
Unless authorised by the supervisor, compaction shall comprise not less than three complete coverages on every portion of the area being compacted.
The supervisor shall be authorised to decide as to when conditions are favourable for compaction and as to when water is to be added by the contractor at his expense to achieve the required density. Measurement for treatment of existing ground in m^2.

Construction Requirements

General:

Road width is specified to be 5m, the height of road embankment shall be 0.3m uniformly

Embankments:

All materials excavated from the road prism shall, insofar as practicable, be used for the construction of embankments pavement layers and for such other purpose as shown on the drawing or as directed by the supervisor.
In case of material shortfall, borrow pits for material shall be located close to the road and material be excavated for the use on the road. The shaping and reinstatement of the borrow areas shall be done in such a way that the borrow areas will be properly drained, whenever practicable and where required the contractor shall place earth banks to divert any surface water away from the borrow area.
Measurement for earth fill in m^3

Gravel wearing course:
Material
The material must consist of hard durable angular particles, produced by crushing rock, crushing gravel or from natural sources and shall be clean and free from organic matters or lumps of clay. The material shall be of such a nature that it can be readily laid and compacted without segregation. They should have sufficient cohesion to prevent revelling and corrugating (specially in dry conditions). The number of fines (particularly plastic fines) should be limited to avoid a slippery surface under wet conditions.

Equipment
Gravel wearing course and shoulder material shall be spread by means of grader or other equipment approved by the supervisor. Gravel wearing course and gravel shoulder material shall be compacted by means of self – propelled or towed steel wheeled rollers capable of achieving the density requirements as per specifications. Water shall be applied by means of equipment, capable of distributing the applied water uniformly over the surface of the layer.

Compaction
Prior to compaction, the moisture content of the spread material shall be adjusted as necessary either by uniform application of water or drying out, to achieve within -1% to +2% of the optimum moisture content when determined in accordance with AASHTO T-180.
The material shall be compacted by the use of approved rollers progressing gradually from the outside towards the centre of the layer, except on super elevated curves, where the rolling shall begin at the low side and progress to the high side. Compact each layer full width. Roll from the sides of the centre, parallel to the centreline of the road. Along all places not accessible to the roller, compact the material with approved tampers or compactors. Each succeeding pass shall overlap the previous pass by at least one-third of the roller width. Compact each layer to at least 95% of maximum density.
Any area, which is inaccessible to rolling equipment, shall be compacted by means of mechanical tampers or other equipment approved by the supervisor.
Upon completion of compaction, the surface of the completed layer shall be tightly bound free from movement under the compaction plant, and free from laminations, ridges, cracks or loose or segregated material.
The in-situ density of the compacted layer shall be 95 % of the maximum dry density when determined in accordance with the requirement of AASHTO T-180 method D. The dry density hall be determined in accordance with the requirements of AASHTO T-190.
Measurement in m^3

Cargo handling areas and bulk storage

The specifications for the cargo handling areas / bulk storage have to be in a manner to withstand the movement of trucks with an axle load of not less than 8t. The build-up of the areas is as follows:

- Removal of top soil
- Depending on soil conditions 200 – 300mm to be cut into existing ground level
- 400mm consolidated hardcore layer to be placed
- 200 mm wearing course to be placed as described for roads
- Measurement in m^2

Storm water drains:

Storm water drains shall be constructed of suitable material, to be approved by the supervisor and shall be placed in such a manner that the water will flow on the natural ground and against the mitre bank. The mitre bank shall be compacted to 90% of modified AASHTO density in layers not exceeding 150mm, unless approved otherwise by the supervisor.
Measurement in m

Harbour Facility Works

Office Building:

Due to unsuitable soil formation the building has to be founded on a bending resistant, rigid reinforced concrete frame foundation and floor slab. Walls shall be of concrete blockwork with a reinforced ring lintel at the top level. Roof to be constructed of steel trusses covered with steel profile roofing sheets. Walls to be plastered with cement mortar internal and pointing external> floor screening of 50mm cement sand mortar with steel trowel finish. Wooden window frames with louvre glass and steel doors to each office with mortice locks. Building to be painted with emulsion paint on cement surface and gloss paint on wooden surfaces. Rain water gutters to be provided for rainwater harvesting.
Measurement in m^2 floor area

Warehouse:

A portal steel frame structure with iron sheet roof cover- and walls, mounted to a bending resistant, rigid reinforced concrete frame foundation and floor slab. On one gable side a double wing sliding gate is to be provided with a concrete ramp. Gutters to be fixed on fascia board for rainwater harvesting. The average height of the ware house should be 6m
Measurement in m^2 floor area

Workshop shed:

A portal steel frame structure with iron sheet roof cover- and walls, mounted to a bending resistant, rigid reinforced concrete frame foundation and floor slab. Gutters to be provided for rainwater harvesting. A concrete block store room is to be constructed inside the shed.
Measurement in m^2 floor area

Quay Wall Works

River Bank Stabilisation System:

In most of the ports new quay walls need to be constructed and / or extended. The consultant proposes to use for the construction of the quay wall the use of Z-profile sheet piles. UNOPS have in stock 112 no. of 11.50 long, AZ 17-700 Z-profile piles, which should be put into use.
Suitable cranes and vibratory hammers for driving the sheet piles into the ground are currently not available in South Sudan and consequently need to be imported from abroad. The equipment shall be transported to Juba by road and mounted on a barge or pontoon. The

barge/pontoon shall provide the work platform for the piling operation and move from port to port. Some of the ports cannot be accessed by road during the rainy season, hence the transportation of material and construction equipment to the ports shall be carried out by river barges.

Sheet piling with vibratory hammers are the most suitable application method for sheet pile walls, is determined by a number of issues:

- type and quality of soil (cohesion) on-site
- height, depth and weight of the sheet piles
- presence of obstacles in the soil
- onshore or offshore

Vibratory hammers:

In general, vibro technology is the most effective, efficient method and therefore best practice to drive steel sheet piles. A vibratory hammer is suitable for driving at limited depth in coarse-grained soils, including gravels and sands. After placing a pile driving frame, the sheet piles are driven by a crane, a rig or excavator mounted vibratory hammer.
The vibratory hammer is positioned on top of the sheet pile with clamps. It produces a sine-wave vertical pressure and the energy of the hammer will quickly drive the pile into the soil. The critical frequency is overruled by the stress waves in the sheet pile and the weight of the hammer acts as static loading.

Figure 106: Vibrating hammer, mounted on sheet pile.

Pressing machines

the technique of pressing (or extracting) a sheet pile wall too, goes without causing any vibrations or disorder for the environment. Pressing is often used for jobs in urban surroundings, close to ancient constructions or at sites that are subject to stringent regulations as to noise and vibrations.
On average, the compression stress of pressing machines varies from 600 to 1500 kN and is supplied by a hydraulic cylinder. Depending what system, single of fourfold sheet piles (not punched) are applied. If soil conditions are heavy, a small amount of water is injected under high pressure (fluidisation).

Pile driving:

The pile driving technique is powered by pneumatic or diesel pile drivers of which the dynamic weight is driven by hydraulics. By pulsating load on top of the sheet pile, the critical frequency is being passed and the sheet pile is driven into the soil. This technique is mainly used for the driving of piles and solid caissons, especially in cohesive soils and fine-grained soils including silts and clays. What pile driver to use, is depending on the soil condition, working depth and strength of the sheet pile wall. For plastic and composed sheet pile walls, there are special pile drivers on the market with less impact pressure in order not to damage the elements. Pile driving can also be done by a conventional drop hammer, with or without steel framework.

Figure 107: Crane with mounted vibrating hammer based on a barge.

List of proposed core equipment

- 1 Track crawler, 150 kw fly wheel output (Cat D6, or equivalent)
- 1 Grader 3.00 blade, 150 kw flywheel output (Cat 140G, or equivalent)
- 1. Self-propelled smooth compaction roller, 10 – 12t. Static weight
- 1 Wheel loader with $2m^3$ loading capacity
- 1 Dump truck, 20t loading capacity
- 1 Water bowser $10m^3$ loading capacity
- 1. Pedestrian plate compactor
- 1 Diesel propelled concrete mixer, $0.50m^3$ capacity
- 1 6' diesel propelled de-watering pump
- 1 Track crane with 15m long boom, mounted on a river barge
- 1 Hydraulic operated vibrating hammer for pile driving

Barges and Pushers for Supply of Humanitarian Aid

As mentioned in Section 5.5.2, it is not recommended by the consultant to procure additional pushers and barges, in particularly not as it is possible that the border to Sudan re-opens and a large river transport capacity currently stuck in Kosti, Sudan becomes accessible for river transport operations in South Sudan.

Following consultations with local operators and international suppliers, some basic recommendations for minimum specs required for barges and pushers to operate in South Sudan are outlined below.

Barges

Barges should, at a minimum be able to carry about 400t. Self-propelled barges are less fuel-efficient but if they are equipped with a landing ramp very flexible to operate independently. At present, a sufficient number of non-self-propelled barges and pushers are operational or could be repaired (Section 5.5.1). However, it was reported that only very little self-propelled barges are available and operational. Therefore the following technical specifications (Table 27) are for a 450t modular barge, which could be procured from overseas, transported by cargo-ship to Mombasa and from there by truck to Juba for local assembly.

Table 27: Technical specifications for a self-propelled barge with 450t carrying capacity

Technical Specifications Modular Barge (Self-Propelled)	
Loading type	Combined fuel + deck cargo / lockable cargo bay + additional deck-load
Fuel cargo capacity (l / m^3)	Depends on requirements, can be customised
Ramp (Y/N)	Y/RO-RO
Self-propelled (Y/N)	Y
Length – overall (m)	55
Width	12
Draft when fully loaded	1.5
Max. payload (t)	450
Range (km)	1,500
Fuel capacity (l)	52,000
Propulsion power	2 x 700 HP
Propulsion type	Steerable rudder propeller
Operating speed (kn)	9-10
Max river current (kn)	4.5

Pushers

Again, it is not recommended by the consultant to procure any additional pusher boats. For Nile River operations, a pusher should usually have two engines, each at a minimum 500BHP of power. It should be able to, at a minimum push four barges of a total of 1,200t. Further, the minimum pushing speed should be around 8 to 9 knots to assure safe operation even when passing areas of high flow velocities (refer to Section 5.5 for details). Currently, most cooling systems of the existing pushers have an internal cooling water cycle that is connected with a heat exchanger, which is cooled by an external cooling water cycle for which water is directly pumped from the river, passes the heat exchanger and is reverted to the river. When manoeuvring in shallow sections of the river, a lot of silt can be swirled up, which can clog the external cooling cycle and lead to overheating issues and engine failure. This should be considered when procuring new pushers. Table 28 outlines the minimum technical specifications for a pusher for White Nile River operations in South Sudan.

Table 28: Minimum Technical Specifications for a Pusher Boat

Technical Specifications Pusher	
Loading type	N/A
Fuel cargo capacity (l)	N/A
Min. pushing capacity (t)	1,200
Ramp (Y/N)	N
Self-propelled (Y/N)	Y
Max. draft when fully loaded (m)	1.5
Min. range (km)	1,500
Min. propulsion power	2 x 600 bhp
Min. operating speed (kn)	9.0

Annex VI Cost Estimates for Proposed Projects

Dredging and River Training

Dredging and river training requires significant capital investments and operation costs. Prices as collected from quality suppliers are listed below. The prices are estimates. Actual prices will have to be established through a competitive bidding process.

Capital cost per unit

- Dredger $3,100,000
- Dredger delivery $1,000,000
- Workboat, etc. $2,000,000
- Docking pontoon $2,000,000
- Split barge $3,000,000
- Self-propelled pontoon + hydraulic excavator for vegetation clearing $1,000,000

The above list applies per unit. The number of dredgers procured will have a significant impact on the implementation time of any dredging works. In addition, it needs to be considered that after the first-year maintenance dredging will need to be conducted to secure the achieved channel depth. Volume and location of maintenance dredging as well as the required number of dredgers can only be solidly defined after experience has been collected but it is estimated that for the first maintenance year one single dredger with the required auxiliary equipment will be sufficient.

Considering that with a single dredger the dredging works proposed in this report cannot be conducted within a year, it is suggested that at least two dredgers including the necessary auxiliary equipment are procured.

The need for a docking pontoon and split barges will depend on the chosen methodology for disposing the dredged material. If decided that disposal by floating pipe is sufficient, the docking pontoon and fleet of split barges are not required. A comparative overview is shown below, showing that costs are about tripled using split barge operations with only three barges per set, which can be considered the very lower limit, potentially leading to significant delays in dredging works if transport distances are far.

Table 29: Cost estimates for dredging options

Equipment	Dredged material disposal via floating pipe ($)	Dredged material disposal by split barge ($)
2x dredger including delivery	8,200,000	8,200,000
2x workboats and accessories incl. transport to South Sudan	4,000,000	4,000,000
2x docking pontoon	-	4,000,000
2x self-propelled pontoon + hydraulic excavator	2,000,000	2,000,000
6x Split barges (2x3)	-	18,000,000
Total	**14,200,000**	**36,200,000**

Next to capital costs operation costs for dredging works are significant. Again, it can be differentiated between floating pipe and split barge operations.

Estimated annual operation cost:

- Dredging operation 500,000 $/year
- Dredger maintenance package 600,000 $/year
- Split barge operation 330,000 $/year
- Split barge maintenance package 100,000 $/year
- 2x self-propelled pontoon + hydraulic excavator 100,000 $/year

Table 30: Operational cost for dredging operations

Annual operation	Dredged material disposal via floating pipe ($/year)	Dredged material disposal by split barges ($/year)
2x Dredging operations	1,000,000	1,000,000
2x Dredging maintenance	1,200,000	1,200,000
6x Split barge operations (2x3)	-	2,000,000
6x Split barge maintenance	-	600,000
2x self-propelled pontoon + hydraulic excavator operations	200,000	200,000
2x self-propelled pontoon + hydraulic excavator maintenance	200,000	200,000
Total	**2,600,000**	**5,200,000**

All prices are estimates. Dredging operations are calculated with an assumed fuel consumption of 1,500l/day, i.e. 1,500 $/day at current fuel prices, leading to 3,000 $/day for the two dredgers. Operation costs are based on assumed near full time one shift daytime operations with two dredgers. Operating three split barges in each of the two dredging teams adds another 6000 $/day. This is calculated assuming a fuel consumption of 1,000l/barge/day assuming each barge doing three trips/day times six barges.

Staff is to be provided by the Ministry of Transport. Staff costs are not included in the estimates. It is estimated that about 30 professional staff are required for operating each dredging unit.

Navigation Aid Systems

Navigation aid systems have been budgeted based on best practice with actual prices to be established through a competitive bidding process. Necessary items include:

Table 31: Cost estimates for navigation aid systems

Item	Estimated price ($)
Technical study for identifying actual navigation aid needs, types, quantity and distribution including inventory development and design	250,000
Supply of navigation aids, assumed with 700 beacons, 200 poles, 200 buoys	4,000,000
Tools and equipment for temporal maintenance	1,500,000

Shipping	600,000
Training	250,000
9x Working boats including transport	18,000,000
Total	**24,600,000**

Setting up the navigation aids is not included into the above cost, but for setting up the navigation aids the Ministry of Transport, assuming they will be in charge for the navigation aids, will need to create a dedicated unit including sufficient allocated staff for getting trained and carrying out the setup works. Respectively staff and operation costs need to be considered.

Estimated annual operation cost is 450,000 $/year. Staff cost are not included, it is estimated that about 100 professional staff will be required for efficient operations.

Rehabilitation and Expansion of Existing Ports

It must be noted, that detailed cost estimates prepared by JICA for Juba port could not be obtained from MoT.

Budgetary considerations as shown in the below tables consider both mobilisation as well as material and actual construction costs. Mobilisation is considered as one overall item, independent of what construction activities will eventually be conducted (general expenses).

Notes:

- The estimated costs are based on the current rates for civil engineering work in South Sudan.
- Mobilisation costs for sheet piling equipment assume that the machinery is available in Kenya and shall be transported from Nairobi to Juba.
- Cost for buildings, e.g. offices, ware houses and workshops are calculated by square metre. The rate is based on average building costs in South Sudan and shall vary, depending on the location and the related costs for material transport.
- No provision has been made for costs related to insurance of the work and occurrence of force majeure.
- For offloading construction material from the barges the use of an excavator is contained in the rate for the different work items.
- The rates do not include any government taxes, levies of duties.
- In the cost estimates, no provision has been made for unexpected escalation of fuel prices and costs of material.
- No provision has been made for costs related to insurance of the work and occurrence of force majeure.
- The estimates are valid for a time period of 3 month, from the date of submission of the study.
- The consultant has provided cost estimates for rehabilitation of all ports between Juba and Renk. The actual scope of work, to be executed at each port shall be determine by the client.

Mobilisation of Equipment (General Expenses)

Description	Unit	Quantity	Rate $	Amount $
Prime mover 350 hp, with 25m low loader from Nairobi to Juba and return, distance	km	3,000	15	45,000
Earth moving equipment transported by barges, from Juba to Renk and return. The machines will be offloaded at each port and on-loaded after completing earth work and transported to the next port location	days	120	6,000	720,000
Hire charge for barge to be used to transport the piling equipment and as a base for the pile driving machine	days	110	6,000	660,000
Barge transportation of sheet piles from Juba to the ports	days	55	6,000	330,000
Transportation of minor material and personnel to the port sites	LS	1	200,000	200,000
Total mobilisation cost				**1,955,000**

Cost Estimate for Sheet Pile Driving Works

Description	Unit	Quantity	Rate $	Amount $
Cost development for 1m^2 sheet piling, with profile type AZ 17-700				
Material				
1 length sheet pile of 11.50m = 8.07m^2, cost delivered to Juba = 2400, cost for 1m^2 = 300	m^2	1	300	300
Hire charge for crane and vibro driver = 300 $/h				
driving time per 1 length of 11.50m = 0.7 h				
1 sheet 11.50 x 0.70 = 8.05m^2.				
0.7h x 300 =210$/length				
210$/ 8.05m^2 /length = 26.10/m^2				26.1
Labour charge per m^2	h	3	10	30
Costs for 1m^2 sheet piling with AZ 17-700 profile				356.1
Add 50% for overheads and profit				178
Total costs for 1m^2 sheet piling with AZ 17-700 profile				**534.1**

Overview of Port Related Cost

Description	Amount $
Mobilisation	1,955,000
Juba Port	Refer to JICA estim.
Mangalla Port	620,500
Terekeka Port	2,141,550.50
Mingkaman Port	62,600
Bor Port	5,742,222.5
Shambe Port	1,527,757.5
Adok Port	2,141,550.50
Bentiu Port	2,731,543.50
Malakal Town Port	3,050,815
Malakal UN/WFP Port	2,031,865.50
Melut Port	2,521,458
Renk Port	3,571,765.50
Sum	**28,098,628.50**
Add 10% contingencies	2,809,862.85
Total construction and rehabilitation costs	**30,908,491.35**
Add 12% for design and construction supervision /contract management	3,709,018.96
Total estimated project costs	**34,617,510.31**

In the following sections, detailed cost for each port rehabilitation are provided.

Juba Port

JICA has prepared detailed cost estimates for Juba port rehabilitation. Hence, no additional cost estimates for Juba port are outlined here.

Mangalla Port

Description	Unit	Quantity	Rate $	Amount $
Construction of passenger waiting shed	m^2	100	450	45,000
Construction of parking area	m^2	1,000	90	90,000
Rehabilitation of access - and port road	lm	400	600	240,000
Supply of cargo truck with loading gear, 20t cap	no	1	110,000	110,000
Supply conveyor belt 10m long	no	1	8,000	8,000
Supply of jib crane with 5t lifting capacity	no	1	35,000	35,000
Supply of forklift reach stacker container handler	no	1	85,000	85,000
Provision of gabions for river bank protection	m^3	50	150	7,500
Total estimated cost for rehabilitation of Mangalla Port				**620,500**

Terekeka Port

Description	Unit	Quantity	Rate$	Amount$
Quay wall consisting of sheet piling with AZ-17-700 profile	m^2	805	534.10	429,950.50
Reinforced concrete capping on sheet pile walls	m^3	8.40	1,000	8,400
Backfill against quay wall to make level with existing ground below paving of cargo handling area	m^3	700	15	10,500
Construction of cargo handling area pavement	m^2	1,500	90	135,000
Construction of paved bulk storage area	m^2	3,000	90	270,000
Construction of port roads / access roads	lm	800	600	480,000
Construction of parking area	m^2	2,000	90	180,000
Supply and installation of gabions for riverbank protection	m^3	200	150	30,000
Construction of warehouse	m^2	500	450	225,000
Construction of office building	m^2	80	800	64,000
Construction of passenger waiting shed	m^2	100	450	45,000
Construction of ablution block	m^2	32	700	22,400
Construction of guard house	m^2	6	300	1,800
Perimeter fence with steel posts and chaining	lm	900	35	31,500
Supply and install security lights	no	30	400	12,000
Supply and installation of generating set 100 kVA	no	1	40,000	40,000
Supply of mobile crane with 12m boom and lifting capacity of 20t	no	1	70,000	70,000
Supply 10m long conveyor belt	no	1	8,000	8,000
Supply tractor and trailer, 70 HP	no	1	65,000	65,000
Supply and install oil/water separator	no	1	10,000	10,000
Supply and installation of bollards	no	6	500	3,000
Total estimated costs for reconstruction of Terekeka Port				**2,141,550.50**

Mingkaman Port

Description	Unit	Quantity	Rate$	Amount$
Extension of port office	m^2	40	490	19,600
Rehabilitation/replacement of lifting equipment, generating set, submersible pump	LS	1	8,000	8,000
Maintenance on port access road	lm	1,000	35	35,000
Total estimated cost for rehabilitation of Mingkaman Port				**62,600**

Bor Port

Description	Unit	Quantity	Rate$	Amount$
Quay wall, consisting of sheet piling with AZ 17-700 profile	m^2	1,725	534.10	921,322.50
Reinforced concrete class 25 for capping of sheet piling, incl. reinforcement steel and form work	m^3	18	1,000	18,000
Supply and install bollards	no	10	500	5,000
Back fill against new quay wall to make level with existing ground below wearing course	m^3	1,500	15	22,500
Construction of cargo loading /offloading area with interlocking concrete block pavement	m^2	4,500	90	405,000
Construction of bulk storage area with interlocking concrete block pavement	m^2	10,000	90	900,000
Construction of 15 x 30m ware house	m^2	3,000	450	1,350,000
Construction of port office	m^2	100	800	80,000
Ablution block with sewage disposal	m^2	32	600	19,200
Construction of workshop shed	m^2	72	600	43,200
Construction of small water supply, consisting of composite unit and elevated water tank	LS	1	125,000	125,000
Rehabilitation of port- and access roads with interlocking concrete block pavement	lm	1,400	600	840,000
Construction of parking area with interlocking concrete block pavement	m^2	4,000	90	360,000
Construction of storm water drain	lm	400	30	12,000
Erection of new perimeter fence as per specifications	lm	1,700	30	51,000
Supply of mobile crane 15t lifting capacity	no	1	70,000	70,000
Supply of overhead rail - crane with 40t lifting capacity	no	1	115,000	115,000
Supply of conveyor belt	no	1	8,000	8,000
Supply of cargo truck with loading gear 20t capacity	no	1	110,000	110,000
Supply tractor and trailer 75 HP	no	1	65,000	65,000
Supply forklift reach stacker for container handling	no	1	80,000	80,000
Supply fixed jib crane with 5t capacity	no	1	35,000	35,000
Supply and installation of generating set 100 kVA	no	1	40,000	40,000
30,000l fuel underground tank including pumping equipment	no	2	12,000	24,000
Provision of gabion boxes for river bank protection	m^3	220	150	33,000

Supply and installation of water/oil separator	no	1	10,000	10,000
Total estimated cost for rehabilitation of Bor Port				**5,742,222.50**

Shambe Port

Description	Unit	Quantity	Rate$	Amount$
Quay wall, consisting of sheet piling with AZ 17-700 profile	m^2	575	534.10	307,107.50
Reinforced concrete class 25 for capping of sheet piling, incl. reinforcement steel and form work	m^3	6	500	3,000
Back fill against new quay wall to make level with existing ground below wearing course	m^3	1,875	6	11,250
Construction of storm water drain	lm	150	30	4,500
Construction of new port office	m^2	80	800	64,000
Construction of ablution block	m^2	32	700	22,400
Construction of passenger waiting shed	m^2	100	450	45,000
Installation of gabion protection for river banks	m^3	200	150	30,000
Enlargement of cargo handling area	m^2	750	90	67,500
Construction of bulk storage area	m^2	3,000	90	270,000
Construction of parking area	m^2	2,000	90	180,000
Construction of additional warehouse	m^2	500	450	225,000
Provision of cold storage facilities	LS	1	7,000	7,000
Provision of oil/water separator	no	1	10,000	10,000
Supply of fixed jib crane with lifting capacity of 5t	no	1	35,000	35,000
Supply of forklift, 20t capacity	no	1	80,000	80,000
Supply conveyor belt, 10m long	no	1	8,000	8,000
Supply of 20t cargo truck with lifting boom	no	1	110,000	110,000
Supply and install security lights	no	20	400	8,000
Supply and installation of generating set 100 kVA	no	1	40,000	40,000
Total estimated cost for rehabilitation of Shambe port				**1,527,757.50**

Adok Port

Description	Unit	Quantity	Rate$	Amount$
Quay wall consisting of sheet piling with AZ-17-700 profile	m^2	805	534.10	429,950.50
Reinforced concrete capping on sheet pile walls	m^3	8.40	1,000	8,400
Backfill against quay wall to make level with existing ground below paving of cargo handling area	m^3	700	15	10,500
Construction of cargo handling area pavement	m^2	1,500	90	135,000
Construction of paved bulk storage area	m^2	3,000	90	270,000
Construction of port roads / access roads	lm	800	600	480,000
Construction of parking area	m^2	2,000	90	180,000
Supply and installation of gabions for riverbank protection	m^3	200	150	30,000
Construction of warehouse	m^2	500	450	225,000
Construction of office building	m^2	80	800	64,000
Construction of passenger waiting shed	m^2	100	450	45,000
Construction of ablution block	m^2	32	700	22,400
Construction of guard house	m^2	6	300	1,800
Perimeter fence with steel posts and chaining	lm	900	35	31,500
Supply and install security lights	no	30	400	12,000
Supply and installation of generating set 100 kVA	no	1	40,000	40,000
Supply of mobile crane with 12m boom and lifting capacity of 20t	no	1	70,000	70,000
Supply 10m long conveyor belt	no	1	8,000	8,000
Supply tractor and trailer, 70 HP	no	1	65,000	65,000
Supply and install oil/water separator	no	1	10,000	10,000
Supply and installation of bollards	no	6	500	3,000
Total estimated costs for reconstruction of Adok Port				**2,141,550.50**

Bentiu Port

Description	Unit	Quantity	Rate $	Amount $
Quay wall consisting of sheet piling with AZ-17-700 profile	m^2	1,035	534.10	552,793.50
Reinforced concrete capping on sheet pile walls	m^3	10.80	1,000	10,800
Backfill against quay wall to make level with existing ground below paving of cargo handling area	m^3	1,050	15	15,750
Construction of cargo handling area	m^2	2,000	90	180,000

pavement				
Construction of paved bulk storage area	m^2	4,000	90	360,000
Construction of port roads / access roads	lm	600	600	360,000
Construction of parking area	m^2	3,000	90	270,000
Supply and installation of gabions for riverbank protection	m^3	250	150	37,500
Construction of warehouse	m^2	1,000	450	450,000
Construction of office building	m^2	80	800	64,000
Construction of passenger waiting shed	m^2	100	450	45,000
Construction of ablution block	m^2	32	700	22,400
Construction of guard house	m^2	6	300	1,800
Perimeter fence with steel posts and chaining	lm	1,100	35	38,500
Supply and install security lights	no	40	400	16,000
Supply and installation of generating set 100 kVA	no	1	40,000	40,000
Supply of mobile crane with 12m boom and lifting capacity of 20t	no	1	70,000	70,000
Supply 10m long conveyor belt	no	1	8,000	8,000
Supply tractor and trailer, 70 HP	no	1	65,000	65,000
Supply and install oil/water separator	no	1	10,000	10,000
Supply of cargo truck with loading gear 20t	no	1	110,000	110,000
Supply and installation of bollards	no	8	500	4,000
Total estimated cost of reconstruction of Bentiu port				**2,731,543.50**

Note: Costs for dredging are not included in this estimate.

Malakal Town Port

Description	Unit	Quantity	Rate $	Amount $
Quay wall, consisting of sheet piling with AZ 17-700 profile	m^2	1,150	534.10	614,215
Reinforced concrete class 25 for capping of sheet piling, incl. reinforcement steel and form work	m^3	12	1,000	12,000
Supply and installation of bollards	no	10	5,000	50,000
Back fill against new quay wall to make level with existing ground below wearing course	m^2	1,000	15	15,000
Construction of storm water drain	lm	200	30	6,000
Rehabilitation of port- and access roads	lm	700	600	420,000
Construction of interlocking concrete blocks pavement and bulk storage area and cargo handling area	m^2	6,000	90	540,000
Construction of paved parking area	m^2	2,000	90	180,000

Supply and install gabions for riverbank protection	m^3	300	150	45,000
Rehabilitation of office building, ablution block and warehouse	LS	1	80,000	80,000
Construction of new ablution block	m^2	32	700	22,400
Construction of additional warehouse	m^2	1,000	450	450,000
Construction of passenger waiting shed	m^2	100	450	45,000
Construction and equipping on small workshop	m^2	72	600	43,200
Restore port water supply	LS	1	25,000	25,000
Supply and install 100 kVA generator set	no	1	40,000	40,000
Supply and installation of security lights, mounted on steel posts	no	30	400	12,000
Repair fence and gates	LS	1	15,000	15,000
Supply of mobile crane with 12m boom and 20t lifting capacity	no	1	70,000	70,000
Supply of fixed jib crane with lifting capacity of 5t	no	1	35,000	35,000
Supply and install fuel storage and pumps 30,000l	no	2	12,000	24,000
Supply forklift reach stacker container handler	no	1	80,000	80,000
Supply of overhead rail crane with 40t capacity	no	1	115,000	115,000
Supply of weigh bridge with a weighing capacity of 50t	no	1	112,000	112,000
Supply of conveyor belt 10m long	no	1	8,000	8,000
Supply cargo truck with lifting boom, 20t	no	1	110,000	110,000
Supply tractor with trailer 70 HP	no	1	65,000	65,000
Supply generating set 100 kVA	no	1	40,000	40,000
Supply and install oil/water separator	no	1	10,000	10,000
Total estimated cost for rehabilitation of Malakal port				**3,050,815**

Malakal UN/WFP Port

Description	Unit	Quantity	Rate $	Amount $
Quay wall, consisting of sheet piling with AZ 17-700 profile	m^2	1,955	534.10	1,044,165.50
Reinforced concrete class 25 for capping of sheet piling, incl. reinforcement steel and form work	m^3	30.40	1,000	30,400
Supply and installation of bollards	no	6	200	1,200

Back fill against new quay wall to make level with existing ground below wearing course	m^3	900	15	13,500
Construction of cargo handling area with interlocking concrete block pavement	m^2	1,500	90	135,000
Construction of interlocking concrete block paving for bulk storage area	m^2	1,500	90	135,000
Construction of port/access road	lm	300	600	180,000
Construction of passenger waiting shed	m^2	100	450	45,000
Construction of parking area with interlocking concrete blocks	m^2	2,000	90	180,000
Construction of ablution block	m^2	32	600	19,200
Supply and erection of office container	no	1	8,000	8,000
Supply and installation of small water treatment plant with elevated storage tank	LS	1	20,000	20,000
Supply and installation of generator set (100 kVA)	no	1	40,000	40,000
Supply and installation of chain-link fence, fixed to angle iron steel posts with concrete footing	lm	400	35	14,000
Supply and installation of security lights, mounted on steel posts	no	15	400	6,000
Construction of storm water drain	lm	120	20	2,400
Supply of mobile crane with 12m boom and 20t lifting capacity	no	1	70,000	70,000
supply of 10m long conveyor belt	no	1	8,000	8,000
Supply forklift reach stacker container handler	no	1	80,000	80,000
Supply and install water/oil separator	no	1	10,000	10,000
Total estimated cost for improvements of WFP jetty				**2,031,865.50**

Melut Port

Description	Unit	Quantity	Rate $	Amount $
Cost estimate for improvements of Melut port				
Quay wall, consisting of sheet piling with AZ 17-700 profile	m^2	1,380	534.10	737,058
Reinforced concrete class 25 for capping of sheet piling, incl. reinforcement steel and form work	m^3	18	1,000	18,000
Supply and installation of bollards	no	6	500	3,000
Back fill against new quay wall to make level with existing ground below wearing course	m^3	900	15	13,500

Construction of cargo handling area with interlocking concrete block pavement	m^2	1,500	90	135,000
Construction of interlocking concrete block paving for bulk storage area	m^2	3,000	90	270,000
Construction of port roads	lm	400	600	240,000
Construction of parking area with interlocking concrete blocks	m^2	2,000	90	180,000
Rehabilitation of access road	lm	1,550	70	108,500
Construction of ablution block	m^2	32	600	19,200
Repair office and warehouse buildings	LS	1	60,000	60,000
Construction of new ware house	m^2	500	450	225,000
Construction of passenger waiting shed	m^2	100	450	45,000
Construction of ablution bloc	m^2	32	600	19,200
Construction of small water supply	LS	1	75,000	75,000
Repair 400m fence and gate	LS	1	10,000	10,000
Supply and install generator set 100 kVA	no	1	40,000	40,000
Supply of 10m long conveyor belt	no	1	8,000	8,000
Supply of mobile crane with 12m boom and 20t lifting capacity	no	1	70,000	70,000
Supply forklift reach stacker container handler	no	1	80,000	80,000
Supply of cargo truck with lifting gear 20t	no	1	110,000	110,000
Construction of storm water drain	lm	200	20	4,000
Provision of gabions for river bank protection	m^3	300	150	45,000
Supply and install security lights	no	15	400	6,000
Total estimated cost for rehabilitation of Melut port				**2,521,458**

Renk Port

Description	Unit	Quantity	Rate $	Amount $
Quay wall, consisting of sheet piling with AZ 17-700 profile	m^2	1,955	534.10	1,044,165.50
Reinforced concrete class 25 for capping of sheet piling, incl. reinforcement steel and form work	m^3	20.40	500	10,200
Supply and installation of bollards	no	6	500	3,000
Back fill against new quay wall to make level with existing ground below wearing course	m^3	1,200	15	18,000
Port roads rehabilitation	lm	400	600	240,000
Rehabilitation of access road	lm	500	70	35,000
Construction of interlocking concrete block paving for bulk storage area	m^2	4,000	90	360,000
Construction of cargo handling area with interlocking concrete block pavement	m^2	2,550	90	229,500

Construction of parking area with interlocking concrete blocks	m^2	3,000	90	270,000
Construction of storm water drain	lm	350	10	3,500
Gabions for river bank protection	m^3	300	150	45,000
Construction of port office	m^2	80	490	39,200
Construction of ablution block with sewerage disposal	m^2	32	650	20,800
Construction of warehouse	m^2	1,000	490	490,000
Construction of workshop shed	m^2	72	700	50,400
Construction of passenger waiting shed	m^2	100	450	45,000
Rehabilitation of water treatment composite unit and elevated water tank	LS	1	45,000	45,000
50,000l fuel underground tank including pumping equipment	no	1	40,000	40,000
Repair of perimeter fence and gate and lights	LS	1	8,000	8,000
Supply and installation of generating set 100 kVA	no	1	40,000	40,000
Supply forklift reach stacker container handler	no	1	80,000	80,000
Supply of overhead rail crane with 40t capacity	no	1	115,000	115,000
Supply of weigh bridge with a weighing capacity of 50t	no	1	112,000	112,000
Supply of conveyor belt 10m long	no	1	8,000	8,000
Supply cargo truck with lifting boom, 20t	no	1	110,000	110,000
Supply tractor with trailer 70 HP	no	1	65,000	65,000
Supply of fixed jib crane with lifting capacity of 5t	no	1	35,000	35,000
Supply water/oil separator	no	1	10,000	10,000
Total estimated cost for rehabilitation of Renk port				**3,571,765.50**

Barges and Pushers for Humanitarian Aid

Barges

Design, construction, outfitting, equipment procurement, assembly commissioning and project management for a self-propelled modular barge as per the technical specifications in Annex V will cost around $5.1m. Transport of a modular system to Juba is another very costly option and was quoted to be around $0.8m. It will take around 9 months to build, transport, assemble and commission a modular barge of this type. A non-self-propelled barge was quoted at approx. $2m excl. transport cost to Juba.

Barge type	Cost estimate ($)
Self-propelled, 450T capacity, multi-purpose	5,100,000
Non-self-propelled, 400T capacity	2,000,000
Transport to Juba	800,000

Pushers

Design, construction, outfitting, equipment procurement, assembly commissioning and project management for a pusher as per the technical specifications in Annex V will cost around $3.5m. The cost for transport will be around $0.8m. It will take around 9 months to build, transport, assemble and commission a pusher of this type.

Pusher type	Cost estimate ($)
Pushing capacity approx. 1,500T	3,500,000
Transport to Juba	800,000

Annex VII Knowledge Database

The data and reports used to prepare this study are summarised in the following tables. Further an overview of newly generated data by conducting simulations and modelling is provided.

Data

Table 32: Existing datasets used by the consultant

Title	Type	Author	Year	Publisher	Summary	Filename
Ports	Shapefile	UNMISS	unknown	UNMISS	Point locations of ports of interest within this study	SelectedPorts_9PortsForMaps_32636.shp
Observed discharge and hydraulic data	Spreadsheet	Nile Basin Volumes	1900-1990	Sudan Government	Historical Flow and hydraulic data along the Nile from Juba to Renk and main tributaries	FlowData_Summary_For_Modelling_SelectedData.xlsx
Satellite images	Online Sources	Google, Quantum Geographic Information System (QGIS) Development	2018	Google, QGIS Development team	Google earth satellite images available through the Quick	N/A

Title	Type	Author	Year	Publisher	Summary	Filename
		team			Map services plugin in QGIS used for digitisation works	
White Nile River stream network	Shapefile	UNMISS	unknown	UNMISS	Stream network of the White Nile River and its main tributaries	Nile_river.shp

Table 33: Data generated through modelling and simulations by the consultant

Title	Type	Author	Year	Publisher	Summary	Filename
River Width-Depth ratio derived from the Survey data	Spreadsheet	Kiesel J	2018	HYDROC	Empirical relationship of derived river width and depth for the survey from Juba to Bor to extrapolate unsurveyed depths	Width_Depth_Ratio_from_Survey_JubaBor.xlsx
Modified Digital Elevation Model	Raster	NGA, NASA, Kiesel J	2000, 2018	USGS, HYDROC	30m DEM resampled to 15m using bilinear interpolation for the hydraulic model, merged survey elevation from Juba to Bor	SRTM30_JubaRenk_ModDom[2]_Bilin15m15m_v2_mergedBathymetry_32636.tif https://earthexplorer.usgs.gov/
Bathymetry model derived from the Survey data	Raster	Kubicki A	2018	HYDROC	15m relative bathymetry model from Juba to Bor	juba_bor_15m_depth.tif

Title	Type	Author	Year	Publisher	Summary	Filename
Stream channel Bentiu to Lake No	Shapefile	Kiesel J	2018	HYDROC	Digitised stream channel centreline from Bentiu port to Lake No	Bentiu_LakeNo_32636.shp
Centreline of main channel from Juba to Renk	Shapefile	Kiesel J	2018	HYDROC	Derived stream channel centreline from Juba to Renk	Centerline_NileJubaRenk_simpl5m_32636.shp
Channel islands of main channel from Juba to Renk	Shapefile	Kiesel J, Kubicki A	2018	HYDROC	Digitised channel islands from Juba to Renk	Islands_NileJubaRenk_32636.shp
Left bank of main channel from Juba to Renk	Shapefile	Kiesel J, Kubicki A	2018	HYDROC	Digitised left bank from Juba to Renk	LeftBank_NileJubaRenk_32636.shp
Right bank of main channel from Juba to Renk	Shapefile	Kiesel J, Kubicki A	2018	HYDROC	Digitised left bank from Juba to Renk	RightBank_NileJubaRenk_32636.shp
Cross-section polylines in 100m distance from Juba to Renk	Shapefile	Kiesel J	2018	HYDROC	Cross-sectional polylines which do not intersect and cover the main channel from Juba to Renk	NileJubaRenk_100.0_xs_new.shp
Left boundary of shipping channel	Shapefile	Kiesel J, Kubicki A	2018	HYDROC	Digitised left boundary of the widest possible shipping channel from Juba to Renk	LeftShipChannel_NileJubaRenk_Simpl5m_32636.shp
Right boundary of shipping channel	Shapefile	Kiesel J, Kubicki A	2018	HYDROC	Digitised right boundary of the widest possible shipping channel from Juba to Renk	LeftShipChannel_NileJubaRenk_Simpl5m_32636.shp
Centreline of shipping channel	Shapefile	Kiesel J	2018	HYDROC	Derived and corrected shipping channel centreline from Juba to Renk	ShippingLine_NileJubaRenk_v4_FINAL_32636.shp
Flow data changes at cross-sections	Spreadsheet	Kiesel J	2018	HYDROC	Flow data for HEC-RAS for the 5% low and 5% high scenario including flow splits	FlowDataAtXS_5_5_percent_Scenarios.xlsx
Plausibility check of hydraulic data	Spreadsheet	Kiesel J	2018	HYDROC	Comparison of simulated data with observations at the available gauges	PlausibilityCheck.xlsx

Title	Type	Author	Year	Publisher	Summary	Filename
Navigation width assessment	Spreadsheet	Kiesel J	2018	HYDROC	Calculations of navigation width and channel width assessment	ShipChannel_Properties_JubaRenk_v1.xlsx
Results summary and diagrams	Spreadsheet	Kiesel J	2018	HYDROC	Results of channel assessments: widths, depths, flow velocities, dredged volumes, diagrams and numbers	ResultsDiagrams.xlsm
Bathymetric charts	Results / Literature	Kubicki A	2018	HYDROC	16 Charts containing results of the survey in 1:10,000 scale	01_Juba_Bor_10000.pdf 02_Juba_Bor_10000.pdf 03_Juba_Bor_10000.pdf 04_Juba_Bor_10000.pdf 05_Juba_Bor_10000.pdf 06_Juba_Bor_10000.pdf 07_Juba_Bor_10000.pdf 08_Juba_Bor_10000.pdf 09_Juba_Bor_10000.pdf 10_Juba_Bor_10000.pdf 11_Juba_Bor_10000.pdf 12_Juba_Bor_10000.pdf 13_Juba_Bor_10000.pdf 14_Juba_Bor_10000.pdf 15_Juba_Bor_10000.pdf 16_Juba_Bor_10000.pdf

Table 34: Literature and reports

Title	Type	Author	Year	Publisher	Summary	Filename
SRTM DEM levels over papyrus swamp vegetation – a correction approach	Journal	Petersen G, Lebed I, Fohrer N.	2009	Advances in Geosciences	Used to derive correction factors of elevation in the Sudd Swamp area for the hydraulic simulations.	Petersen_2009_SRTM_Papyrus_Adgeo-21-81-2009.pdf
The Hydrology of the Sudd, Hydrologic Investigation and Evaluation of Water Balances in the Sudd Swamps of Southern Sudan	Dissertation	Petersen G.	2008	University of Kiel	Comprehensive analysis of water balances and environmental properties of the Southern Sudan Sudd region.	Petersen_Diss.pdf
Inland Navigation and Canalisation	Report	USACE	1997	Department of the Army	Contains information on navigation channel properties and design.	InlandNavigationAndCanalization.pdf
Hydraulic Design of Deep-Draft Navigation Projects	Report	USACE	2006	Department of the Army	Contains information on navigation channel properties and design.	HydraulicDesignOfDeep-DraftNavigationProjects.pdf
MALAKAL - MELUT, RIVER	Report	LOGISTICS CLUSTER –	2011	LOGISTICS CLUSTER –	Assess Malakal – Melut Nile River	malakal_melut_river_assessment_report.pdf

Title	Type	Author	Year	Publisher	Summary	Filename
ASSESSMENT REPORT – 10 JULY 2011		SOUTH SUDAN		SOUTH SUDAN	access and monitor volume of traffic on the river Support humanitarian community inter-agency assessments and planning by identifying possible locations for installation of Mobile Storage Units, truck transport capacity in Melut, and Paloich airstrip use, as required to respond to ongoing displaced and returnee beneficiaries gathering in Melut County, Upper Nile State.	
Remote regions, remote data: A spatial investigation of precipitation, dynamic land	Journal	Amelia Sosnowski*, Eman Ghoneim, Jeri J. Burke, Elizabeth	2016	Journal of Applied Geography	To assess the use of remote data derived from remote sensing systems, the wetland extent	Remote regions, remote data.pdf

Title	Type	Author	Year	Publisher	Summary	Filename
covers, and conflict in the Sudd wetland of South Sudan		Hines, Joanne Halls			between 2000 and 2014 was delineated using Moderate-resolution Imaging Spectroradiometer (MODIS) thermal infrared data and baseline changes in the wetland land cover extents were mapped using Normalized Difference Vegetation Index (NDVI) products.	
Riverine Project Capacity Assessment In South Sudan	Report	Francois Henepin	2013	UNMISS	The main objective is this report is to provide an overview of the river transport capacity in South Sudan and provide the mission with relevant information in order to facilitate	Riverine project capacity assessment.pdf & Riverine project capacity assessment.docx

Title	Type	Author	Year	Publisher	Summary	Filename
					the start of UNMISS with river operation as an important tool for fulfilling its mandates.	
Report on Logistics to Kosti	Report	None given.	2004	UNJLC	Useful summary of Kosti facilities and their condition.	KostiAssessment.pdf
WFP Physical Access Constraints map	Map	Donors	2017	WFP	Periodically issued colour map showing whether roads and river reaches are physically passable.	SSD_LC_OP_Accessconstraints_a31_20170925.pdf
South Sudan Statistical Yearbook 2011	Report	None given	2011	SS National Bureau of Statistics	Only statistical yearbook for South Sudan yet published.	SS 2011 Yrbk.xps
A Socio-Economic Appraisal of Inland Water Transport in Sudan	Dissertation	El Kider, Mohammed	2000	University of Khartoum	Much historic data on RTC traffic.	El Kider 2000 Thesis.pdf
Revitalising Sudan's Non-Oil Exports: A Diagnostic Trade Integration	Report	None given	2008	World Bank	Considers all of Sudan. Useful for high level assessment of competitive	Sudan DTIS 2008.pdf

Title	Type	Author	Year	Publisher	Summary	Filename
Study (DTIS) Prepared for the Integrated Framework Programme					position of Sudan's goods.	
Republic of Sudan Diagnostic Trade Improvement Study – Update	Report	None given	2014	World Bank	Update of 2008 report.	Sudan DTIS Update.pdf
Follow-up Co-operation for Emergency Study on the Planning and Support for Basic Physical and Social Infrastructure in Juba Town	Report	Katahira and Engineers International	2009	JICA	Basis for JICA's design of new Juba port. Much useful data on barge arrivals and departures.	JICAJubaPort2009.pdf
South Sudan Corridor Diagnostic Study and Action Plan	Report	Nathan Associates	2012	USAID	Diagnostic study of road transport in the East Africa-Juba corridor.	NathanAss South Sudan Corridor and Action Plan
World Bank South Sudan Economic Overview	Webpage	None given	2016	World Bank	Useful summary of South Sudan economic and social statistics.	SouthSudan Overview WBnk.pdf
Sudan – Transportation and Development	Report	None given	1984	CIA	Some old goods import and export data.	CIA South Sudan transport and development.pdf
Redevelopment of	Web	Ishiwatari, M	2015	ResearchGate	Rather general	Ishiwatari2015.pdf

Title	Type	Author	Year	Publisher	Summary	Filename
river transport for Post-Conflict Reconstruction in Southern Sudan	journal article				article about risk reduction with some Juba data.	
South Sudan Infrastructure Action Plan	Report	None given	2013	African Development Bank	Cost estimates etc. for infrastructure (including river transport) investment.	AfDB Infra Investment Plan 2013.pdf
Crop and Food Security Assessment Mission to South Sudan	Report	Zappacosta, M, Robinson, W I Bonifácio, R	2017	WFP/FAO	Assessment of cereals deficits.	Food security mission May 2017.pdf
The Cost of Being Landlocked	Report	Arvis, J-F, Raballand, G and Marteau, J-F	2010	World Bank	Transport market assessments.	WBnk Cost of Being Landlocked 2010.pdf
Facilitating Trade through Low carbon Transport	Report	Blancas, L and El Hifnawi, M-F	2014	World Bank	Vietnamese river transport review and recommendations.	WBnk Vietnam river transport 2014.pdf
Revival of river transport, Options and Strategies	Report	None given	2007	World Bank	Bangladesh development series paper.	WBnkBangladeshriver transportEval2007.pdf
Africa Transport Prices and Costs Prices	Report	Raballand, G and Teravaninthorn, S	2009	World Bank	Review of African road transport costs and prices.	WBnk Africa Raballand Prices and Costs.pdf

Title	Type	Author	Year	Publisher	Summary	Filename
Joint Assessment Mission	Report	None given	2005	World Bank and UN	Assessment of Sudan's investment requirements post signing the CPA	JAM VolI.pdf
Environmental Aspects of Dredging	eBook	Bray N (ed.)	2010	Taylor & Francis/Balkema, Leiden, Netherlands	Provides detailed overview on planning environmental aspects in dredging projects	Bra-e-2010.pdf
Dredging for Development	Report	Bray N, Cohen M, (eds)	2010	International Association of Ports and Harbours	Provides a selective overview on dredging projects in development settings	Bra-d-2010.pdf
Environmental Impact Assessment of the Bor counties' dyke rehabilitation project, South Sudan: Integrated assessment report	Report	The Centre for Environmental Economics and Policy in Africa, Faculty of Natural and Agricultural Sciences, University of Pretoria	2006	USAID	EIA for the construction of a dyke along the White Nile; provides some detail on the impacts on migratory land species	CEE-e-2006.pdf
Recommendations on Minimum Requirements for	Resolution	Economic Commission of Europe	2017		Some detail on how the incorporate	ECE-r-2017

Title	Type	Author	Year	Publisher	Summary	Filename
the Issuance of Boatmaster's certificates in Inland Navigation with a view to their Reciprocal Recognition for International Traffic – Resolution No. 31					environmental concerns into barge-master's capacity building	
The Economic, Cultural and Ecosystem Values of the Sudd Wetland in South Sudan: An Evolutionary Approach to Environment and Development	Report	Gowdy J, Lang H	2017	United Nations Environment Programme (UNEP), The Evolution Institute	Detailed introduction on the socio-economic importance of ecosystem services provided by the Sudd and their vulnerability to human development	Gow-e-2017.pdf
MRC Navigation Strategy	Report	Mekong River Commission	2003	Mekong River Commission	Some details on the institutional approach of the development of the navigation sector in the Mekong river	MRC-n_2003.pdf
Dangerous Goods Management	Manual	Mekong River Commission-	2013	Mekong River Commission	Insights into the logistics of goods	MRC-d-2013.pdf

Title	Type	Author	Year	Publisher	Summary	Filename
Manual, Prepared for Chiang Saen Commercial Port Area		Navigation Programme			transportation, handling and storage, with special attention to dangerous goods	
Safety net and skills development project, Environmental and Social Management Framework	Report	Ministry of Agriculture, Forestry, Cooperatives and Rural Development	2016		Raises issues on the kind of local legislation on EIAs and land law	MOAF-s-2016.pdf
Fifth national report to the convention on biological diversity	Report	Ministry of Environment	2015	UNEP, GEF	Describes the status of environmental management, and the different biodiversity and protected area management issues	Moe-f-2015.pdf
Environmental and Social policy	Report	Nile Basin Initiative	2013		Explains how different countries are to work together in the management of the Nile, for example what the precautionary	NBI-e-2013.pdf

Title	Type	Author	Year	Publisher	Summary	Filename
					principle entails	
Manual on Good Practices in Sustainable Waterway Planning	Manual	PLATINA	2010	European Commission	Provides essential insight in the broader planning of inland navigations, especially strong on institutional issues and environmental mainstreaming	PLA-m-2010.pdf
Laws and institutions: Reviewing laws and institutions to promote the conservation and wise use of wetlands. Ramsar handbooks for the wise use of wetlands	Manual	Ramsar Convention Secretariat	2010		Provides detail on the legislative context of Ramsar designations	RCS-l-2010.pdf
New environmental performance baseline for inland ports: A benchmark for the European inland port sector	Journal	Seguí, X., Puig, M., Quintieri, E., Wooldridge, C. & Darbra, R.M.	2016	Environmental Science & Policy. 58: 29–40	Lists top ten priorities in environmental concerns for inland ports, based on a large survey	