African Journal of Emerging Issues
Peer reviewed | Double blind | Interdisciplinary

African Journal of Emerging Issues
(AJOEI)
Online ISSN: 2663 - 9335
Available at: https://ajoeijournals.org

ENGINEERING

THE NAAM RIVER DREDGING AND ITS IMPACT ON WATER SECURITY IN SOUTH SUDAN

Malek Cook-Dwach
PhD Candidate, University of Juba, South Sudan
Member, Transitional National Legislative Assembly (TNLA), Republic of South Sudan

Publication Date: September 2026

ABSTRACT

Purpose of the study: The study examined the impact of the Naam River dredging project on water security in South Sudan, with particular attention to hydrological, ecological, livelihood, and governance dimensions within the Sudd wetland system.

Statement of the problem: Although dredging has been promoted as a response to recurrent flooding in Unity State, its site-specific effects remain uncertain. The project has also been repeatedly authorized, suspended, and resumed without a comprehensive peer-reviewed assessment of its implications for the Naam River and the wider Sudd system.

Research methodology: The study adopted a pragmatic, convergent mixed-methods case-study design. The empirical phase combined household surveys, key-informant interviews, focus-group discussions, remote-sensing-based hydrological analysis, water-quality and sediment sampling, and documentary review across communities along dredged and undredged reaches of the Naam River.

Results of the study: The literature synthesis indicates that unmanaged dredging is commonly associated with increased turbidity, altered channel morphology and flow regimes, aquatic habitat loss, and disruption of wetland sediment and carbon dynamics. However, the Sudd's distinctive low-gradient hydrology and limited gauging record make direct transfer of international findings inappropriate without local validation. The policy chronology further reveals recurrent project authorization and suspension in the absence of the impact evidence repeatedly called for by public authorities and academic actors.

Conclusion and recommendation: A rigorous environmental and social impact assessment should precede further large-scale dredging. River management should be integrated with basin-scale flood planning, sustained hydrological and ecological monitoring, and participatory governance so that short-term flood relief does not create longer-term water insecurity.

Keywords: *Naam River, dredging, water security, Sudd wetland, South Sudan, Nile Basin*

INTRODUCTION

South Sudan occupies a hydrologically pivotal position within the Nile Basin. After descending from Lake Victoria through Lakes Kyoga and Albert, the White Nile enters South Sudan and encounters the Sudd, Africa's largest and the world's second-largest freshwater wetland. The wetland comprises an intricate mosaic of permanent swamp, seasonally flooded grassland, and braided river channels, expanding from a permanent core of roughly 30,000 square kilometres to more than 90,000 square kilometres during high-flood years (Biology Insights, 2026; Mohamed et al., 2005). As the river spreads across this low-gradient basin, it loses its defined channel, and evapotranspiration removes approximately half of the inflowing water before the river re-forms as the White Nile north of Lake No (Mohamed et al., 2005; Senay et al., 2014; Sutcliffe & Parks, 1999). This hydrological reality has shaped a century of engineering ambition in the basin, from colonial-era proposals for a bypass canal and the Jonglei Canal Project of the 1970s and 1980s to contemporary tributary-dredging schemes, of which the Naam River project is a prominent example.

The Naam River, also known locally in its lower reaches as part of the Bahr el Ghazal system, is a westward-draining tributary that flows through Unity State before entering the wider Sudd hydrological complex (Radio Tamazuj, 2024; The Hill, 2022). Since 2019, South Sudan has experienced an exceptional sequence of flood years, with 2019, 2020, and 2021 ranking among the most severe in six decades of record. The flooding has been associated with Indian Ocean Dipole-related rainfall anomalies, upstream releases from Lake Victoria, and saturated antecedent soil conditions that prevented floodwaters from receding between seasons (Social Science in Humanitarian Action Platform, 2025; World Bank Group, 2023). Unity State, together with Jonglei and Upper Nile States, has experienced some of the most severe impacts, including prolonged inundation, population displacement, and major disruption to public services. In November 2021 alone, more than 100 schools in Unity State were affected (UNICEF South Sudan, n.d.; World Bank Group, 2023).

Against this background, the Government of South Sudan entered a cooperation arrangement with the Arab Republic of Egypt in 2021 for dredging the Naam River, and Egyptian-donated excavators arrived in Unity State in mid-2022 (Hydro-politics in the Sudd Wetland, 2023; Pachodo.org, 2022). State and national officials argued that removing accumulated sediment, vegetation, and debris would restore channel conveyance, reduce standing floodwater, and reopen the river for transport and economic activity (PaanLuel Wël Media, 2023; Pressreader Mail & Guardian, 2022). The proposal nevertheless generated immediate opposition from South Sudanese scientists, environmentalists, and civil society. The most visible campaign was led by the Vice Chancellor of the University of Juba, who warned that dredging the Naam and other Sudd tributaries without prior assessment could cause irreversible harm to wetland hydrology, biodiversity, and the pastoralist and fishing livelihoods that depend on the system (Hydro-politics in the Sudd Wetland, 2023; PaanLuel Wël Media, 2023). On 9 July 2022, President Salva Kiir Mayardit suspended dredging-related activities nationally, including the Naam River project and the dormant Jonglei Canal scheme, pending evidence-based environmental and social impact studies (The Hill, 2022; Pachodo.org, 2022). Clearance activities nonetheless resumed in Unity State in 2023 and again in 2024, sustaining debate between state authorities and the national academic and environmental community (Kazi Njema News, 2023; Radio Tamazuj, 2024).

This unresolved controversy, between an urgent local imperative to reduce flooding and scientific concern about the ecological consequences of large-scale river engineering, provides the empirical and political context for the study. The dispute is not solely technical; it also concerns competing conceptions of development, sovereignty over shared Nile waters, and the balance between short-term humanitarian relief and long-term environmental stewardship. It is fundamentally a water-security problem in the sense articulated by Grey and Sadoff (2007), who define water security in terms of acceptable water quantity and quality for health, livelihoods, ecosystems, and production, together with an acceptable level of water-related risk. The Naam River dredging project lies at this intersection because an intervention intended to reduce flood risk may, if inadequately assessed, generate other forms of water insecurity, including reduced dry-season storage, poorer water quality, and ecosystem degradation.

STATEMENT OF THE PROBLEM

Despite the scale of public and political controversy surrounding the Naam River dredging project, no peer-reviewed, evidence-based study currently provides a systematic assessment of its hydrological, ecological, and socio-economic implications for water security in South

Sudan. Government arguments for dredging have focused primarily on the visible, short-term relief of standing floodwater, whereas opposing arguments have drawn largely on international wetland and river-ecology literature rather than site-specific evidence from the Naam River and the Bahr el Ghazal-Sudd system (Hydro-politics in the Sudd Wetland, 2023). This evidence gap creates three interrelated problems.

First, the hydrology of the Sudd is exceptionally complex and remains only partially understood. In situ hydrological monitoring in the wetland was largely abandoned during the political and military disruptions that halted the Jonglei Canal project in the 1980s. The region consequently remains one of the least-gauged major wetlands in the world, requiring contemporary researchers to depend heavily on satellite remote sensing and regional climate modelling rather than direct measurement (Sciencedirect Hydrologic Modeling of the Sudd, 2021). Without local validation, it is therefore scientifically risky to extrapolate findings from dredging studies conducted in temperate, well-gauged rivers in North America and Europe to the Sudd's tropical, low-gradient, seasonally pulsing floodplain system.

Second, the Naam River intervention has been initiated, suspended, and resumed several times since 2021 without completion of a comprehensive environmental and social impact assessment, despite the July 2022 presidential directive requiring such an assessment before work continued (The Hill, 2022; Kazi Njema News, 2023). This creates a governance problem in which infrastructure decisions with potentially irreversible ecological consequences are repeatedly made and revised without the evidence that both proponents and opponents have publicly acknowledged as necessary.

Third, the underlying policy question that motivated dredging remains unresolved: how should South Sudan manage flood risk and water security in the Sudd-Bahr el Ghazal system under increasing hydro-climatic variability? Flooding in Unity State is a severe humanitarian problem (World Bank Group, 2023), but the central scientific question is whether channel dredging offers an effective and sustainable response. It is equally important to determine whether dredging merely displaces, delays, or intensifies other forms of water insecurity while providing localized and temporary relief. This study addresses that gap through a mixed-methods research design intended to generate the site-specific evidence that has been missing from the Naam River debate.

RESEARCH OBJECTIVES

The general objective of the study was to examine the impact of the Naam River dredging project on water security in South Sudan. The study is guided by the following specific objectives:

i. To examine the hydrological and hydromorphological effects of dredging on the flow regime, sediment dynamics, and seasonal flooding pattern of the Naam River and its confluence with the wider Sudd wetland system.
ii. To assess the ecological consequences of the dredging project for aquatic biodiversity, riparian vegetation, and wetland ecosystem services in the affected reaches of Unity State.
iii. To evaluate the socio-economic and livelihood implications of the dredging project for riverine communities, including its effects on fishing, pastoralism, flood-recession agriculture, and access to safe water.
iv. To analyze the governance, institutional, and transboundary policy context within which the Naam River dredging decision was made, suspended, and resumed.
v. To develop evidence-based recommendations for water security policy and river management practice in South Sudan and the wider Nile Basin.

RESEARCH QUESTIONS

The central research question was: What is the impact of the Naam River dredging project on water security in South Sudan? The study addressed this question through the following sub-questions:

i. How has dredging altered the hydrological and sediment regime of the Naam River and its interaction with the Sudd wetland?
ii. What ecological changes, if any, are attributable to the dredging activity in the affected river reaches?
iii. How have riverine communities in Unity State experienced changes in flood risk, water availability, and livelihood security since dredging began?
iv. What governance and institutional factors explain the contested authorization, suspension, and resumption of the project?
v. What policy and management recommendations follow from the evidence for future river-training interventions in South Sudan?

THEORETICAL REVIEW/FRAMEWORK

Political Ecology

The study is principally grounded in political ecology and is supplemented by hydro-social theory. Political ecology treats large water-infrastructure projects not as purely technical interventions, but as socially and politically constituted processes in which decisions about where, how, and for whose benefit water is engineered reflect existing power relations (Carse & Lewis, 2020). Comparative research on harbour and river dredging in the United States similarly demonstrates that dredging is simultaneously hydrological, geomorphological, economic, and political, requiring analysis that bridges these dimensions rather than reducing dredging to an engineering question (Carse & Lewis, 2020). This perspective is directly relevant to the Naam River case, where channel clearance has been framed variously as humanitarian flood relief, economic development, environmental negligence, and a matter of national interest (Hydro-politics in the Sudd Wetland, 2023).

Hydro-Social Theory

Hydro-social theory complements political ecology by treating rivers and wetlands as systems co-produced through physical processes and social, institutional, and discursive practices. Applied to the Sudd, the theory helps explain how the same wetland can be represented simultaneously as an obstacle to development that constrains drainage and as an irreplaceable ecological and cultural asset that supports pastoralist and fishing livelihoods. Rather than treating these representations as mutually exclusive, the study examines how their interaction shapes the Naam River controversy and the governance of water security.

EMPIRICAL REVIEW

Hydrology of the Sudd Wetland and the Naam-Bahr el Ghazal System

The Sudd forms where the Bahr el Jebel, the principal White Nile channel, crosses an exceptionally flat clay plain in central South Sudan. The low gradient causes the river to lose its single-channel form and spread across a complex network of lagoons, lakes, and seasonally inundated grasslands (Biology Insights, 2026). The wetland's permanent core covers roughly 30,000 square kilometres but may expand to 90,000-130,000 square kilometres during flood years, depending on inflow from Lake Victoria and local rainfall (Biology Insights, 2026; Click Petroleo e Gas, 2026; Geography Worlds, 2026). High evapotranspiration across the vast, shallow, vegetated surface removes roughly half of the White Nile's inflowing volume,

estimated at about 16,000 million cubic metres annually, before the river re-forms downstream (Mohamed et al., 2005; Senay et al., 2014). This evaporative loss has made the Sudd a recurring target of engineering proposals intended to increase water availability for downstream users in Sudan and Egypt (Mohamed et al., 2005).

Hydrological modelling also indicates that the Sudd performs an important flow-regulation function by absorbing and attenuating the seasonal flood pulse from the upper basin and releasing water gradually. This process helps stabilize downstream White Nile discharge and buffers both excess and deficit flows (Geography Worlds, 2026; Ramsar Secretariat, 2006, as cited in the Sudd hydrology literature). Mohamed et al. (2005) found that fully draining the Sudd would have a comparatively modest effect on the regional water cycle because the wetland occupies a relatively small proportion of the wider basin. For the Naam River, this finding cautions against assuming that the consequences of localized dredging will be directly proportional to the scale of the intervention. Site-specific assessment is therefore necessary. Long-term water-balance reconstructions further indicate that Sudd extent is shaped jointly by regional climate, particularly Lake Victoria outflow, and local precipitation and evaporation, underscoring the system's sensitivity to upstream operations and local climatic variability (ResearchGate, Wetlands Ecology and Management, 2014).

The Naam River forms part of the western Bahr el Ghazal drainage feeding the Sudd. The wider Bahr el Ghazal is approximately 716 kilometres long and is the principal western tributary of the Nile, flowing through the Sudd wetlands to Lake No, where it joins the White Nile (World Bank Group, 2023). In situ hydrological measurement across the Sudd, including precipitation, evaporation, and discharge gauging, declined substantially after the Jonglei Canal project collapsed in the 1980s, and basin flow data have been largely unavailable in international databases since 1985 (Sciencedirect Hydrologic Modeling of the Sudd, 2021). Contemporary assessment of the region therefore depends heavily on satellite remote sensing and regional climate modelling, a constraint that directly informs the methodological approach adopted in this study.

Historical Antecedents: The Jonglei Canal Project

Contemporary Nile tributary engineering in South Sudan must be interpreted against the history of the Jonglei Canal, the twentieth century's most ambitious attempt to re-engineer the Sudd. The approximately 360-kilometre canal was designed to bypass the wetland and divert a substantial share of Bahr el Jebel flow northward, thereby reducing evaporative losses and

increasing water available to Sudan and Egypt (Click Petroleo e Gas, 2026; Geography Worlds, 2026). Construction began in the 1970s under joint Sudanese-Egyptian sponsorship but stopped in 1983 during the outbreak of the second Sudanese civil war, leaving the canal roughly two-thirds complete (Geography Worlds, 2026).

The Jonglei experience created two enduring legacies that inform the Naam River study. Technically, subsequent hydrological research demonstrated that the Sudd's evaporative losses and flow-regulation functions are linked; interventions that reduce inundation extent or residence time can therefore produce cascading effects on downstream flow timing, local microclimate, ecosystems, and livelihoods (Mohamed et al., 2005). Politically, the Jonglei Canal remains a powerful symbol in South Sudanese discourse of externally driven, top-down water engineering perceived to benefit downstream states more than local communities. Opponents of Naam River dredging explicitly invoked this history during the public campaign against the project (Hydro-politics in the Sudd Wetland, 2023). The Naam controversy must therefore be understood as part of a longer national debate over control of, and benefits from, engineering interventions in the Sudd.

Global Scientific Evidence on the Ecological Impacts of River Dredging

Turbidity, Sedimentation, and Aquatic Biodiversity

A substantial international literature documents the ecological effects of channel dredging across freshwater and estuarine systems. Dredging commonly resuspends bottom sediments and increases turbidity and suspended-sediment concentrations during operations and, in some cases, after dredging has ceased (Pineda et al., as cited in ResearchGate, 2023; Sciencedirect Water Injection Dredging, 2020). Increased turbidity reduces light penetration and can suppress photosynthesis in submerged vegetation and benthic algae, thereby weakening the primary productivity that supports aquatic food webs (ResearchGate Dredging of Harbours and Rivers, 2023). Suspended sediments can also affect fish physiology and behaviour. Reviews of dredging impacts indicate that eggs and larvae are particularly vulnerable to lethal effects, whereas adult fish more often exhibit sub-lethal behavioural responses, with impact severity depending on both sediment concentration and exposure duration (ResearchGate Dredging of Harbours and Rivers, 2023). Controlled studies cited in this literature show species-specific habitat declines at elevated suspended-sediment concentrations, including an approximately 50% reduction in habitat suitability for bluegill sunfish at about 150 mg/L (Stuber et al., 1982; Kundell & Rasmussen, 1995, as cited in Springer Environment Systems and Decisions, 2015).

Field research on riverine gravel and substratum dredging, rather than harbour or estuarine dredging alone, has found reductions in fish abundance and species diversity following channel modification (Pennsylvania State University, 2013). Dredging can convert structurally complex reaches into deeper and more homogeneous channels with less gravel, cobble, and woody debris, reducing habitat used for spawning and refuge. The same research documented a shift in fish-community composition toward sediment-tolerant and disturbance-tolerant generalist species at the expense of specialists that require stable, structured substrate (Pennsylvania State University, 2013). Evidence from estuarine and low-salinity systems also suggests that post-dredging turbidity may persist and impair fish foraging, predator avoidance, macroinvertebrate respiration, and feeding even where low-disturbance dredging methods are used (Sciencedirect Water Injection Dredging, 2020).

Hydromorphological and Flow-Regime Alteration

Dredging also changes channel form and flow behaviour. Bed-material removal increases channel depth, may homogenize natural pool-riffle sequences, and can trigger bank erosion and upstream head-cutting as the river adjusts to altered geometry (Pennsylvania State University, 2013). In rivers carrying high fine-sediment loads, dredged channels may re-sediment rapidly, creating a need for repeated maintenance and raising questions about the long-term sustainability and cost-effectiveness of dredging compared with measures such as floodplain restoration or managed realignment (Sciencedirect Water Injection Dredging, 2020; Thorne, 1995). Thorne (1995) concluded that river-maintenance decisions are most effective when embedded within an integrated basin-management framework that anticipates future maintenance needs. This finding is directly relevant to the Naam River, where dredging has been pursued primarily as a localized response to flooding rather than as one component of an integrated Sudd-Bahr el Ghazal management strategy.

Wetland Water Balance and Carbon Effects

In wetland-fed systems, channel modifications that alter water residence time and inundation extent can change the water balance in ways that are difficult to predict and may differ from anticipated project outcomes. The Sudd is recognized not only as a hydrological regulator but also as an important carbon store supported by dense papyrus vegetation and peat-forming soils (Biology Insights, 2026). Sustained drainage or accelerated through-flow could reduce floodplain inundation duration, with implications for vegetation composition, carbon storage, and flood-recession grazing and fishing cycles used by pastoralist communities, including the

Dinka and Nuer of Unity State (Biology Insights, 2026). The magnitude of these effects for a tributary-scale intervention such as the Naam River project has not been empirically established and remains a central question for this study.

The Naam River Dredging Project: Chronology of a Contested Intervention

The Naam River case can be reconstructed from South Sudanese and international reporting. In April 2022, then Minister of Water Resources and Irrigation Hon. Manawa Peter Gatkuoth announced that South Sudan and Egypt had signed a cooperation agreement for dredging the Naam River (Hydro-politics in the Sudd Wetland, 2023). The announcement prompted immediate public and social-media opposition led by academics and activists, including the Vice Chancellor of the University of Juba, who cited the risk of adverse environmental effects (Hydro-politics in the Sudd Wetland, 2023). In May and June 2022, Egyptian-donated dredging equipment, including at least 21 machines according to contemporaneous reporting, arrived in Unity State. The state government presented the project as a flood-mitigation measure for communities that had experienced extensive displacement (The Hill, 2022; Hydro-politics in the Sudd Wetland, 2023; Pachodo.org, 2022).

On 9 July 2022, during South Sudan's 11th independence anniversary, President Salva Kiir Mayardit ordered a nationwide suspension of dredging-related activities, including the Bahr el Ghazal-Naam River project and the dormant Jonglei Canal scheme, pending evidence-based studies of impacts on communities and ecosystems (The Hill, 2022; Pachodo.org, 2022). The President acknowledged that both sides had advanced legitimate arguments and emphasized the importance of feasibility and impact studies before further work proceeded (The Hill, 2022). Later in 2022, however, the Council of Ministers approved the project and directed that clearance resume to mitigate continued flooding in Unity State. In April 2023, the Unity State government published images of machinery operating on the river, renewing public debate (Kazi Njema News, 2023).

The controversy intensified again in September 2023 during South Sudan's first National Economic Conference in Juba, where the Governor of Unity State, Dr. Joseph Nguen Monytuil, and the Vice Chancellor of the University of Juba, Professor John Apurut Akech, publicly disagreed over the continuing clearance of the Naam River (PaanLuel Wël Media, 2023). Supporters of Governor Monytuil framed dredging as a necessary response to four years of flooding that had displaced a large proportion of Unity State's population and damaged crops, livestock, and infrastructure (PaanLuel Wël Media, 2023). Professor Akech maintained that

dredging posed risks to the river ecosystem, biodiversity, and water quality. At the same time, the national Vice President for the Economic Cluster criticized environment ministry officials for continuing to oppose a cabinet-approved project (Kazi Njema News, 2023; PaanLuel Wël Media, 2023). By June 2024, clearing had resumed using excavators mounted on pontoons and reportedly received a positive local response in flood-affected communities, while civil society and academic actors continued to call for a comprehensive scientific and environmental impact assessment (Radio Tamazuj, 2024).

The chronology reveals repeated authorization, suspension, and resumption without completion of the impact assessment that government statements have identified as necessary for responsible implementation. This gap between political recognition of the need for evidence and the continued absence of that evidence provides a central justification for the study.

Flooding, Displacement, and Water Insecurity in South Sudan

The urgency surrounding the Naam River project reflects the scale of South Sudan's recent flood crisis. The country experienced three consecutive years of exceptionally severe flooding in 2019, 2020, and 2021, a sequence described as unprecedented in six decades of record, while subsequent climate outlooks continued to indicate elevated flood risk (World Bank Group, 2023). In 2022, South Sudan was ranked as the world's most climate-vulnerable country with the lowest adaptive coping capacity, reinforcing a cycle of water insecurity and political fragility (World Bank Group, 2023). In 2021 alone, flooding affected approximately 1.2 million people, displaced more than 300,000, and caused an estimated US$671 million in economic damage (World Bank Group, 2023). Between 2020 and 2022, about 2.6 million people were displaced by conflict and flooding, with flooding accounting for roughly 1.5 million displacements; these pressures also intensified competition between pastoralists and farming communities over increasingly scarce dry land (University of Reading, 2024).

Unity, Jonglei, and Upper Nile States have repeatedly been identified as the most flood-affected areas, together accounting for roughly three-quarters of affected people nationally (UNICEF South Sudan, n.d.). The consequences extend beyond displacement. Stagnant floodwater has been associated with water-borne disease, including cholera and hepatitis E, as well as increased snakebite incidence and vector-borne disease, while chronic malnutrition compounds these risks (University of Reading, 2024). In November 2021, flooding affected more than 100 schools in Unity State and disrupted education for more than 60,000 students (UNICEF South Sudan, n.d.). Research on the humanitarian-peace-development nexus further indicates that

exceptional 2019 rainfall, linked to Indian Ocean Dipole warming and climate change, combined with upstream releases from Lake Victoria to overwhelm regional waterways. Waterlogged soils left by the 2020 floods then contributed to rapid and severe flooding in 2021 even under less exceptional rainfall conditions (Social Science in Humanitarian Action Platform, 2025).

This flood crisis provides a legitimate humanitarian basis for the political urgency behind the Naam River project. It does not, however, resolve whether dredging is an effective, sustainable, and net-beneficial response from a water-security perspective. The key issue is whether the intervention reduces acute flood risk without creating slower-developing structural risks to water availability, water quality, ecosystems, and livelihoods. Resolving this question requires the localized, evidence-based assessment proposed in this study.

Governance, Institutions, and Transboundary Considerations

The Naam River controversy also exposes broader governance weaknesses in South Sudan's water-resources sector. The project originated in a bilateral cooperation arrangement with Egypt and was implemented at state level in Unity State, while national policy shifted between suspension and approval over more than two years (Hydro-politics in the Sudd Wetland, 2023; Kazi Njema News, 2023). Regional hydro-political literature suggests that water decisions with basin-wide and transboundary implications have often been shaped by state-level advocacy, bilateral relationships, and periodic national intervention rather than by an integrated, science-based national planning process (Hydro-politics in the Sudd Wetland, 2023). Public claims that Egyptian involvement demonstrated a project serving foreign rather than South Sudanese interests further show how domestic water infrastructure remains entangled with long-standing disputes over Nile water allocation (Hydro-politics in the Sudd Wetland, 2023). A comprehensive water-security assessment must therefore examine not only hydrology and ecology, but also the institutional arrangements through which decisions are made, contested, and revised.

RESEARCH METHODOLOGY

Research Paradigm and Design

The study adopts a pragmatic research paradigm and a convergent mixed-methods case-study design. Pragmatism is appropriate because the research questions combine quantitative hydrological and biophysical dimensions, including flow regime, sediment load, and water quality, with qualitative social and institutional dimensions such as lived experiences of

flooding, livelihood change, and governance processes. No single methodological tradition can adequately capture all these dimensions. The case-study design was selected because the Naam River dredging project is a bounded, contemporary, real-world intervention whose effects require in-depth and context-sensitive investigation rather than a decontextualized cross-sectional approach (Carse & Lewis, 2020). Within the convergent design, quantitative hydrological, remote-sensing, and household-survey data will be collected and analyzed alongside qualitative interview, focus-group, and documentary data. The two strands will be integrated during interpretation to produce a triangulated assessment of water-security outcomes.

Study Area

The study area comprises the Naam River corridor in Unity State, Republic of South Sudan, including reaches affected by dredging and clearance since 2022, adjacent floodplain communities, and the confluence with the wider Bahr el Ghazal-Sudd system. Unity State was selected purposively because it is the site of the dredging intervention and has been among the areas most severely affected by the 2019-2024 flood sequence (UNICEF South Sudan, n.d.; World Bank Group, 2023). The study will sample payams and bomas along dredged and undredged river reaches to support comparative analysis across different exposure conditions. Given the documented gaps in hydrological gauging since the 1980s (Sciencedirect Hydrologic Modeling of the Sudd, 2021), final site selection will also be informed by satellite-derived inundation mapping so that sampled locations capture meaningful hydrological variation.

Target Population and Sampling Strategy

The target population comprises three overlapping groups: households living in payams and bomas along the Naam River corridor whose livelihoods depend on fishing, flood-recession agriculture, or pastoralism; key institutional informants from the Ministry of Water Resources and Irrigation, Ministry of Environment and Forestry, Unity State government, University of Juba, and relevant international and non-governmental organizations; and technical or scientific stakeholders with direct knowledge of dredging implementation, including engineers and operational personnel. For the household survey, the study will use a multistage cluster-sampling strategy. Payams will first be stratified by proximity to dredged and undredged reaches and by reported flood-exposure history; clusters will then be randomly selected within strata, followed by systematic household selection within clusters. The final household sample will be determined through a formal power calculation after baseline population figures are

confirmed. Key informants will be selected purposively and through snowball sampling to ensure representation of government, academia, civil society, technical actors, and affected communities, with recruitment continuing until thematic saturation is reached.

Data Collection Instruments and Procedures

Data will be collected using five complementary instruments and procedures.

Household Survey

A structured household questionnaire will collect demographic data, livelihood characteristics, self-reported flood exposure before and after dredging, perceptions of water access and quality, and livelihood outcomes such as fish catch, crop yields, and livestock condition. The questionnaire will be piloted and adapted for administration in local languages by trained enumerators.

Key Informant Interviews and Focus-Group Discussions

Semi-structured interviews will be conducted with government officials, academic experts, civil society representatives, and technical personnel associated with the project. The interviews will examine the governance history, decision-making process, and contrasting risk assessments documented in the public record (Hydro-politics in the Sudd Wetland, 2023; Kazi Njema News, 2023). Focus-group discussions, disaggregated by gender and livelihood group, will be conducted in affected communities to capture collective and gendered experiences of flooding, displacement, and river change that may not be fully captured through household surveys.

Remote Sensing and Hydrological Analysis

Because long-term in situ gauging in the Sudd has been limited since the 1980s (Sciencedirect Hydrologic Modeling of the Sudd, 2021), satellite-derived datasets will be used to reconstruct pre- and post-dredging inundation patterns, flood timing, and flood extent along the Naam River corridor. These datasets will include optical and radar-based surface-water mapping, precipitation estimates, and, where available, satellite altimetry, following analytical approaches applied in earlier Sudd hydrology research (Sciencedirect Hydrologic Modeling of the Sudd, 2021; Senay et al., 2014).

Water Quality and Sediment Sampling

Where field access permits, water samples will be collected from paired dredged and undredged sites. The analysis will measure turbidity, total suspended solids, and basic water-

quality parameters, enabling direct comparison with impact patterns and thresholds identified in the international dredging literature (ResearchGate Dredging of Harbours and Rivers, 2023; Springer Environment Systems and Decisions, 2015).

Document and Media Review

A systematic review of government policy documents, cabinet decisions, legislative records, and South Sudanese and international media coverage will reconstruct the governance chronology of the project and triangulate interview accounts with documentary evidence.

Data Analysis Techniques

Household-survey data will be analyzed using descriptive statistics and inferential techniques, including comparisons of flood exposure, livelihood indicators, and water-access outcomes across dredged and undredged sites and across pre- and post-dredging periods. Remote-sensing indicators, including inundation extent, flood timing, and flood duration, will be analyzed using time-series and change-detection techniques to identify shifts associated with the onset of dredging. Interview and focus-group data will be analyzed thematically, with coding organized around the study objectives. Governance data will also be subjected to chronological process tracing to map the sequence of project authorization, suspension, and resumption. Quantitative and qualitative findings will be integrated through a joint-display matrix to identify convergence, complementarity, and divergence across data sources.

Validity, Reliability, and Trustworthiness

Quantitative instruments will be piloted before full deployment to assess item clarity and internal consistency, and enumerators will be trained using a standardized protocol to strengthen measurement reliability. Qualitative trustworthiness will be enhanced through triangulation across household, institutional, remote-sensing, and documentary sources; member checking of preliminary findings where feasible; and maintenance of an audit trail documenting coding and analytical decisions. The use of multiple independent data streams is intended to address the evidence gap identified in the literature, where public debate has often relied on competing assertions rather than triangulated evidence (Hydro-politics in the Sudd Wetland, 2023).

Ethical Considerations

The study will comply with the research-ethics requirements of the University of Juba and applicable national authorization procedures. Free, prior, and informed consent will be

obtained from all household and key-informant participants, with a clear explanation of voluntary participation and the right to withdraw. Because the dredging debate is politically sensitive, particular care will be taken to protect the confidentiality and, where requested, anonymity of informants expressing potentially contentious views. Data will be stored securely and reported in aggregate or de-identified form unless an individual explicitly consents to attribution. The researcher's dual role as a doctoral candidate and a sitting member of the Transitional National Legislative Assembly will be disclosed as a potential source of positionality bias. External peer debriefing and transparent analytical procedures will be used to reduce the risk that this positionality influences interpretation.

Anticipated Limitations

Three principal limitations are anticipated. First, the absence of long-term in situ hydrological gauging constrains the development of a fully quantified pre-dredging baseline. Satellite remote sensing and community-based historical recall will partly mitigate this limitation, although both methods have inherent uncertainty. Second, access and security conditions in parts of Unity State may restrict the geographic or seasonal scope of fieldwork and may require adaptive or remote data-collection approaches. Third, because dredging has occurred intermittently rather than as a single discrete intervention, the study examines an evolving process. Its findings should therefore be interpreted as an early evidence base rather than a final assessment of long-term outcomes.

RESULTS AND DISCUSSIONS

The reviewed evidence yields three principal findings. First, international dredging literature consistently associates channel modification with increased turbidity and sediment disturbance, altered channel morphology, and reduced aquatic biodiversity, with some effects persisting after active dredging ends (ResearchGate Dredging of Harbours and Rivers, 2023; Pennsylvania State University, 2013). Second, the Sudd's extreme flatness, high evapotranspiration, poor gauging record, and basin-scale flow-regulation function mean that these general findings cannot be transferred directly to the Naam River without local validation. Previous modelling also indicates that hydrological responses to wetland interventions may not scale linearly with intervention size (Mohamed et al., 2005; Sciencedirect Hydrologic Modeling of the Sudd, 2021). Third, despite sustained political and scientific contestation since 2022, no peer-reviewed empirical study has measured the Naam River project's effects on hydrology, ecology, livelihoods, and water security, even though government statements have

repeatedly called for such an assessment (The Hill, 2022). The proposed methodology is therefore designed to address both the substantive evidence gap and the historical shortage of long-term hydrological observations in the Sudd.

CONCLUSION

This article establishes the conceptual, empirical, and methodological foundations for examining the impact of Naam River dredging on water security in South Sudan. The reviewed literature shows that dredging can alter water quality, hydromorphology, and aquatic biodiversity, but the Sudd's distinctive low-gradient hydrology and limited gauging record make direct local validation essential. The political history of the Naam River further demonstrates that dredging has been repeatedly authorized, suspended, and resumed without the comprehensive impact assessment that government and academic actors have identified as necessary. The proposed mixed-methods design combines household, institutional, remote-sensing, water-quality, and documentary evidence to address this gap. The study is therefore positioned to provide a rigorous basis for evaluating whether dredging reduces flood risk without transferring water insecurity to ecosystems, livelihoods, or other timeframes and locations.

RECOMMENDATIONS

i. Further dredging of the Naam River should be preceded by a comprehensive environmental and social impact assessment that evaluates hydrological, ecological, livelihood, and governance effects at both river-reach and Sudd-system scales.

ii. River clearance should be incorporated into an integrated Sudd-Bahr el Ghazal basin-management framework rather than implemented as an isolated flood-control measure. The framework should compare dredging with alternative flood-management options and account for long-term maintenance and re-sedimentation risks.

iii. South Sudan should strengthen hydrological and environmental monitoring along the Naam River by combining in situ water-level, water-quality, sediment, and biodiversity observations with satellite remote sensing. This would improve the evidence base for adaptive management in a historically under-gauged system.

iv. Future decision-making should institutionalize meaningful participation by affected communities, state and national agencies, academic institutions, civil society, and relevant Nile Basin actors so that flood-risk reduction, livelihood protection, ecosystem integrity, and transboundary implications are evaluated together.

REFERENCES

Biology Insights. (2026). What is the Sudd? Africa's largest wetland explained. https://biologyinsights.com/what-is-the-sudd-africas-largest-wetland-explained/

Carse, A., & Lewis, J. A. (2020). New horizons for dredging research: The ecology and politics of harbor deepening in the southeastern United States. WIREs Water, 7(6), e1485.

Click Petroleo e Gas. (2026). In South Sudan, the Sudd swamp, the size of England, causes the White Nile to lose more than half of its volume due to evaporation. https://en.clickpetroleoegas.com.br/

Erftemeijer, P. L. A., & Lewis, R. R. R. (2006). Environmental impacts of dredging on seagrasses: A review. Marine Pollution Bulletin, 52(12), 1553–1572.

Frontiers in Water. (2021). (Re-)orienting the concept of water risk to better understand inequities in water security. Frontiers in Water, 3, 799515.

Geography Worlds. (2026). White Nile River: Lake Victoria, Sudd wetland & complete guide. https://geographyworlds.com/blog/white-nile-river-complete-guide/

Grey, D., & Sadoff, C. W. (2007). Sink or swim? Water security for growth and development. Water Policy, 9(6), 545–571.

Hydro-politics in the Sudd Wetland. (2023). Swisspeace. https://www.swisspeace.ch/assets/publications/downloads/Hydropolitics_FINAL_290323-1.pdf

International Water Association Publishing. (2021). How is water security conceptualized and practiced for rural livelihoods in the global South? A systematic scoping review. Water Policy, 23(5), 1129–1148.

Kazi Njema News. (2023). South Sudan leaders clash over Naam River clearance. https://kazi-njemanews.com/wani-igga-lambasts-environment-ministry-for-opposing-naam-river-clearance/

MDPI. (2019). Urban water security: Definition and assessment framework. Resources, 8(4), 178.

Mohamed, Y. A., van den Hurk, B. J. J. M., Savenije, H. H. G., & Bastiaanssen, W. G. M. (2005). Impact of the Sudd wetland on the Nile hydroclimatology. Water Resources Research, 41(8), W08420.

PaanLuel Wël Media. (2023). Dredging of the Nile Basin: A call for unity and support for Governor Dr. Joseph Muonytuil. https://paanluelwel.com/2023/09/09/

Pachodo.org. (2022). South Sudan suspends dredging of Naam River, Sudd wetlands. https://pachodo.org/news-from-various-sources/36074-south-sudan-suspends-dredging-of-naam-river-sudd-wetlands

Pennsylvania State University. (2013). River dredging reduced fish numbers, diversity. ScienceDaily. https://www.sciencedaily.com/releases/2013/06/130610113008.htm

Pressreader / Mail & Guardian. (2022). Anger over Nile marsh dredge plan. https://www.pressreader.com/south-africa/mail-guardian/20220916/281659668891875

Radio Tamazuj. (2024). Naam River clearing starts to a jubilant reception in Unity State. https://www.radiotamazuj.org/en/news/article/naam-river-clearing-starts-to-a-jubilant-reception-in-unity-state

ResearchGate. (2014). Impact of climate variability on the hydrology of the Sudd wetland: Signals derived from long term (1900–2000) water balance computations. Wetlands Ecology and Management. https://www.researchgate.net/publication/263727147

ResearchGate. (2023). Dredging of harbours and rivers: Review of practices and associated environmental impacts. https://www.researchgate.net/publication/374708192

Senay, G. B., Asante, K., & Artan, G. (2014). Understanding the hydrologic sources and sinks in the Nile Basin using multisource climate and remote sensing data sets. Water Resources Research, 50(11), 8625–8650.

Sciencedirect. (2021). Hydrologic modeling of the Sudd wetland using satellite-based data. Journal of Hydrology: Regional Studies. https://www.sciencedirect.com/science/article/pii/S2214581821001518

Sciencedirect. (2020). The effects of water injection dredging on low-salinity estuarine ecosystems: Implications for fish and macroinvertebrate communities. Estuarine, Coastal and Shelf Science. https://www.sciencedirect.com/science/article/pii/S1470160X20311833

Social Science in Humanitarian Action Platform. (2025). Responding to floods in South Sudan through the humanitarian-peace-development nexus. https://www.socialscienceinaction.org/

Springer Nature. (2015). A review of the potential effects of suspended sediment on fishes: Potential dredging-related physiological, behavioral, and transgenerational implications. Environment Systems and Decisions, 35(3), 334–350.

Sutcliffe, J. V., & Parks, Y. P. (1999). The hydrology of the Nile (IAHS Special Publication No. 5). IAHS Press.

The Hill / Associated Press. (2022). South Sudan suspends dredging of Naam river, Sudd wetlands. https://thehill.com/homenews/ap/ap-international/south-sudan-suspends-dredging-of-naam-river-sudd-wetlands/

Thorne, C. R. (1995). Fluvial maintenance operations in managed alluvial rivers. Aquatic Conservation: Marine and Freshwater Ecosystems, 5(2), 189–207.

UNICEF South Sudan. (n.d.). Climate change and flooding. https://www.unicef.org/southsudan/what-we-do/climate-change-and-flooding

University of Reading. (2024). South Sudan floods: The first example of a mass population permanently displaced by climate change? Connecting Research. https://research.reading.ac.uk/research-blog/2024/09/19/south-sudan-floods-population-displacement/

World Bank Group. (2023). Water security and fragility in South Sudan. https://shorthand.worldbankgroup.org/water-security-and-fragility-in-south-sudan/