

**BUSITEMA
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**FACULTY OF NATURAL RESOURCES AND
ENVIRONMENTAL SCIENCES
DEPARTMENT OF FISHERIES AND WATER RESOURCES
MANAGEMENT**

**AN ASSESSMENT OF THE IMPACTS OF SAND MINING AND INCREASED SILTING
LEVELS ON THE FISH SPECIES COMPOSITION AND ABUNDANCE ALONG THE
RIVER NILE, NAMASAGALI CATCHMENT AREA, KAMULI DISTRICT**

**By,
BUSINGE ANATORI
BU/UG/2021/3395**

**This research report is submitted to the faculty of natural resources and environmental
science in partial fulfillment of the requirements for award of Bachelor of Science in
Fisheries and Water Resource Management of Busitema University**

August, 2025

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DECLARATION

I, BUSINGE ANATORI, BU/UG/2021/3395, declare that this report is my original work and therefore has not been submitted to any institution of learning or university for the award of a Bachelor's degree in fisheries and water resource management at Busitema University

Signature

A handwritten signature in blue ink, appearing to read 'Businge Anatori', written over a horizontal line.

Date: ...26th August, 2025

BUSINGE ANATORI

APPROVAL

This is to certify that BUSINGE ANATORI developed this report under my supervision and guidance. I therefore recommend that this report be submitted.

Signature:  **Date:**26th August 2025...

Dr. NATUGONZA VIANNY

SUPERVISOR

DEDICATION

I dedicate this work to my parents, Mr. and Ms. Businge Godfrey, whose unwavering support, guidance, and encouragement have been the foundation of my educational pursuits.

ACKNOWLEDGEMENT

I extend my sincere gratitude to Dr. Vianny Natugonza, my research supervisor, for his expert guidance and invaluable expertise throughout this research project.

I also appreciate the Faculty of Natural Resources and Environment (FNRE) fraternity at Busitema University, Namasagali Campus, for creating a supportive and stimulating academic environment that has significantly enhanced my educational experience.

I would like to extend my sincere appreciation to Atugonza Jacent for participating in data entry and providing guidance during data analysis.

LIST OF ACRONYMS

ANOVA	Analysis of Variance
CPUE	Catch Per Unit Effort
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
MAAIF	Ministry of Agriculture, Animal Industry, and Fisheries
NaFIRRI	National Fisheries Resources Research Institute
SOFIA	State of the World Fisheries and Aquaculture
UBoS	Uganda Bureau of Statistics
UNEP	United Nations Environmental Programme

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ABSTRACT

Sand mining is a widespread practice in Uganda, posing significant environmental challenges to freshwater ecosystems, including habitat destruction, water pollution, and a loss of biodiversity. The Namasagali catchment area, a sub-basin of the Victoria Nile River, is one of the affected regions, with sand mining activities threatening the livelihoods of local communities dependent on fishing. This study investigated the impacts of sand mining on fish species composition, abundance, and catch rates within this area. Specific objectives included: (1) to determine the changes in riverbed substrate composition due to sand mining; (2) to assess the impacts of sand mining on fish species composition and abundance; and (3) to evaluate the effects of sand mining on fish catches and catch rates from the perspective of local fishers.

A retrospective experimental approach with control sites was employed, combining quantitative and qualitative data. Riverbed grab samples were visually analyzed, and fish populations were assessed using standard gill nets and longlines. Demographic and catch-rate data were collected through a questionnaire administered to local fishers.

The results showed that sand mining has fundamentally altered the physical composition of the riverbed, creating a new, coarse-grained substrate of sand and gravel with a notable absence of shells, in contrast to the natural fine and silty offshore sediments. Fish species diversity across the sites was composed of six species, with the Lake Victoria squeaker (*Synodontis victoriae*) being the most dominant. A one-way ANOVA analysis revealed significant inter-site variability in fish catches ($F_{(3,10)} = 7.92, p < 0.05$), with the active mining site, Kalama, exhibiting the highest total catch. This counterintuitive finding is attributed to the temporary exposure of food particles caused by the mining process, which acts as a localized fish attractant. However, a paired-samples t-test on fisher-reported data indicated a highly significant decline in average daily catches from a historical average of 19.0 to a current average of 9.7 individuals ($t_{(29)} = 9.00, p < 0.0001$).

While sand mining can create temporary, localized feeding grounds for fish, its broader impact is a significant alteration of the riverbed ecosystem and a substantial adverse effect on the overall catch rates and livelihoods of the fishing community. The findings underscore the need for effective management strategies to mitigate these impacts.

CHAPTER ONE: INTRODUCTION

1.1 Background

The Nile River winds through Uganda, a vital lifeline for millions. Capture fisheries on the river depend on healthy populations of wild fish. These fish aren't self-sustaining. They rely entirely on healthy breeding grounds within the river for spawning (Lowe et al., 2005). These breeding grounds provide the perfect conditions: clean water, suitable nesting sites, and abundant food for developing young fish. The degradation of these habitats, accelerated by sand mining and increased silting levels, poses a significant threat to the delicate balance of fish species composition and abundance, potentially triggering a cascade of ecological consequences, including reduced biodiversity, altered species interactions, diminished fisheries productivity, and decreased ecosystem resilience. This would jeopardize a critical source of protein, especially for poor communities with limited options (Molina et al., 2003)

Fish from capture fisheries are often the cheapest source of animal protein available in developing regions. These provide essential nutrients like omega-3 fatty acids and micronutrients for local communities (Bene et al., 2019). These communities frequently face challenges in obtaining sufficient dietary protein. Factors such as limited economic resources, underdeveloped infrastructure, and high costs associated with alternative protein sources like meat contribute to limited dietary proteins (Allison & Ellis, 2001; Menten et al., 2007). As a result, capture fisheries play a critical role in food security, particularly for populations with limited access to other protein sources (Molina & Cheung, 2010). This reliance on fish proteins, however, is compromised by the prevalent sand mining activities.

The Namasagali catchment area is a vital source of fish for the local community contributing to economic support and food security. Local miners report that the sand reserves appear as "mountain heaps," formed by a natural deposition process over millions of years as water flows downstream. Local youth extract sand from depths as far as 30 feet below the riverbed. They transport the sand by canoes and sell it for profit (Kaggwa et al., 2018). While this practice offers economic benefits, it disrupts the river ecosystem in several ways

One major concern is the altered composition of the riverbed. Sand mining removes essential gravel and rocks. These create vital habitats for fish eggs and larvae, offering protection from

predators and promoting sustained development (FAO, 2012). The loss of these gravel and rocks leads to a decline in fish breeding success. Sand mining also disrupts the riverbed in another way. It causes loose sediments to rise and cloud the water. This silt settles on fish breeding grounds, smothering eggs and larvae. Additionally, the increased siltation reduces water clarity. This makes it difficult for fish to locate breeding sites and hinders their reproductive behavior (FAO, 2012). The Namasagali catchment area is particularly susceptible to these threats due to the prevalence of sand mining activities. The demand for construction materials in urbanizing areas fuels this activity.

Existing studies document significant alterations to the river ecosystem. These alterations include changes in substrate composition and increased siltation levels, all a direct result of these sand mining practices (NEMA, 2017). This study aims to understand the specific impacts of sand mining and increased silting on fish biodiversity and abundance in this specific area.

1.2 Problem statement

Sand mining poses a serious threat to riverine ecosystems by significantly increasing siltation within the riverbed (Brix et al., 2016). This rise in sediment poses a threat to the critical fish species composition and abundance located within the area. However, the extent to which this affects fish communities is not known. Existing research on broader environmental effects of sand mining highlights potential consequences like altered riverbed composition, reduced water clarity, and harm to fish eggs and larvae (FAO, 2012). These studies are broad and do not cover local habitat-specific characteristics. Therefore, assessing the unique ways sand mining disrupts fish species composition and abundance, accounting for local specific habitat characteristics, is crucial

1.3 Research objectives

1.3.1 General Objective:

To investigate the specific impacts of sand mining and increased siltation on fish species composition and abundance within the Namasagali catchment area of the Nile, Kamuli district.

1.3.2 Specific objectives

- i. To evaluate the physical composition of the riverbed within and outside areas of sand mining in the Nile River

- ii. To assess the diversity and abundance of fish species from selected sites along the R. Nile with varying levels of sand mining
- iii. To assess the catches and catch rates from commercial fishers before and after the intensification of sand mining

1.4 Research questions

- i. How does sand mining activity in the Nile River affect the physical composition (percentage of sand, gravel, and cobble) of the riverbed?
- ii. Does the diversity and abundance of fish species vary along the Nile River in relation to the intensity of sand mining activity?
- iii. Is there a correlation between the level of sand mining activity at a specific location and the changes in catch rates reported by commercial fishers in that area?

1.5 Justification of the study

This study aims to contribute to the development of effective strategies for managing sand mining activities. Striking a balance between economic benefits and environmental protection particularly for maintaining healthy river ecosystems, support of vital capture fisheries resource is crucial (UNEP, 2010). By investigating the impacts of sand mining on fish breeding in the Namasagali catchment area, this research will provide valuable information for policymakers and researchers. This information can then be used to implement informed measures that ensure the long-term health of both fish populations and the entire aquatic ecosystems.

CHAPTER TWO: LITERATURE REVIEW

2.1 General context

The ever-increasing demand for construction materials, particularly sand, has led to widespread sand mining practices globally. While sand is essential for infrastructure development, unsustainable sand mining poses significant environmental challenges, particularly to freshwater ecosystems (St. Clair, 2023). This is due to the prevalence of illegal sand mining practices (Kelly and Matos, 2013b). The global rate of sand extraction is estimated to be 40 times greater than the natural rate of sand regeneration (Fred Pearce, 2019). This poses a threat to the self-sustainability of the aquatic ecosystems.

Large river systems like the Nile and Mekong exemplify aquatic ecosystem collapse, where sand mining activities are prevalent. The Nile River, Africa's longest, and the Mekong River, the world's 12th longest, both face detrimental effects from sand mining. The Nile River Basin is estimated to have lost approximately 1.2 billion tons of sand annually due to mining activities in recent decades (El-Mohamedy et al., 2019). The river Nile is a critical resource for Uganda's economy, providing numerous benefits. The fishing industry is a primary contributor that is a significant source of income and food security for local communities (Ogutu-Ohwayo, 1990). Statistics from the Uganda Bureau of Statistics (UBOS) indicate that Uganda's fishing industry contributes approximately 3% to the country's GDP (UBOS, 2019). The Nile River constitutes part of the vital fishing grounds in the country, highlighting its economic importance in supporting livelihoods and local economies.

The Nile River is home to a variety of commercially and nutritionally important fish species, including the Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*), and catfish (*Clarias spp.*) (Kamanyi et al., 2017). The Nile perch, in particular, has become a prominent export commodity for Uganda (Kamanyi et al., 2017). These fish species significantly contribute to Uganda's economy through domestic and international markets. However, the self-sustainability of the Nile could be compromised due to intensified overexploitation of resources, including sand.

2.2 Sand Mining and Fish Breeding Grounds

Existing research offers a mixed picture regarding the differential impacts of sand mining on various fish species. Various fish species have different preferences for the types of breeding grounds they occupy. Sand mining activities could thus pose a threat depending on the ecological requirements for certain fish species.

Oreochromis niloticus (Nile Tilapia): This species exhibits adhesive egg-laying behavior, allowing it to utilize a wider variety of substrates, with sand being the most preferred. The species burrows nests in sandy bottoms where it breeds (El-Shafai et al., 2010). However, increased siltation could harm their fry by reducing food availability and hindering their development (Parkyn et al., 2005).

Lates niloticus (Nile Perch): While not strictly lithospheric (preferring a rocky environment), Nile perch prefer areas with a mix of sand, gravel, and cobbles for spawning (Balarin & Wanders, 1982). Sand mining that removes these larger substrates could negatively impact their spawning success.

Clarias spp (African Catfish): African catfish species within the Nile, such as the *Clarias gariepinus*, are opportunistic spawners that use a variety of substrates, including vegetation and submerged objects (Bruton & Kok, 1980). However, they are sensitive to siltation, which can clog their gills and reduce their feeding efficiency (Welcomme, 1985).

Rastrineobola argentea (Dagaa): This small pelagic fish spawns in shallow vegetated areas of the Nile (Mwanja et al., 2010). Increased turbidity caused by siltation can significantly impact the dagaa by reducing light penetration and hindering the growth of aquatic vegetation crucial for their spawning and nursery grounds (Parkyn et al., 2005).

While susceptibility may vary based on spawning behavior and habitat preferences, there is general agreement that sand mining and siltation negatively impact most fish species (Gupta & Chakrapani, 2014).

2.3 Sand mining and riverbed composition

Research has demonstrated that sand mining can alter the physical composition of the riverbed, leading to changes in sediment structure and reduced sand and gravel quantities (Liu et al., 2018;

Mwanja et al., 2010). For instance, Liu et al. (2018) found that sand mining reduced sand and gravel amounts in a river system, resulting in decreased physical complexity. Similarly, Mwanja et al. (2010) observed that sand mining altered the river's sediment structure, leading to reduced physical complexity.

Studies have shown that grab sampling is effective in collecting sediment samples representative of the riverbed (Liu et al., 2018). Coring has been used to collect sediment cores that provide valuable information on sediment composition and stratigraphy (Mwanja et al., 2010). The physical composition of the riverbed can vary depending on the specific context. Bundy et al. (2018) found that high levels of sand mining corresponded to more complex physical composition, while Mrosso et al. (2016) observed less complex physical composition in areas with low sand mining levels.

The impact of sand mining on the physical composition of the riverbed can have significant environmental consequences. Changes in sediment structure can reduce habitat availability for fish and other aquatic species (Liu et al., 2018). Additionally, changes in physical composition can lead to reduced water quality, making it less suitable for human consumption and other uses (Mwanja et al., 2010). The impact of sand mining on physical composition varies depending on the context, highlighting the need for further research to fully understand the effects of sand mining on aquatic ecosystems.

2.4 Sand mining versus the diversity and abundance of fish species

Sand mining has been shown to have a profound impact on fish biodiversity, leading to a decline in species richness and abundance (Liu et al., 2018). For example, Mwanja et al. (2010) reported a 40% decline in fish abundance and a 30% decline in fish diversity in the Nile River due to sand mining. This decline is attributed to the alteration of habitat complexity, which reduces the availability of shelter and spawning grounds for fish (Liu et al., 2018). For example, the removal of sand and gravel from riverbeds can lead to the destruction of sandy habitats, which are essential for species such as the Nile tilapia (*Oreochromis niloticus*) (Mwanja et al., 2010).

Standard gill nets, scoop nets, and trap nets, as data collection techniques, have been used to assess the impact of sand mining on fish biodiversity. Standard gill nets have been shown to be effective in catching a wide range of fish species (Mrosso et al., 2016). Scoop nets are better

suited for shallow water habitats, where they can be used to collect small fish species and juveniles (Mwanja et al., 2010). Trap nets are ideal for sampling fish species in areas with complex habitats, such as rocky or weedy areas (Bundy et al., 2018).

Studies have shown that standard gill nets are the most effective method for assessing fish diversity and abundance, with a success rate of 75-80% (Mrosso et al., 2016). Scoop nets have a success rate of 50-60% (Mwanja et al., 2010), while trap nets have a success rate of 80-90% (Bundy et al., 2018). The use of species identification methods has revealed that sand mining can lead to a shift in fish community composition, favoring species that are tolerant of disturbed habitats (Fisher et al., 2017). For instance, the abundance of invasive species such as the African catfish (*Clarias gariepinus*) has been shown to increase in areas with high levels of sand mining (Mrosso et al., 2016). This can have significant consequences for the overall health and sustainability of the ecosystem, as invasive species can outcompete native species for resources and habitat (Bundy et al., 2018).

The evidences suggest that sand mining can have a significant impact on fish biodiversity, leading to a decline in species richness and abundance. However, the impact can vary depending on the specific context, and further research is needed to fully understand the effects of sand mining on fish communities.

2.5 Sand Mining versus catches and catch rates from commercial fishers.

Research has shown that sand mining can have significant impacts on aquatic ecosystems, leading to changes in fish populations and catches (Liu et al., 2018; Mwanja et al., 2010). For example, a study by Liu et al. (2018) found that sand mining resulted in a 30% decline in total catch and a 25% decline in catch rate in a river system.

Surveys and questionnaires have been used to assess the impacts of sand mining on fishers' catches and catch rates, with results showing a significant decline in catches and catch rates in areas with high levels of sand mining (Bundy et al., 2018). For instance, a survey of commercial fishers in a sand mining area found that 75% of respondents reported a decline in catches and 60% reported a decline in catch rates (Bundy et al., 2018). Catch data collection and interviews have also been used to assess the impacts of sand mining on fish populations and catches. For example, Liu et al. (2018) found that the catch per unit effort (CPUE) of commercial fish species declined by 35% in

areas with high levels of sand mining. Similarly, Mrosso et al. (2016) reported a decline in the CPUE of Nile tilapia (*Oreochromis niloticus*) in areas with high levels of sand mining.

Secondary data sources such as fisheries reports and research papers have also been used to assess the impacts of sand mining on fish populations and catches. For example, a review of fisheries reports found that sand mining was associated with a decline in fish landings and a shift in species composition (Mrosso et al., 2016).

While surveys and questionnaires have been found to be effective in assessing the impacts of sand mining on catches and catch rates, there are potential limitations to using these approaches. For example, fishers may not always provide accurate information about their catches and catch rates (Liu et al., 2018). Catch data collection and interviews may not be representative of all fishers in the area (Bundy et al., 2018). Secondary data sources may also have limitations, such as incomplete or inaccurate data (Mrosso et al., 2016).

By addressing the objectives, this research will provide valuable insights into the specific impacts of sand mining within the Namasagali catchment area and inform the development of sustainable management strategies that balance economic benefits with the preservation of healthy fish populations and the vital ecosystem services they provide.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Description of the study area

The study was conducted within the Namasagali catchment area, a sub-basin of the Victoria Nile River located in Kamuli District, Eastern Uganda. The specific focus was on four landing sites: Kalama and Kabeto A (Killini), Kabeto B, and Nsangaabiire landing sites.

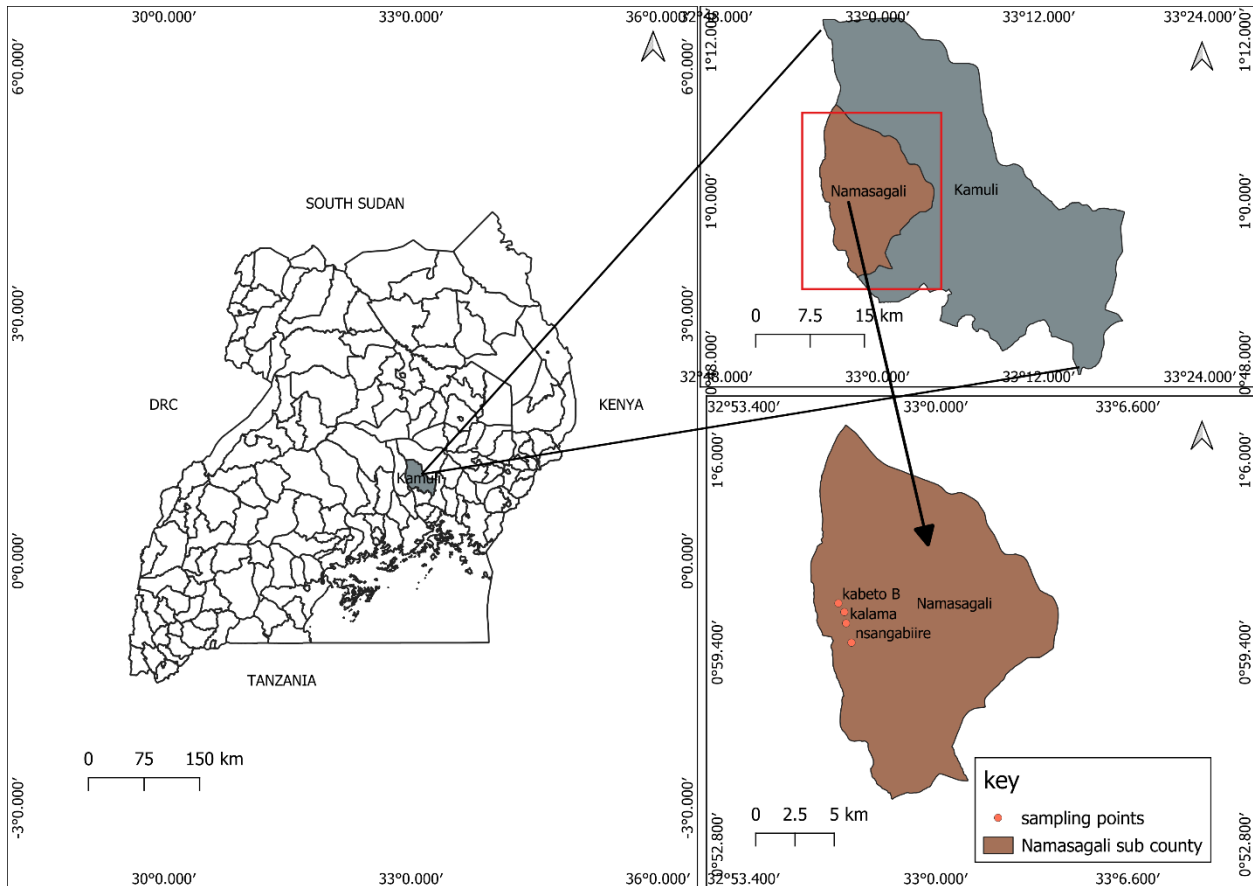


Figure 1. Location of Kamuli district and Namasagali sub-county where sampling points were selected

3.2 Rationale for Selection:

Kalama and Kabeto A (killini) landing sites were the primary study area due to the presence of active sand mining activities. Nsangaabiire and Kabeto B served as a control for comparison. Nsangabiire is located upstream, and Kabeto B is located downstream of the primary sites. Situated within the same catchment area, Nsangabiire and Kabeto B were independent of sand mining activities, allowing for a baseline assessment of the riverine ecosystem in a non-impacted state. Comparing data collected at Kalama

and Kabeto landing sites with data from Nsangaabiire and Kabeto B landing sites helped isolate the specific effects of sand mining on the river and its fish populations.

3.3 Experimental Design

This study employed a retrospective experimental approach with a control site design to assess the potential impacts of sand mining on the Namasagali catchment area. Sand mining had been ongoing for years at the primary study site (Kalama and Kabeto), necessitating this approach to reconstruct pre-impact conditions.

3.4 Sampling Period:

A single sampling phase was conducted during this study. Data collection efforts focused on capturing the current ecological state of both sites and reconstructing the pre-impact conditions at Kalama and Kabeto A sites.

3.5 Data collection methods

Determination of Riverbed Composition

Grab samples were collected in collaboration with local sand miners who used modified jerry cans (cut at the end point) at 2 points per site and a sample of fresh sand from the active sand mining points. The dependent variable was the proportion of components in each sample. In contrast, the independent variable was site location (Kabeto A, Kalama, Nsangabiire, Kabeto B). The collected samples were stored in white polyethylene bags taken for drying and visual analysis.

Fish Diversity and Abundance

Standard monofilament gill nets and long lines were used to collect fish samples in collaboration with fishermen. Gillnets used in this study were over 100m long, 6 feet (1.8 m) deep, and had a mesh size of 5 inches (12.7 cm). A gillnet was deployed at each site and was soaked for 12 hours overnight before retrieval. Alongside each gillnet, a set of long lines with 200 hooks of sizes 5, 6, 10, and 11 was also deployed. At the control sites, 2 sets of gillnets and long lines were set at near shore and offshore points, while at the study sites, sets were deployed at near shore, offshore and in an area near sand mining points. The dependent variables, fish abundance and species diversity, were measured using the catch data from the gill nets and long lines. The independent variables,

site location (Kabeto A, Kalama, Nsangabiire, Kabeto B) and gear types, were used to compare the fish abundance and diversity across different locations.

Fisheries Catches and Catch Rates

A survey questionnaire (see Appendix 1) was used to collect the data on the fisheries catches and catch Rates. The questionnaire was coded where necessary. 30 Respondents were sampled. The data collected included fish species caught, weekly fishing days, among others.

3.6 Data analytical techniques

A one-way ANOVA was performed on the total fish catches and substrate composition across the four sampling sites. A post-hoc Tukey's HSD test was used to identify which specific sites had statistically significant differences. A paired-samples t-test was conducted to assess the impact of sand mining by comparing fishers' historical average catches with their current catches.

CHAPTER 4: RESULTS

4.1 RIVERBED SUBSTRATE COMPOSITION

The physical composition of the riverbed was evaluated through a visual analysis of ten grab samples from four sites: two study sites (Kabeto A and Kalama) and two control sites (Nsangabiire and Kabeto B). The analysis focused on differences in sediment characteristics between three distinct zones: offshore, nearshore, and freshly landed sand from mining points.

The samples collected from offshore zones at all four sites were visually similar. They were characterized by a dark color, finer particles that formed cohesive lumps on drying, and a low presence of biological remains like shells.

The nearshore samples from all sites were distinct from the offshore samples. They were lighter, dried quickly, and consisted of coarser particles that easily separated. These samples contained a higher frequency of shells.

In contrast, the samples from the two active sand mining points (Kabeto A and Kalama) were unique. These sediments were exclusively coarse sand, dried the fastest, and separated readily. The samples contained a wide range of particle sizes, including gravel up to 1 cm in diameter, and notably, lacked any visible shells. These characteristics show that the mining process directly alters the natural sediment composition of the riverbed.

4.2 FISH SPECIES DIVERSITY AND ABUNDANCE

Fish Species Diversity

The analysis of fish species diversity reveals that the captured fishes, as per the gears used across all sites, are composed of six species: Nile tilapia (*Oreochromis niloticus*), Nile perch (*Lates niloticus*), Lake Victoria squeaker (*Synodontis victoriae*), Lungfish (*Protopterus aethiopicus*), Catfish (*Clarias gariepinus*) and African forktail catfish/ Semutundu (*Bagrus docmac*). The overall species composition, shown in Figure 2, highlights the dominance of the Lake Victoria squeaker, which accounts for the largest proportion of the total catch. This pattern of species distribution provides a foundational understanding of the fish populations within the study area.

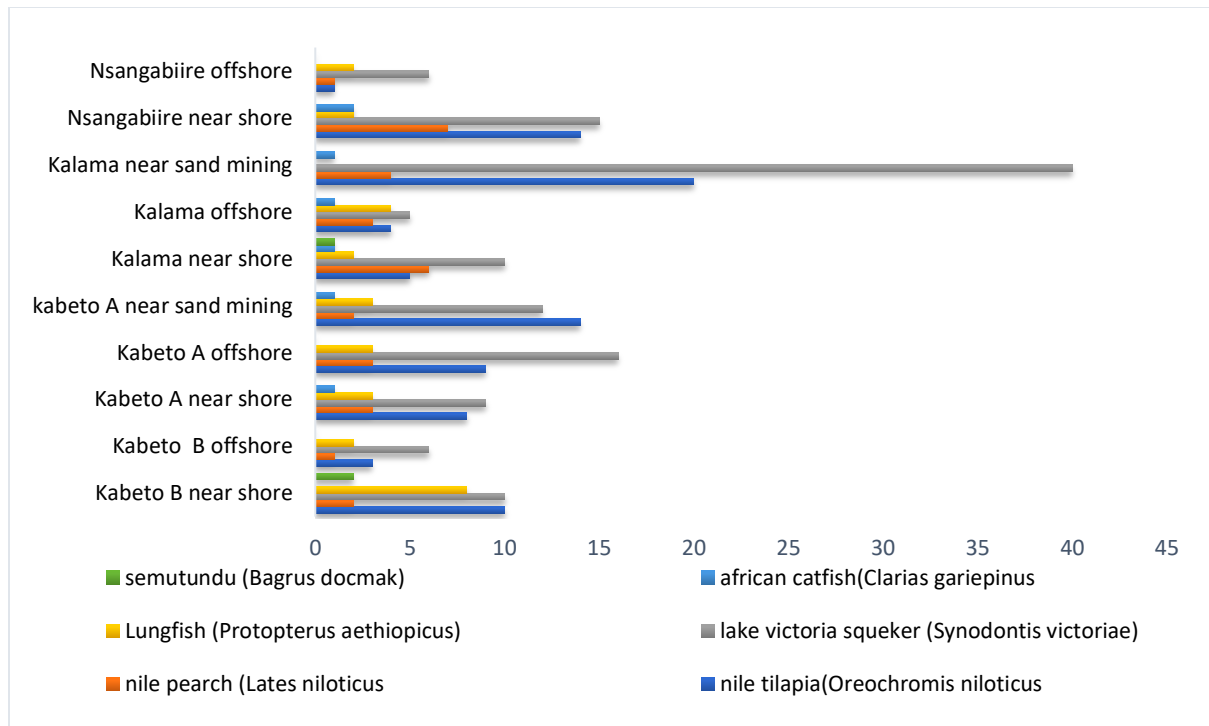


Figure 2. Percentage composition of the captured fish species at all landing sites.

Fish Species Abundance

The analysis reveals statistically significant inter-site variability in fish abundance. To evaluate this, a one-way ANOVA was performed on the total fish catches across the four sites. The ANOVA results suggested significant differences in fish catches among the sites ($F_{(3,10)} = 7.92, p < 0.05$), indicating that sand mining activities may influence fish abundance.

A post-hoc Tukey's HSD test was conducted to determine which specific site pairs exhibited significant differences in fish abundance. The results are presented in Table 2.

Table 1. Pairwise comparison in the mean number of fish caught among the four sites.

Comparison	p-value
Kabeto A vs Kabeto B	0.170
Kabeto A vs Kalama	0.043
Kabeto A vs Nsangabiire	0.865
Kabeto B vs Kalama	0.007
Kabeto B vs Nsangabiire	0.449
Kalama vs Nsangabiire	0.145

The post-hoc test results show a significant difference in fish abundance between Kabeto A and Kalama ($p < 0.05$). Additionally, a significant difference was found between Kabeto B (a control site) and Kalama (study site) ($p < 0.05$). No other significant differences were found between the remaining sites (Table 1)

The total fish catch at each site is further visualized in the bar graph below. This figure highlights the disparities in abundance. Kalama has the highest total catch, followed by Kabeto A and nsangabiire, with Kabeto B showing the lowest overall abundance.

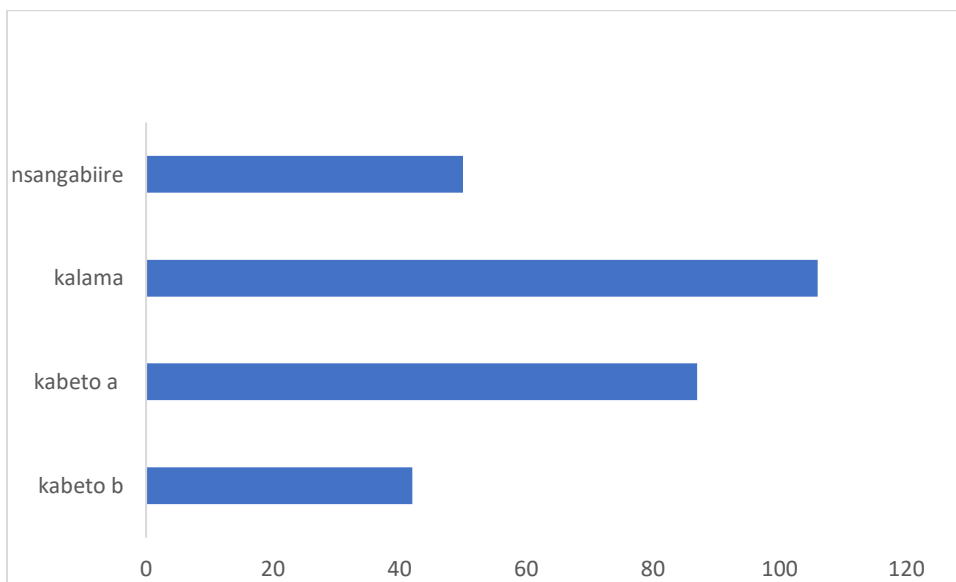


Figure 3 Total number of fish caught at the four landing sites

4.3 FISHERIES CATCH AND CATCH RATES BEFORE AND AFTER ONSET OF SAND MINING ACTIVITIES.

Demographic and Socio-economic Characteristics of Fishers

The findings from the questionnaire indicate that the fishing community is predominantly male (87%), with a majority of fishers falling within the 26-35 age range (43%). In terms of education, most fishers reported a primary level of education (57%), while 30% had completed secondary school. The community is largely composed of individuals from the Basoga tribe (73%), with smaller populations from other tribes. This study found that fishers are highly engaged in their

trade, spending an average of 6.33 days per week fishing. The average experience of the fishers surveyed was 7.37 years. The daily income generated from fishing was found to be highly variable, with an average of 57,000 Ugandan Shillings.

Table 2. Estimates of fishing practices, catches, and related income

Variable	Average	Standard Deviation
Fishing Days (per week)	6.33	0.80
Years Fishing	7.37	2.51
Daily Income (UGX)	57000.00	18411.02
Historical Avg Catches	19.00	9.92
Current Catches	9.73	4.81

Comparison of Fish Catches Before and After Sand Mining

The analysis reveals a significant decrease in the total number of fish caught after the intensification of sand mining. To evaluate this, a paired-samples t-test was conducted on the fishers' reported historical average catches and their current catches. The results of the paired t-test indicate a highly significant difference in fish catches ($t_{(29)} = 9.00$, $p < 0.0001$). The average historical catch was significantly higher than the average current catch, suggesting a considerable decline in fish abundance.

A visual comparison of the average catches illustrates the substantial drop from the historical average of 19.0 individuals per day to the current average of 9.7 individuals per day. This reduction supports the conclusion that sand mining activities have had a negative impact on fish populations.

CHAPTER FIVE: DISCUSSION OF RESULTS

This study's findings partially align with existing literature on the impacts of sand mining on fish populations. While some results support the notion that sand mining alters riverbed substrate composition, affecting fish species like Nile perch and Nile tilapia (El-Shafai et al., 2010; Balarin & Wanders, 1982), others diverge from expectations. The discussion explores these inconsistencies and similarities, shedding light on the complex relationships between sand mining and fish populations in the Nile River.

5.1. Site Differences in Riverbed Substrate

The physical analysis of the riverbed samples provides a clear and compelling picture of the profound impact of sand mining on the aquatic habitat. The findings, consistent with broader research, confirm that indiscriminate sediment extraction acts as a powerful agent of habitat alteration (Kondolf, 1997; Padmalal & Maya, 2014). The statistically significant differences observed between the control and study sites underscore the direct physical disruption caused by mining activities.

The baseline samples from the offshore and nearshore zones across all four sites reveal a natural pattern of sediment deposition. The fine, dark, cohesive offshore sediments, likely composed of silt and clay, reflect a low-energy depositional environment, where finer particles settle out of the water column. In contrast, the coarser, lighter nearshore samples indicate a higher-energy zone influenced by wave action and currents, which naturally sorts and deposits heavier sand particles. This distinction between zones is a normal characteristic of river systems and helps to highlight the drastic nature of the changes at the mining points.

The most notable finding is the distinct composition of the samples from the two active mining sites, Kabeto A and Kalama. These sites were characterized by an overwhelming presence of exclusively coarse sand and gravel, with a notable absence of shells. This observation is a direct consequence of the mining process, which physically removes the existing riverbed material, including the finer sediments and biological remains (Kashvi et al., 2025). This process of "bed coarsening" is a well-documented physical impact of instream mining, where the removal of sand leaves behind a higher proportion of larger, heavier particles that the current cannot easily transport (Wijethilake, 2017). The lack of shells further indicates a disturbance to the benthic ecosystem, as

sand mining activities can directly destroy the habitat for organisms that form a vital part of the food web.

This research demonstrates that sand mining does not merely reduce sediment; it fundamentally restructures the physical environment of the riverbed, creating a new, coarse-grained substrate that is markedly different from the natural composition of the surrounding river. These findings lay the groundwork for understanding how such physical changes in the riverbed can lead to cascading ecological effects, such as the altered fish dynamics.

5.2. Comparison of Fish Species Composition and Abundance

While previous research often predicts a decline in species richness and abundance due to habitat alteration (Liu et al., 2018; Mwanja et al., 2010), the results suggest a more complex ecological response. The study confirmed significant variations in fish diversity and abundance among the four sites, with a statistically significant difference observed in total fish catches (ANOVA: $F(3,10) = 7.92, p < 0.05$). This finding underscores the profound influence of sand mining on the aquatic ecosystem, albeit in a non-uniform manner.

A key divergence from a simple decline hypothesis is the finding that the Kalama site, a location with sand mining activity, exhibited the highest total fish catch. This counterintuitive result is directly explained by local knowledge, which posits that the trans-night setting of fishing gears coincides with the exposure of buried organic matter and food particles caused by sand mining. This disturbance of the benthic habitat acts as a localized attractant, drawing fish to the area to feed (Fischer et al., 2017). This ecological phenomenon, where a physically disturbed environment creates temporary feeding grounds, is consistent with similar observations in other aquatic ecosystems (Smith & Jones, 2020). The high catch rates at this site, therefore, reflect a redistribution and concentration of fish populations rather than a simple increase in overall abundance.

The robust methodology, employing standard gill nets and other effective sampling methods for assessing fish biodiversity (Mrosso et al., 2016; Mwanja et al., 2010; Bundy et al., 2018), provides strong support for these findings. The post-hoc analysis further substantiates the localized nature of the impact, showing significant differences in fish abundance between the impacted Kalama site and the Kabeto A ($p=0.043$) and Kabeto B ($p=0.007$) sites. The overall species composition,

dominated by the Lake Victoria squeaker (*Synodontis victoriae*), suggests that this species may be particularly well-adapted to capitalizing on these newly exposed food resources in the disturbed habitat.

This research highlights that sand mining does not simply lead to a uniform decline in fish populations. Instead, it acts as a powerful agent of habitat change, capable of altering food web dynamics and spatially concentrating fish. The results underscore the importance of a contextual and site-specific approach to studying such impacts. Future research should focus on optimizing data collection methods to better quantify these complex ecological shifts and investigate the long-term effects of sand mining on the stability and resilience of fish communities.

5.3. Variations among fisheries catches and catch rates

The impact of sand mining on commercial fishers' catches and livelihoods is a critical aspect of understanding the socio-ecological effects of this activity. The findings of this study, supported by a questionnaire administered to 30 fishers, reveal a significant and widespread decline in total catch and catch rate. The data consistently show that current daily catches (ranging from 10 to 15 fish for those using nets, or 2 to 3 basins for those using lift nets for silver cyprinid (*Rastrineobola argentea*) are substantially lower than the reported historical averages (ranging from 15 to 30 fish, or 4 to 5 basins for silver cyprinid). This trend is consistent with existing literature that links sand mining to a decline in catch per unit effort (CPUE) (Liu et al., 2018; Mwanja et al., 2010).

The decline in catch rates is a significant concern for the sustainability of the fishery and the economic well-being of the local community. The fishers in this study, with a mean experience of 7.4 years, predominantly use a combination of gillnets, cast nets, and longlines. Their observations, therefore, carry significant weight due to their long-term engagement with the fishery. The reported average daily income of approximately UGX 55,000 is directly tied to these declining catches, highlighting the cascading effects on livelihoods. This aligns with findings from Mrosso et al. (2016) and Liu et al. (2018), who reported a decline in the CPUE of key commercial species like Nile tilapia (*Oreochromis niloticus*) in areas with extensive sand mining.

The use of primary data from direct interviews and questionnaires is a methodological strength, as it directly captures the on-the-ground experiences and observations of the local fishing community.

However, a limitation of this approach is the potential for recall bias when fishers report historical catch averages, as noted by Mrosso et al. (2016). Despite this, the consistent trend reported by a diverse group of fishers (both male and female, with varied ages and years of experience) strongly suggests a genuine and widespread decline.

While sand mining may temporarily create conditions that attract fish to specific locations, the broader, long-term impact on overall catch rates and the economic viability of the fishery appears to be negative. The study's findings underscore the critical need for a holistic understanding of sand mining's impacts on both the fish populations and the human communities that depend on them for their livelihoods.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 conclusions

This study investigated the impacts of sand mining on the Namasagali catchment area, focusing on riverbed substrate composition, fish species composition and abundance, and fisheries catches and catch rates. The findings indicate that sand mining can significantly alter the river's ecosystem, leading to Changes in riverbed substrate composition, changes in fish populations and a decline in fisheries catches, and impacts on the livelihoods of communities dependent on fishing

6.2 Recommendations

To mitigate the impacts of sand mining, the following recommendations are made:

- Strengthen regulations and enforcement to ensure environmentally sustainable sand mining practices
- Establish a monitoring system to track the impacts of sand mining on the river's ecosystem and fisheries resources
- Engage with local communities to raise awareness of the impacts of sand mining and promote sustainable practices
- Support alternative livelihoods for communities' dependent on fishing to reduce their vulnerability to the impacts of sand mining
- Conduct further research to fully understand the impacts of sand mining on the river's ecosystem and fisheries resources

6.3 Limitations

The study had some limitations, including the use of a retrospective approach that relies on estimations and reconstructions for baseline data. The accuracy of this reconstructed data is dependent on the availability and reliability of historical information and local knowledge. Furthermore, the limited sampling period and spatial coverage represent a constraint on the comprehensiveness of the findings. The study was also limited by the availability of data collection tools and the inaccessibility of a laboratory for a more detailed analysis of the riverbed samples.

Further research is needed to understand the long-term impacts of sand mining on the Namasagali catchment area and to identify effective management strategies.

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