



A Study on the Biodiversity, Relative Abundance and Artisanal Fishing Gear Dynamics in Kiri Reservoir, Adamawa State, Nigeria

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Abstract

This study provides a baseline assessment of the Kiri Reservoir in Adamawa State, Nigeria, focusing on fish biodiversity and artisanal fishing practices, which are critical for food security in sub-Saharan Africa. A mixed-methods approach were employed, combining quantitative fish sampling, structured surveys of 540 fishermen, processors, and traders across three sites of the reservoir over a period of 12 months. The findings documented 1,280 fish specimens from three commercially dominant species: *Clarias gariepinus* (38.7%), *Synodontis clarias* (32.4%), and *Tilapia zilli* (28.9%). Gill nets were the most prevalent fishing gear, used by 78.3% of respondents, followed by cast nets and hook and line. Significant seasonal variation in catch was observed, with the rainy season contributing 62.3% of the total annual catch. A clear gender division of labor was evident, with men comprising the majority of active fishermen (82.4%) and women dominating processing (89.7%) and marketing roles. The most experienced group of fishermen were those with 6–10 years in the practice. The study highlights that the dominance of *Clarias gariepinus* reflects its ecological adaptability, while the heavy reliance on gill nets raises sustainability concerns due to potential impacts on breeding stocks. Seasonal catch patterns are linked to hydrological cycles that enhance fish recruitment during rainy season. It is concluded that Kiri Reservoir supports a productive but vulnerable artisanal fishery. Proper management interventions focusing on gear selectivity, seasonal breeding closures, and gender-sensitive policies need to be put in place to ensure sustainability.

Keywords: Fish biodiversity, relative abundance, artisanal fisheries, Kiri Reservoir

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Introduction

Inland fisheries constitute a cornerstone of food security, nutrition, and livelihoods for millions of people across sub-Saharan Africa (Lynch *et al.*, 2017; FAO, 2018). Nigeria, with its extensive network of rivers, lakes, and reservoirs, ranks among the continent's largest producers of inland fish, contributing significantly to the national economy and rural employment (Egwu *et al.*, 2011; Olaoye *et al.*, 2014). Reservoirs, as man-made aquatic ecosystems constructed primarily for irrigation, hydropower, and water supply, have progressively assumed critical roles in inland

fish production, particularly in regions where natural water bodies are over-exploited or degraded (DeGraaf and Garibaldi, 2014).

Kiri Reservoir, an earth-filled dam constructed in 1982 on the Gongola River in Adamawa State, exemplifies such a multipurpose water body. With a storage capacity of 615 million cubic meters and a catchment area spanning nine communities, the reservoir supports artisanal fisheries that provide sustenance and income for thousands of households (Olaoye *et al.*, 2014). Despite its socio-economic importance, comprehensive scientific documentation of the reservoir's fish

biodiversity and the dynamics of fishing practices remains remarkably limited. Understanding fish species composition and relative abundance is foundational to fisheries management (Moyle and Leidy, 2012; Cowx *et al.*, 2015). Species diversity not only reflects ecosystem health but also determines the resilience of fisheries to environmental perturbations and fishing pressure (Guégan *et al.*, 2018). Moreover, the types of fishing gear employed by artisanal fishermen directly influence catch selectivity, fishing mortality, and the sustainability of fish stocks (Emmanuel, 2010; Adeyemi *et al.*, 2012). Traditional fishing communities often utilize diverse gears based on accumulated local knowledge, target species, water conditions, and seasonal factors, making documentation of these practices essential for developing context-appropriate management interventions (Akinkali and Jamabo, 2011). Gender dimensions in artisanal fisheries represent another critical, yet often overlooked, aspect of fisheries management (Nwabeze *et al.*, 2013). Across West Africa, clear divisions of

labor exist, with men predominantly engaged in catching activities while women assume primary roles in processing, preservation, and marketing (Simman and Funge-Smith, 2018). Understanding these gender dynamics is essential for ensuring that fisheries policies and interventions are equitable and effective. This study therefore aim to address these knowledge gaps by providing a comprehensive assessment of fish species diversity, relative abundance, and artisanal fishing gear utilization in Kiri Reservoir.

Materials and Method

Study Area

Kiri Reservoir is located in Kiri village, Guyuk Local Government Area, Adamawa State, Nigeria. It lies at 9°40'47"N and 12°51'01"E (Figure 1). The reservoir is an earth-filled dam constructed around an internal clay core of the Gongola River, with a dam length of 1.25 km and a height of 20 m. The reservoir has an estimated terrain elevation of 158 m above sea level and a storage capacity of 615 million m³.

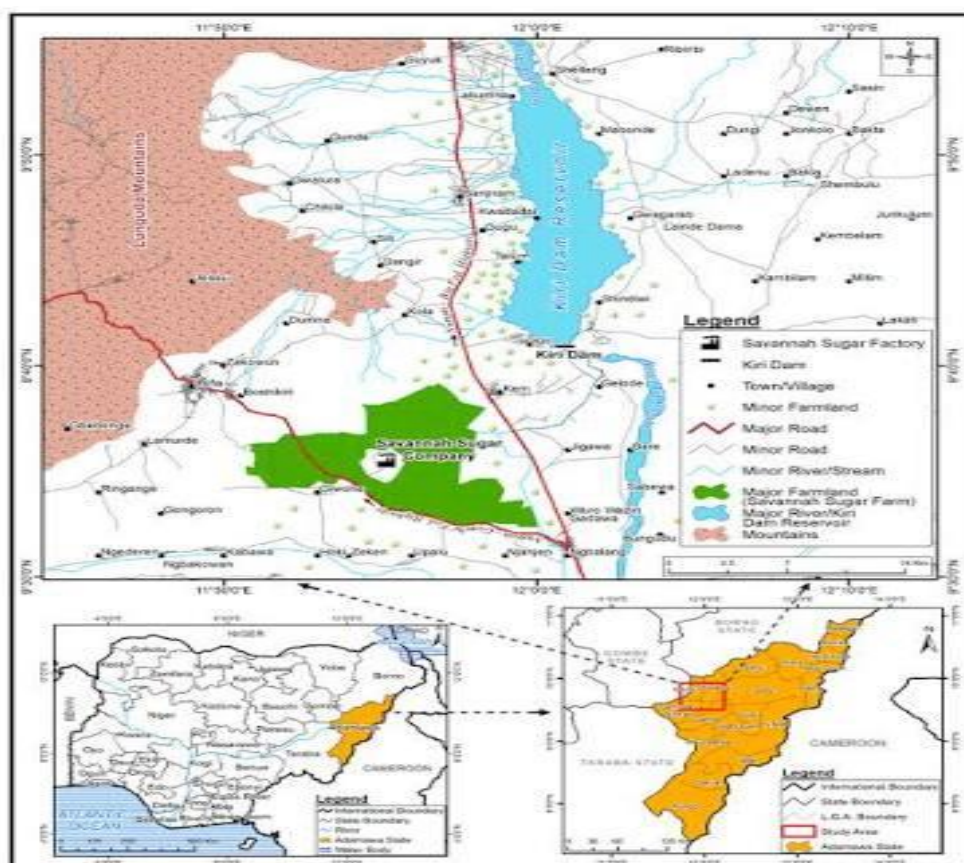


Figure 1. Map of the Study area (Kiri Reservoir) (GIS MAUTECH, 2019)

The reservoir serves as a source of water for the Savannah Sugar Company's 6,000-hectare plantation and supports artisanal fishing activities across nine surrounding villages: Kiri, Bobare, Gundo, Gwangulam, Sabon Pegi, Wuro Ladde, Babban Daba, Gombayel, and Donge.

Sampling Design

The reservoir was systematically divided into three sampling sites based on geographic distribution of the surrounding communities:

Site A: Kiri, Bobare, and Gundo (upstream section)

Site B: Gwangulam, Sabon Pegi, and Wuro Ladde (midstream section)

Site C: Babban Daba, Gombayel, and Donge (downstream section)

Monthly sampling was conducted over a 12-month period from January to December, encompassing both the rainy season (April–October) and dry season (November–March). This temporal coverage was designed to capture seasonal variations in fish catch composition and fishing practices.

Questionnaire Survey

A structured questionnaire was developed, pre-tested with 30 respondents, and subsequently administered to 540 randomly selected participants across the nine communities. The sample size was determined based on population estimates of fishing households in the study area, with proportional allocation across the three sampling sites.

The questionnaire captured information on:

- Demographic characteristics (age, gender, marital status, household size)
- Fishing experience (years of engagement, training received)
- Fishing gear types (gill nets, cast nets, hook and line, traps, drag nets, etc.)
- Seasonal patterns of fishing activity
- Estimated monthly catch quantities
- Fish processing and marketing activities
- Perceived challenges facing the fishery

Interviews were conducted in the local language (Hausa) to ensure comprehension and accurate responses. Focus group discussions were held with key informants, including village elders, fisheries officers, and

cooperative leaders, to validate questionnaire responses and obtain qualitative insights.

Fish Sampling and Identification

Fish specimens were collected monthly from the catches of assigned fishermen operating standardized gill nets at each sampling site. All fish captured were removed, sorted by species, counted, and recorded. Fish identification was performed using standard taxonomic keys and field guides, including Holden and Reed (1991), Olaosebikan and Raji (1998), and Froese and Pauly (2015).

Determination of Fish Relative Abundance

Relative abundance for each fish species was calculated as:

$$\text{Relative Abundance (\%)} = (\text{Number of individuals of species} / \text{Total number of individuals of all species}) \times 100$$

Statistical Analysis

Data from questionnaires and fish sampling were compiled in Microsoft Excel and analyzed using SPSS version 25. Descriptive statistics (frequencies, percentages, means, and standard deviations) were computed for all variables. Chi-square tests were used to examine associations between categorical variables (e.g., gear type and season). Analysis of variance (ANOVA) was employed to compare catch composition across sampling sites and seasons, with post-hoc comparisons conducted using Tukey's HSD test.

Results

Socio-demographic Characteristics of Respondents

A total of 540 questionnaires were successfully administered and retrieved, representing a 100% response rate. The socio-demographic characteristics of respondents are summarized in Table 1.

The results indicate a strong male predominance in fishing activities (82.4%), while females were primarily engaged in processing and marketing (89.7% of female respondents). The majority of fishermen were within the 31–45 years age bracket (45.2%), representing the most productive segment of the population. Married individuals constituted 76.3% of respondents, reflecting the family-oriented nature of fishing communities.

In terms of occupational engagement, 49.4% identified fishing as their sole occupation, while 33.0% combined fishing with farming, indicating the multi-occupational nature of rural livelihoods. Experience distribution

showed that fishermen with 6–10 years of experience formed the largest group (38.7%), suggesting a relatively stable and experienced fishing workforce.

Table 1: Socio-demographic Characteristics of Respondents in Kiri Reservoir

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	445	82.4
	Female	95	17.6
Age Group	18–30 years	173	32.1
	31–45 years	244	45.2
	46–60 years	99	18.3
	>60 years	24	4.4
Marital Status	Married	412	76.3
	Single	98	18.1
	Divorced	18	3.3
	Widowed	12	2.2
Primary Occupation	Fishing only	267	49.4
	Fishing + farming	178	33.0
	Processing/marketing	95	17.6
Fishing Experience	1–5 years	100	18.5
	6–10 years	209	38.7
	11–15 years	169	31.2
	>15 years	62	11.6

Fishing Gear Types and Utilization

Table 2 presents the types of fishing gears employed by artisanal fishermen in Kiri Reservoir. Gill nets were the most commonly used gear, employed by 78.3% of fishermen. Cast nets ranked second (45.6%), followed by hook and line (34.2%). Traps, drag nets, close netted ropes, and induruttu were less

frequently utilized. Seasonal analysis revealed that gill net usage increased during the dry season (82.1%) compared to the rainy season (74.5%), while cast net usage was higher during the rainy season (52.3% vs. 38.9% in dry season). These seasonal differences were statistically significant ($\chi^2 = 8.94$, $p = 0.003$).

Table 2: Distribution of Fishing Gear Types in Kiri Reservoir

Gear Type	Frequency (n)	Percentage (%)
Gill net	423	78.3
Cast net	246	45.6
Hook and line	185	34.2
Trap (pot type)	125	23.1
Drag net	67	12.4
Close netted ropes	34	6.3
Induruttu	28	5.2

Note: Multiple gear types could be reported by individual fishermen, thus percentages sum to >100%

Fish Species Composition and Relative Abundance

Three commercially important fish species were documented during the study period: *Clarias gariepinus* (African sharptooth catfish), *Synodontis*

clarias (Clarotes catfish), and *Tilapia zilli* (Zilli's tilapia). Table 3 presents the relative abundance of these species. *Clarias gariepinus* was the most abundant species, accounting for 38.7% of the total catch, followed by *Synodontis clarias* (32.4%)

and *Tilapia zilli* (28.9%). The relative abundance varied across sampling sites, with Site C (downstream) exhibiting the highest

abundance of *Clarias gariepinus* (44.2%) and Site B (midstream) showing the highest abundance of *Tilapia zilli* (34.7%).

Table 3: Fish Species Composition and Relative Abundance of Kiri Reservoir

Species	Total Count (n)	Relative Abundance (%)
<i>Clarias gariepinus</i>	495	38.7
<i>Synodontis clarias</i>	415	32.4
<i>Tilapia zilli</i>	370	28.9
Total	1,280	100.0

Seasonal Variation in Fish Catch

Significant seasonal variation in fish catch was observed across all three species (Table 4). The rainy season accounted for 62.3% of the total annual catch, representing a 1.65-fold increase over dry season catches. ANOVA

revealed significant differences in catch between seasons for all species ($F = 14.28$, $p < 0.001$). *Clarias gariepinus* exhibited the most pronounced seasonal variation, with 64.2% of its annual catch occurring during the rainy season

Table 4: Seasonal Distribution of Fish Catch in Kiri Reservoir

Species	Rainy Season (%)	Dry Season (%)	Total (%)
<i>Clarias gariepinus</i>	64.2	35.8	100
<i>Synodontis clarias</i>	60.8	39.2	100
<i>Tilapia zilli</i>	61.5	38.5	100
Overall	62.3	37.7	100

Fishing Activity Patterns

Table 5 presents the temporal patterns of fishing activities. The majority of fishermen (67.3%) preferred early morning fishing, citing higher catch rates and favourable

weather conditions. Night fishing was least common (9.2%), primarily due to safety concerns and the difficulty of navigation on the reservoir after dark.

Table 5: Temporal Patterns of Fishing Activity in Kiri Reservoir

Time of Day	Percentage of Fishermen (%)
Early morning (4:00–8:00)	67.3
Late afternoon (15:00–18:00)	23.5
Night (19:00–4:00)	9.2

Discussion

Gender Dynamics and Socio-demographic Characteristics

The strong male predominance in fishing activities (82.4%) observed in this study aligns with findings from other Nigerian water bodies, including Lake Kainji (Nwabeze *et al.*, 2013) and the Niger Delta (Akinkali and Jamabo, 2011). This gender division of labor reflects traditional social structures where fishing is perceived as male-dominated work, while processing and marketing are considered female domains in agreement with the findings of Simmance & Funge-Smith

(2018). The high percentage of married individuals (76.3%) suggests that fishing households in Kiri Reservoir are typically family units where income from fishing supports household livelihoods. This finding has important implications for fisheries management, as interventions that affect fishing income will impact not only individual fishermen but entire family units.

The concentration of fishermen in the 31–45 years age bracket (45.2%) represents the prime productive years, while the presence of younger (18–30 years: 32.1%) and older (>60 years: 4.4%) fishermen indicates multi-

generational participation in the fishery enterprise. The substantial proportion of fishermen with 6–15 years of experience (69.9%) suggests a stable workforce with accumulated local ecological knowledge, which represents a valuable resource for fisheries management (Johannes et al., 2000).

Fishing Gear Dynamics and Sustainability Implications

Gill nets emerged as the predominant fishing gear, consistent with findings from Lekki Lagoon (Emmanuel, 2010) and other Nigerian inland waters (FAO, 2011). The popularity of gill nets can be attributed to their effectiveness, relatively low cost, ease of operation, and versatility across different water conditions. However, the dominance of gill nets raises sustainability concerns for several reasons. First, gill nets are highly size-selective, targeting specific length classes of fish, which can alter population size structure and reduce reproductive potential (Limbu and Gupta, 2019). Second, gill nets can result in high bycatch rates when not properly monitored, including non-target species and juvenile fish (Tsagarakis et al., 2013). Third, the increased use of monofilament nets has been associated with ghost fishing, where lost nets continue to capture fish indefinitely (Blaber, 2012).

The seasonal variation in gear utilization increased gill net use during the dry season and increased cast net use during the rainy season reflects adaptation to changing water levels and fish behavior. During the dry season, reduced water levels concentrate fish, making gill nets more effective, while the rainy season's higher water levels and increased turbidity favor cast nets and hook and line (Rijnsdorp et al., 2012).

Fish Species Composition and Relative Abundance

The dominance of *Clarias gariepinus* in the catch (38.7%) reflects the species' ecological adaptability and resilience to reservoir conditions. *Clarias gariepinus* is known for its air-breathing capability, which allows it to survive in low-oxygen conditions that may occur in reservoirs during dry periods (Abubakar et al., 2012). Additionally, its omnivorous feeding habits enable it to exploit

diverse food resources, giving it a competitive advantage over more specialized species (Wakil et al., 2014).

The presence of *Synodontis clarias* (32.4%) and *Tilapia zilli* (28.9%) as the other dominant species indicates a moderately diverse fish community. *Tilapia zilli*, as a herbivorous species, occupies a different trophic niche than the omnivorous *C. gariepinus* and the benthivorous *S. clarias*, allowing for resource partitioning that facilitates coexistence (Kadye & Marshal, 2016). The spatial variation in species distribution, with *C. gariepinus* more abundant downstream and *T. zilli* more abundant midstream, likely reflects differences in habitat characteristics, including substrate type, vegetation cover, and water depth (Kadye and Marshal, 2016).

Seasonal Variation in Fish Catch

The pronounced seasonal variation in fish catch, with the rainy season accounting for 62.3% of total annual catch, aligns with patterns observed in other tropical water bodies (Emmanuel et al., 2018). Several factors contribute to this seasonal pattern. First, the rainy season corresponds to the peak breeding period for many tropical fish species, including *C. gariepinus* and *T. zilli*, leading to increased abundance of juvenile fish (Christy, 2013). Second, increased water levels during the rainy season expand available habitat, allowing fish to access floodplain areas rich in food resources (Junk et al., 2015). Third, nutrient inputs from runoff during the rainy season enhance primary productivity, supporting higher fish production (Yuan et al., 2017). Fourth, reduced fishing pressure during the rainy season when some fishermen shift to farming activities allows fish populations to recover (Olaoye et al., 2014).

The variation in seasonal patterns across species, with *C. gariepinus* showing the strongest rainy season bias (64.2%), may reflect differences in reproductive timing and habitat preferences. *C. gariepinus* typically spawns at the onset of the rainy season, while *T. zilli* may have extended breeding periods (Akintunde, 2010).

Fish Processing, Marketing, and Value Chain

The predominance of smoking as the primary processing method (68.4%) reflects both tradition and practicality. Smoking not only preserves fish but also imparts desirable flavor characteristics that command higher market prices (Davies & Davies, 2012). The use of sun drying (45.2%) and salting (32.1%) provides alternative preservation methods that are accessible and affordable for small-scale processors. The low utilization of refrigeration (18.7%) is attributable to limited electricity access in rural areas and the high cost of alternative energy sources.

The gender distribution in processing and marketing, with women comprising 89.7% of those engaged, highlights the critical but often undervalued role of women in fisheries value chains (Nwabeze *et al.*, 2013). Women's involvement extends beyond processing to include market information gathering, price negotiation, and consumer relations, representing significant contributions to household income and community food security (Macfadyen *et al.*, 2012).

The dominance of local markets (72.3%) for fish sales suggests that the fishery primarily serves local food security needs, with surplus production reaching nearby urban centers (23.1%). This pattern is typical of artisanal fisheries, where limited transportation infrastructure and perishability constrain market reach (Oparinde and Ojo, 2014).

Implications for Fisheries Management

The findings of this study have several implications for fisheries management in Kiri Reservoir. First, the dominance of gill nets and the observed seasonal patterns suggest that gear-based management measures, including minimum mesh size regulations and seasonal gear restrictions, could improve sustainability. Second, the significant seasonal variation in catch indicates that closed seasons during peak breeding periods could enhance reproductive success and recruitment. Third, the gender dimensions of the fishery suggest that management interventions should be designed to recognize and support the distinct roles of men and women in the value chain. Fourth, the reliance of the fishery on three species

highlights the vulnerability of the system to species-specific environmental perturbations or overfishing, suggesting the need for ecosystem-based management approaches (Punt and Smith, 2015).

Conclusion

This study that Kiri reservoir supports a productive fishery enterprise dominated by three commercially important species: *Clarias gariepinus* (38.7%), *Synodontis clarias* (32.4%), and *Tilapia zilli* (28.9%). Gill nets were found to be the most predominant fishing gear, used by 78.3% of fishermen. There is also a significant seasonal variation in fish catch, with the rainy season accounting for 62.3% of total annual catch. Gender analysis reveals a strong division of labor, with men predominantly engaged in catching and women in processing and marketing of the fish. Proper management interventions focusing on gear selectivity, seasonal closures, and gender-sensitive policies need to be put in place to ensure sustainability.

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