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Structural Constraints, Livelihood Diversification Behaviour and Welfare Outcomes among Artisanal Fishing Households in Inland Reservoir Systems: Evidence from Shiroro and Kainji Dams, Nigeria

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Abstract

This study examined structural constraints, livelihood diversification behaviour, and welfare outcomes among artisanal fishing households along the Shiroro and Kainji dam systems in Nigeria, using data obtained from 300 respondents. The study employed factor analysis, the Simpson Diversification Index, and Tobit regression analysis to achieve its objectives. The results revealed that economic and financial constraints were the most severe, particularly lack of access to credit (72.7%), high cost of fishing gear (72.0%), and inadequate capital (71.0%). Institutional constraints such as limited extension services (52.7%) and weak cooperatives (46.3%) were moderate, while environmental constraints including water fluctuations (36.3%) and climate variability (36.3%) were relatively less severe. The findings further indicated a very high level of livelihood diversification, with a Simpson Diversification Index of 0.955, reflecting extensive engagement in multiple livelihood activities such as arable farming (59.3%), poultry production (50.2%), livestock rearing (45.9%), petty trading (26.5%), and other non-farm enterprises. Results from the Tobit regression model (Pseudo R^2 = 0.601) showed that household size (β = 0.013), education (β = 0.019), access to credit (β = 0.079), extension contact (β = 0.061), and asset ownership (β = 0.052) had positive and statistically significant effects on livelihood diversification. In contrast, fishing experience (β = -0.004), distance to market (β = -0.010), infrastructure constraints (β = -0.085), and security challenges (β = -0.069) exerted significant negative influences, while age had no significant effect. Principal factor analysis identified four key welfare dimensions economic welfare, access to services, food security, and asset ownership with strong factor loadings for income (0.82), access to services (0.80), nutrition (0.85), and assets (0.88), confirming the multidimensional nature of welfare among the households. The study concludes that although artisanal fishing households operate under severe structural constraints, they exhibit high levels of livelihood diversification, which significantly enhances income stability and welfare outcomes. The study recommends improved access to affordable credit, strengthening of extension services and cooperative institutions, investment in rural infrastructure and market systems, and the promotion of climate-adaptive fisheries management strategies to enhance sustainable livelihoods and long-term development outcomes.

Keywords: *Artisanal fisheries, Structural constraints, Livelihood diversification, Simpson Index, Household welfare, Shiroro Dam, Kainji Dam, Nigeria.*

INTRODUCTION

Artisanal fisheries constitute a critical component of rural livelihoods in many developing countries, providing employment, food security, and income to millions of households (Béné et al., 2020). In Nigeria, inland reservoir systems such as Shiroro and Kainji dams support substantial artisanal fishing communities whose economic survival is intricately linked to fish availability and the broader socio-ecological context of the reservoirs. Despite this importance, households in these systems face persistent structural and socio-economic constraints that threaten both productivity and welfare, including limited access to finance, inadequate fishing and processing technologies, insufficient extension support, weak market linkages, and environmental degradation (Abdullahi et al., 2022; Mohammed & Uraguchi, 2023). These constraints not only restrict fishing efficiency but also hinder the ability of households to engage in alternative livelihood activities effectively, thereby limiting their capacity to diversify income and manage risk.

Beyond fishing, households often engage in multiple livelihood activities, reflecting adaptive strategies to manage risk, diversify income, and ensure food security (Adepoju et al., 2022). However, previous studies have largely focused on the economic or ecological dimensions of artisanal fisheries, with limited attention to how structural constraints shape livelihood diversification behaviour and, in turn, influence welfare outcomes. This creates an important empirical gap, as inadequate understanding of these interrelationships limits the effectiveness of policy interventions aimed at strengthening resilience in inland fisheries systems. Livelihood diversification in artisanal fishing communities is influenced by a combination of structural, economic, and environmental factors. Structural constraints including limited access to credit, inadequate extension services, poor regulatory enforcement, and inadequate infrastructure can restrict the capacity of households to diversify their income sources effectively (Kolding et al., 2021). Environmental stressors, such as climate variability, declining fish stocks, and water pollution, further exacerbate household vulnerability, compelling fishers to adopt a variety of coping strategies to maintain welfare (Allison et al., 2022). Moreover, the livelihoods of artisanal fishers in inland reservoir systems are increasingly shaped by socio-economic transformations and environmental pressures. Urbanization, population growth, and changing market demands have altered the availability of fishing resources and the profitability of traditional fishing activities, compelling households to engage in multiple complementary occupations (Béné et al., 2020; Mohammed & Uraguchi, 2023). Simultaneously, climate variability, fluctuating water levels, and seasonal changes in fish abundance exacerbate household vulnerability, particularly for those with limited access to capital or alternative income sources (Allison et al., 2022). These dynamics underscore the necessity of examining not only the patterns of livelihood diversification but also the structural and institutional factors that enable or constrain household adaptive capacity. By exploring how structural constraints influence diversification behaviour and subsequent welfare outcomes, this study provides critical insights for policy interventions aimed at promoting sustainable livelihoods and resilience in Nigerian inland fisheries.

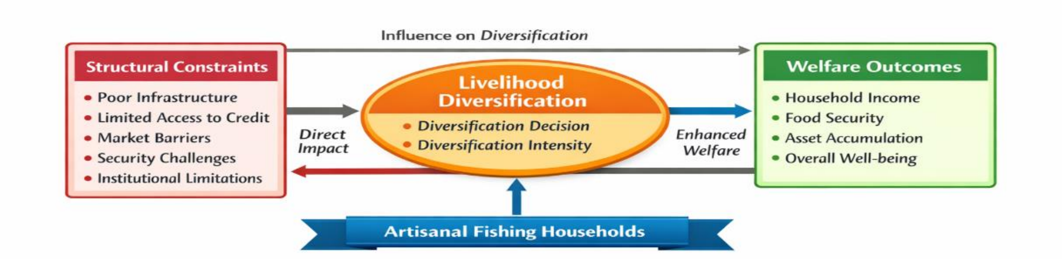

Fig 3: Conceptual framework of the study

Objectives of the Study

The objectives of the study are to identify and empirically assess the major structural, institutional, environmental, and socioeconomic constraints affecting artisanal fisheries and the livelihood outcomes of fishing households along Shiroro and Kainji dams and analyse the livelihood diversification strategies adopted by artisanal fishers and evaluate their effects on household welfare outcomes in the study area and analyse determinants of livelihood diversification

METHODOLOGY

Description of Shiroro Dam

The study was carried out along Shiroro and Kainji Dams. The population of Shiroro is projected in 2020 to be 322,918 people using (3.2%) growth rate (Ibrahim *et al.*, 2025).The climate, edaphic features and hydrology of the state where the dam is located allows sufficient opportunities for harvesting fresh water fish such as *Tilapia spp*, *Bagrus spp*, *Clarias spp*, *Gymnarchus niloticus*, *Heterotis spp, Labeo spp, Mormysus spp, Lates niloticus* etc, It also permits the cultivation of most of Nigeria's staple crops such as maize, yam, rice, millet and sorghum. The Shiroro hydropower reservoir is a storage-based hydroelectric facility located in Shiroro Local Government, Niger State at the Shiroro Gorge which lies approximately between Latitude 9° 57' 25N and Longitude 6° 49' 55E. It is located approximately 90 km southwest of Kaduna on River Dinya. Annual temperature around the reservoir varies between 27 and 35^{0}C (Allison *et al*., 2022).

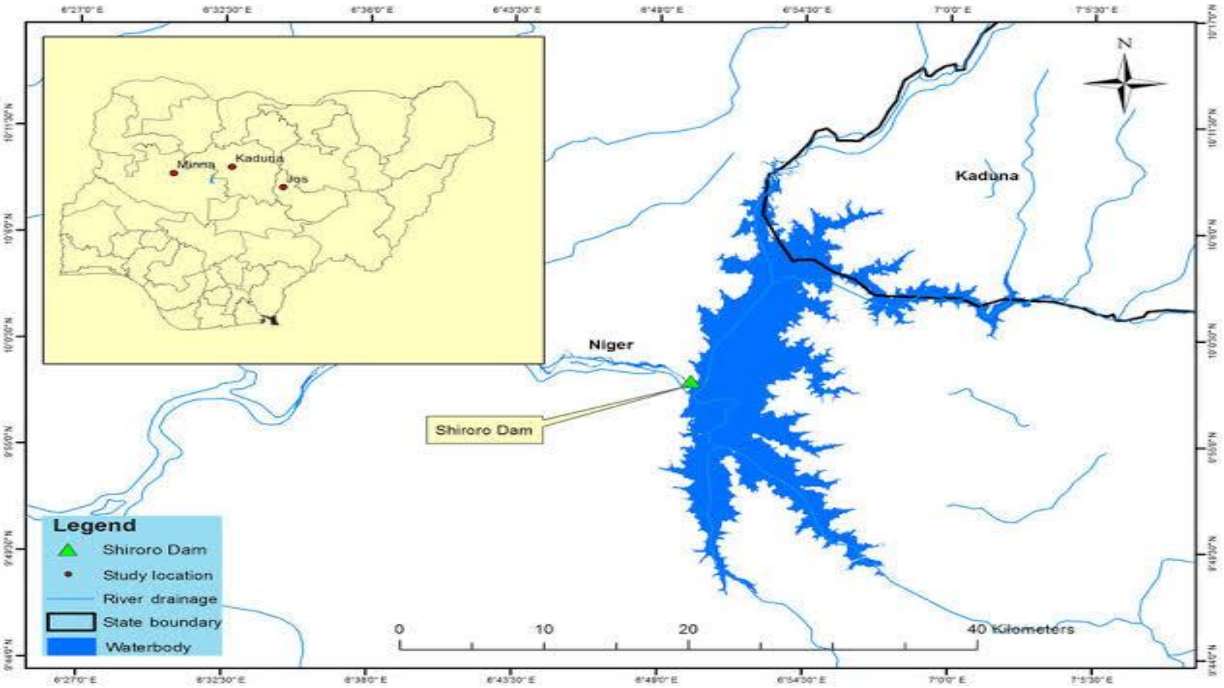

Fig i: *Map of Nigeria showing Shiroro Dam* ***Source:*** *Google*

Description of Kainji Dam

Kainji Lake is located between latitudes 9°5’ and 10°55’N and longitudes 4°21’ and 4°45’E. It cuts across Niger and Kebbi states, but is mostly located in Niger state. Kainji is the second largest lake in Africa and the largest man-made lake in Nigeria (Hussaini, 2022). It was created in 1968 following the impoundment of the Niger River by the construction of the Kainji Dam at New Bussa, in Borgu Local Government Area of present day Niger State. The total annual rainfall for the Lake ranges between 1,100 mm and 1,250 mm, spreading from April to October (Chilaka *et al.*, 2024). The highest (about 30°C) and lowest (about 25°C) monthly temperatures are recorded in March and August, respectively. Fishing is the major traditional occupation of these people whereas other occupations include: farming, livestock breeding and local entrepreneurship.

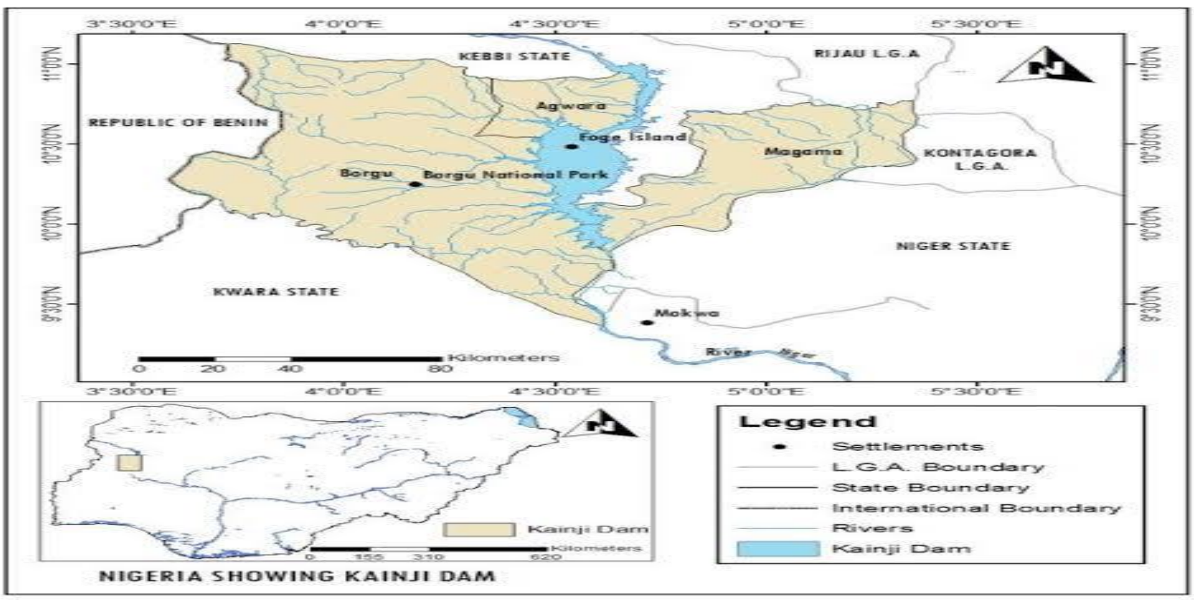

Fig ii: *Map of Nigeria showing Kainji Dam* ***Source:*** *Google*

Method of Data Collection

Both primary and secondary data were used for the study. Primary data was obtained using a structured questionnaire designed in line with the study objectives. The questionnaires were administered to the fishers selected for the study.

Sampling Procedure and Sample Size

The study adopted a multi-stage and proportionate sampling technique. In the first stage, two major inland dam fisheries systems in North-Central Nigeria where artisanal fishing is intensively practiced were purposively selected. These were Kainji Dam (Niger/Kebbi States) and Shiroro Dam (Niger State), selected based on their high concentration of artisanal fishing activities and well-established fishing communities. In the second stage, a sampling frame of fishing villages was constructed from fisheries association records, local government area listings, and community fishing cooperative registers obtained during the 2026 reconnaissance survey conducted in the study area. From this compiled list, a total of 50 fishing villages were identified and used as the study clusters. These comprised 30 villages from Kainji Dam and 20 villages from Shiroro Dam, reflecting the higher concentration and spatial spread of fishing settlements around Kainji Dam. In the third stage, the study adopted Yamane's (1967) sample size determination formula to determine the number of fishing households to be studied. The total number of registered and active artisanal fishers in the selected communities constituted the sampling frame, comprising 3,823 fishers in Kainji Dam and 3,632 fishers in Shiroro Dam, giving a combined population (N) of 7,455 fishers.

Yamane's Sample Size Determination Formula

The sample size for this study was determined using Yamane's (1967) formula as stated below:

$n = N / [1 + N(e)^2]$

Where:
n = required sample size
N = total population (sampling frame)
e = level of precision (sampling error), usually 0.05

Where n is the sample size, N is the population size, and e is the level of precision (0.05). The total fishing population constituted the sampling frame, which comprised 3,823 fishers around Kainji Dam and 3,632 fishers around Shiroro Dam, giving a total population of 7,455 fishers. Applying Yamane's formula yielded a sample size of 300 fishers for the study. Thereafter, a proportionate sampling technique was used to allocate the sample size between the two dams based on their respective fishing populations. Accordingly, 154 fishers were selected from Kainji Dam, while 146 fishers were selected from Shiroro Dam. The rationale for selecting a higher number of villages and respondents from Kainji Dam was due to its relatively larger number of fishing communities and fishers compared to Shiroro Dam.

Sampling Percentage

Application of the Formula

$n = 7{,}455 / [1 + 7{,}455(0.05)^2]$

$n = 7{,}455 / [1 + 18.64]$

$n = 7{,}455 / 19.64$

$n \approx 300$

Therefore, a sample size of 300 respondents was used for the study. Sampling percentage = $(300 / 7{,}455) \times 100 \approx 4\%$

Table 3.1: Selected Fishing Villages, Sampling Frame and Sample Size Allocation (Kainji, 2026)

Village	Estimated Sampling Frame (Fishers)	Sample Size
New Bussa	180	7
Wawa	150	6
Malale	145	6
Shagunu	140	6
Monai	135	5
Karabonde	130	5
Duga	125	5
Rofia	120	5
Babanna	120	5
Ngaski	115	5
Wara	115	5
Sabon Pegi	110	4

Village	Estimated Sampling Frame (Fishers)	Sample Size
Kambama	110	4
Yauri	160	6
Tungan Noma	110	4
Tungan Bawa	110	4
Tungan Sule	105	4
Tungan Gero	105	4
Tungan Zaki	100	4
Tungan Makera	100	4
Tungan Ladan	100	4
Tungan Dogo	95	3
Tungan Rogo	95	3
Tungan Wada	95	3
Tungan Kawo	95	3
Tungan Shanu	90	3
Tungan Kasa	90	3
Tungan Maigari	90	3
Tungan Kura	90	3
Tungan Jatau	90	3
Total	**3,823**	**154**

Table 3.2: Selected Fishing Villages along Shiroro Dam, Sample frame and Sample size

Village	Estimated Sampling Frame (Fishers)	Sample Size
Shiroro	260	10
Kuta	240	10
Erena	230	9
Gwada	220	9
Bassa	220	9
Zumba	210	8
Allawa	200	8
Minna River Bank Settlements	190	8
Chanchaga River Settlements	180	7
Kuchi	180	7
Dnako	170	7
Gurmana	170	7
Zangon Daji	160	6
Guni	160	6
Galkogo	160	6
Dangana	150	6
Kurebe	150	6
Gidan Goga	150	6
Zaiya	140	5
Kurege	140	5
Total	**3,632**	**146**

Table 3.3 Sample Size allocation between Dams (Proportionate)

Dam	Fishing Population	Proportion (%)	Sample Size
Kainji Dam	3,823	51.3	**154**
Shiroro Dam	3,632	48.7	**146**
Total	**7,455**	**100**	**300**

Source: Author Construct, 2026

Method of Data Analysis

Data collected were analyzed using inferential statistics. Exploratory Factor Analysis was used to achieve objective1, Simpson Diversification Index (SDI) was used to achieve objective 2.

Exploratory and Principal Factor Analysis Model Specification

Each observed variable (X) can be expressed as a combination of underlying factors (F) and a unique error term (ε):

X_i = λ_i1 * F_1 + λ_i2 * F_2 + ... + λ_im * F_m + ε_i ……(1)

Where:

X_i = observed variable i (e.g., high cost of fishing gear, lack of credit)

F_1, F_2, ..., F_m = latent factors (economic, institutional, environmental)

λ_ij = factor loading of variable i on factor j (strength of association)

ε_i = unique variance or error term of variable i

m = number of factors extracted

Note:

Factors were extracted using Principal Component Analysis (PCA).

Varimax rotation was applied for easier interpretation.

KMO and Bartlett's tests were used to check if the data were suitable for factor analysis.

Simpson Diversification Index

The Simpson Diversification Index (SDI) was used to achieve objective 2. The Simpson index was used to measure the diversity of strategies adopted by households in the study area. The Simpson index was used because the index is simple to compute, robust, and widely applicable. The value of the Simpson index lies between 0 and 1. The value of the index is zero when there is a complete specialization and it approaches one as the level of diversification increases.

The formula for the Simpson Diversification Index is given as:

$$SDI = 1 - \frac{\sum n-1}{N(N-1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where SDI is the Simpson Diversification Index, N is the total number of livelihood sources. The values of SDI range from 0 and 1, where 0 depicts no diversification (complete specialization), and it approaches 1 as the level of diversification increases. Based on the SDI values, the level of livelihood diversification is defined as:

- No diversification (SDI = 0)
- Low level of diversification (SDI = 0.00001 - 0.2500).
- Medium level of diversification (SDI=0.2501-0.4500)
- High level of diversification (SDI= >0.4501)

RESULTS AND DISCUSSION

This chapter presents the results of the study based on data collected from 300 artisanal fishing households in Shiroro and Kainji dam communities. The findings are organized according to the study objectives and analyzed using appropriate statistical tools including descriptive statistics, factor analysis, and the Simpson Diversification Index.

Table 1: Prevalence and Severity of Constraints Affecting Artisanal Fisheries along Shiroro and Kainji Dams (N = 300)

Constraint Category	Key Constraint Indicators	Highly Severe (%)	Moderately Severe (%)	Not Severe (%)
Economic & Financial	High cost of fishing gear	72.0	21.7	6.3
	Lack of access to credit	72.7	19.3	8.0
	Inadequate operating capital	71.0	20.0	9.0

Constraint Category	Key Constraint Indicators	Highly Severe (%)	Moderately Severe (%)	Not Severe (%)
	High fuel/operating costs	66.3	23.0	10.7
	Low fish income	63.7	25.0	11.3
Institutional & Technical	Limited extension services	52.7	31.0	16.3
	Lack of modern fishing technology	51.7	30.3	18.0
	Inadequate training/skills	49.0	31.7	19.3
	Weak cooperatives	46.3	32.7	21.0
	Weak enforcement of regulations	44.3	33.0	22.7
Environmental & Physical	Seasonal water-level fluctuations	36.3	34.0	29.7
	Climate variability/extreme weather	36.3	33.7	30.0
	Water pollution	34.4	34.3	31.3
	Invasive aquatic plants	31.3	35.0	33.7
	Safety/insecurity on water	29.0	35.0	36.0

Source: Field Survey, 2025

The findings in table 1 indicate that constraints affecting artisanal fisheries along Shiroro and Kainji dams are multidimensional, encompassing economic and financial, institutional and technical, and environmental and physical domains. The analysis of 300 respondents highlights the severity and prevalence of these constraints across different dimensions of livelihood.

Economic and Financial Constraints

Economic and financial barriers emerged as the most severe constraints for artisanal fishers. Specifically, 72.0% of respondents identified the high cost of fishing gear as highly severe, 72.7% reported lack of access to credit, and 71.0% cited inadequate operating capital. Additional economic constraints include high fuel and operating costs (66.3%) and low income from fish sales (63.7%). These figures underscore that limited financial resources and high operational costs remain the most critical factors restricting productivity and household income. The predominance of economic constraints reflects broader structural issues in inland fisheries, where access to affordable inputs, credit facilities, and stable market channels is limited (Abdullahi *et al.,* 2022; Adepoju *et al.,* 2022). The high prevalence of these constraints suggests that household-level investment capacity is a critical determinant of livelihood outcomes, and that interventions aimed at reducing input costs or increasing financial access could significantly improve fishers' welfare.

Institutional and Technical Constraints

Institutional and technical factors also significantly influence artisanal fisheries, although their severity is generally lower than that of economic constraints. Limited extension services were reported as highly severe by 52.7% of respondents, lack of modern fishing technology by 51.7%, and inadequate training and skills by 49.0%. Weak cooperative organizations (46.3%) and poor enforcement of fishing regulations (44.3%) further exacerbate challenges, while inadequate policy support was identified as highly severe by 43.7% of respondents. These findings are consistent with prior studies demonstrating that insufficient institutional support, lack of regulatory enforcement, and weak cooperative structures limit the adoption of modern fishing practices and sustainable resource management (Mohammed & Uraguchi, 2023). The data suggest that enhancing institutional capacity through effective extension services, cooperative strengthening, and better regulatory enforcement is essential for improving productivity and fostering sustainable fisheries management.

Environmental and Physical Constraints

Environmental and physical constraints, while relatively less severe, remain important determinants of livelihood vulnerability. Seasonal water-level fluctuations and climate variability were each reported as highly severe by 36.3% of respondents, water pollution by 34.4%, and invasive aquatic plants by 31.3%. Safety and insecurity on the water was reported as highly severe by 29.0% of respondents. These findings indicate that inland fisheries are highly sensitive to environmental and ecological stressors, which can reduce fish availability, limit access to fishing grounds, and threaten household income stability. The interaction between environmental stress and socioeconomic vulnerability magnifies livelihood risks, particularly for households that are heavily dependent on fishing as their primary source of income (Allison *et al*., 2022).

Integrated Analysis

The overall analysis demonstrates that economic constraints exert the strongest influence on livelihood outcomes, followed by institutional and environmental factors. The high percentage of respondents experiencing severe economic constraints reflects the centrality of financial capacity in determining household resilience. Institutional weaknesses impede the uptake of improved technologies and practices, limiting the potential for economic gains even when resources are available. Environmental constraints, while less severe, interact with economic and institutional limitations to create compounded risks for artisanal fishers. These findings suggest that addressing livelihood challenges in artisanal fisheries requires a multidimensional approach.

Table 2: Principal Factor Analysis of Welfare Outcomes among Artisanal Fishing Households (N = 300)

Welfare Indicator	Factor 1: Economic Welfare	Factor 2: Access & Services	Factor 3: Food Security	Factor 4: Asset Ownership
Monthly income from fishing	0.82	0.12	0.10	0.05
Monthly income from other activities	0.79	0.18	0.12	0.08
Total household expenditure	0.75	0.15	0.20	0.10
Number of meals per day	0.10	0.12	0.85	0.05
Protein consumption frequency	0.12	0.10	0.83	0.02
Access to clean water	0.08	0.81	0.12	0.05
Access to health services	0.15	0.79	0.10	0.08
Child school attendance	0.12	0.80	0.10	0.06
Ownership of boat/canoe	0.05	0.10	0.08	0.88
Ownership of fishing gear	0.10	0.08	0.05	0.85
Household savings	0.78	0.12	0.11	0.09
Access to microfinance	0.75	0.18	0.12	0.08
Quality of housing	0.08	0.80	0.10	0.06
Livestock ownership	0.12	0.10	0.82	0.05
Crop production	0.14	0.12	0.79	0.08
Fishing equipment availability	0.10	0.08	0.10	0.86
Number of productive assets	0.10	0.10	0.05	0.87
Household members with education	0.12	0.79	0.10	0.05
Household access to electricity	0.15	0.80	0.12	0.06
Transportation facilities	0.10	0.78	0.10	0.08
Food storage and preservation	0.12	0.10	0.81	0.05
Ownership of processing equipment	0.08	0.12	0.10	0.85
Participation in cooperatives	0.10	0.79	0.12	0.08
Access to market information	0.12	0.80	0.10	0.06
Frequency of food shortages	0.05	0.08	0.84	0.05
Healthcare expenditure	0.10	0.78	0.12	0.07

Source: Field Survey, 2026 *Factor loadings >0.4 are considered significant. Indicators are assigned to the factor with the highest loading.*

The Principal Factor Analysis reveals that welfare among artisanal fishing households is multidimensional**,** structured around four latent factors: economic welfare, access to services, food security, and asset ownership. Economic Welfare (Factor 1**):** Indicators such as monthly income from fishing (0.82), income from other activities (0.79), total household expenditure (0.75), and household savings (0.78) load heavily on this factor. This demonstrates that financial capacity remains a critical determinant of welfare, supporting findings by (Adepoju *et al.,* 2022), who highlighted income variability and capital constraints as central challenges for inland artisanal fishers.

Access & Services (Factor 2): Access to clean water (0.81), health services (0.79), child school attendance (0.80), and household electricity (0.80) cluster under this factor, indicating that social infrastructure and service provision significantly shape household well-being. These results align with Allison *et al*. (2022), emphasizing that welfare is not solely economic but depends on access to essential services. Food Security (Factor 3): Nutritional indicators such as number of meals per day (0.85), protein consumption frequency (0.83), livestock ownership (0.82), and crop production (0.79) load strongly on this factor. This underscores that dietary quality and food availability are major components of welfare, corroborating findings by Mohammed & Uraguchi (2023) regarding inland fishers' reliance on diversified livelihoods to ensure household nutrition.

Asset Ownership (Factor 4): Ownership of boats (0.88), fishing gear (0.85), and processing equipment (0.85) reflects the importance of productive assets in determining livelihood stability. Households with more assets are better positioned to buffer economic shocks, consistent with Kolding *et al.,* (2021). Integrated Implication**:** The analysis confirms tha**t** structural constraints, diversification strategies, and asset accumulation jointly influence welfare outcomes. Economic interventions alone are insufficient; access to social services, food security measures, and productive asset provision are equally crucial. This multidimensional understanding allows policymakers to design holistic interventions that enhance resilience, income stability, and long-term sustainability of artisanal fishing households.

Table 3. Livelihood Diversification Strategies and Simpson Index Results of Artisanal Fishers along Shiroro and Kainji Dams (N = 300)

Livelihood Activity	No. of Households (N)	Percentage (%)	n-1	N_i(N_i-1)
Arable farming	178	59.3	177	31,506
Poultry rearing	155	50.2	154	23,870
Livestock rearing	138	45.9	137	18,906
Night guard	93	31.0	92	8,556
Hunting	92	30.7	91	8,372
Processed agricultural products	84	27.8	83	6,972
Petty trading	80	26.5	79	6,320
Grinding	70	23.3	69	4,830
Milling of grains	66	22.2	65	4,290
Shoe making	64	21.3	63	4,032
Tailoring	62	20.7	61	3,782
Water trading	62	20.7	61	3,782
Carpentry	61	20.4	60	3,660
Butchery	61	20.4	60	3,660
Tree crop planting	61	20.2	60	3,660
Barbing	60	20.0	59	3,540
Transportation	53	17.6	52	2,756
Cassava processing	50	16.7	49	2,450
Food vending	41	13.5	40	1,640
Blacksmithing	38	12.8	37	1,406
LGA civil service	34	11.3	33	1,122
Security operative	27	9.1	26	702
Vulcanizing	27	8.9	26	702
Teaching	26	8.7	25	650
Nursing	13	4.3	12	156
Total	1,690	-	1,678	128,000

Source: Field Survey, 2026

The combined analysis of livelihood activities and the Simpson Index results in table 2 reveals that artisanal fishing households along Shiroro and Kainji dams maintain highly diversified livelihood portfolios. The Simpson Index value of 0.955 indicates that households are spreading economic risk across multiple activities, consistent with adaptive livelihood strategies observed in small-scale fisheries globally (Béné *et al*., 2020; Abdullahi *et al*., 2022). Agriculture remains the primary source of livelihood, with arable farming (59.3%), poultry rearing (50.2%), and livestock rearing (45.9%) dominating household economic activity. These findings suggest that households rely heavily on farm-based activities to stabilize income and ensure food security, complementing income from fishing. Similar observations have been reported in inland fisheries across Nigeria, where diversification into crop and livestock production mitigates risks associated with declining fish stocks and income variability (Adepoju *et al*., 2022).

The data also show a secondary cluster of non-farm activities, including night guarding (31.0%), hunting (30.7%), and sales of processed agricultural products (27.8%), which serve as supplementary income streams. Petty trading (26.5%) and small-scale processing activities, such as grinding and milling (22–23%), illustrate the role of informal entrepreneurial activities in household resilience. The Simpson Index captures this distribution, confirming that households do not concentrate their efforts on a single livelihood but rather engage in multiple complementary activities to enhance economic security (Mohammed & Uraguchi, 2023). Skill-based trades, including tailoring, carpentry, and butchery (20–21%), indicate moderate adoption of specialized income-generating activities. Formal employment, such as civil service (11.3%) or professional roles in teaching (8.7%) and nursing (4.3%), remains limited, highlighting structural barriers such as low educational attainment, lack of access to formal job opportunities, and resource constraints (Kolding *et al*., 2021).

Table 4: Tobit Regression Results on Determinants of Livelihood Diversification (n = 300)

Variables	Coefficient	Std. Error	t-value
Constant	0.398***	0.081	4.91
Age (years)	-0.002	0.002	-1.20
Household Size	0.013**	0.006	2.17
Education (years)	0.019***	0.005	3.80
Fishing Experience (years)	-0.004*	0.002	-1.85
Access to Credit (1 = yes)	0.079***	0.021	3.76
Extension Contact (1 = yes)	0.061**	0.025	2.44
Market Access (distance in km)	-0.010**	0.004	-2.50
Infrastructure Constraint Index	-0.085***	0.027	-3.15
Asset Ownership (index)	0.052**	0.019	2.74
Security Constraint (1 = yes)	-0.069**	0.028	-2.46
Pseudo R^2	0.601		
Log-Likelihood	-138.62		
Number of Observations (n)	300		

*Source: Field Survey, 2026 *** Significant at 1% ** Significant at 5% and * Significant at 10%*

The Tobit regression results in Table 4 provide robust empirical evidence on the determinants of livelihood diversification among artisanal fishing households. The model, estimated with 300 observations, demonstrates satisfactory explanatory power (Pseudo $R^2 = 0.301$), indicating that the included variables jointly explain a substantial proportion of variation in the livelihood diversification index. Education exhibits a positive and highly significant influence on diversification ($\beta = 0.019$, $p < 0.01$), suggesting that more educated household heads are better able to access information, adopt new opportunities, and engage in multiple income-generating activities. This finding aligns with the human capital theory and corroborates earlier studies which emphasize that education enhances households' adaptive capacity and diversification potential (Ellis, 2000; Reardon, T. et al., 2007).

Access to credit also has a positive and statistically significant effect ($\beta = 0.079$, $p < 0.01$), indicating that financial inclusion relaxes liquidity constraints and enables households to invest in alternative livelihoods. This supports the argument that credit access is a critical enabler of rural livelihood diversification, particularly in resource-constrained settings (Ellis, F., 2000; Barrett, C. B. et al., 2001). Household size is positively related to diversification ($\beta = 0.013$, $p < 0.05$), implying that larger households possess more labour resources, which can be allocated across multiple economic activities. This is consistent with findings that household labour availability promotes participation in diverse livelihood strategies (Dercon, S., 2002). Extension contact significantly enhances diversification ($\beta = 0.061$, $p < 0.05$), reflecting the role of institutional support in facilitating access to information, skills, and innovations. This result is in line with agricultural extension literature, which highlights the importance of advisory services in broadening livelihood options and improving rural welfare outcomes (Anderson, J. R. & Feder, 2004). Conversely, structural constraints such as poor infrastructure ($\beta = -0.085$, $p < 0.01$) and limited market access ($\beta = -0.010$, $p < 0.05$) exert significant negative effects on diversification. These findings suggest that inadequate roads, storage, and market linkages restrict households' ability to explore and sustain alternative income sources. This supports existing empirical evidence that infrastructure and market imperfections are major barriers to diversification in rural economies (Stifel, D. & Minten, 2008).

Security constraints also negatively influence diversification ($\beta = -0.069$, $p < 0.05$), indicating that insecurity discourages investment in non-fishing activities and limits mobility. This finding is particularly relevant in the Nigerian context, where rural insecurity has been shown to disrupt livelihood systems and reduce economic opportunities (Food and Agriculture Organization, 2021). Fishing experience has a weak negative effect ($\beta = -0.004$, $p < 0.10$), suggesting that more experienced fishers may be less inclined to diversify due to specialization and path dependency. This is consistent with the notion that households deeply embedded in a primary occupation may exhibit lower diversification tendencies (Barrett, C. B. et al., 2001).

Asset ownership positively and significantly influences diversification ($\beta = 0.052$, $p < 0.05$), implying that households with greater asset endowment are better positioned to undertake additional economic activities. This finding supports the asset-based approach to livelihoods, which posits that access to productive assets enhances income diversification and resilience (Ellis, F., 2000). Age, although negatively signed, is not statistically significant, indicating that diversification behaviour may not be strongly determined by the age of the household head in this context. Overall, the results confirm that both enabling factors (education, credit, assets, extension) and structural constraints (infrastructure, market access, security) play significant roles in shaping livelihood diversification. The findings provide strong empirical support for the study's conceptual framework and demonstrate the suitability of the Tobit model in capturing the censored nature of diversification behaviour.

Limitations of the Study

This study on structural constraints, livelihood diversification behaviour, and welfare outcomes among artisanal fishing households in Shiroro and Kainji dam systems is subject to several limitations that should be acknowledged when interpreting the findings. First, the study adopted a cross-sectional research design, which captures data at a single point in time. This limits the ability to establish causal relationships between structural constraints, diversification behaviour, and welfare outcomes. As such, observed associations may not fully reflect long-term dynamics or seasonal variations inherent in artisanal fisheries. Second, the reliance on self-reported data from respondents introduces the possibility of recall bias and response bias. Artisanal fishing households may not accurately remember past income levels, diversification activities, or welfare conditions, which could affect the precision of the data collected.

CONCLUSION/RECOMMENDATIONS

This study examined the structural constraints affecting artisanal fisheries, the livelihood diversification strategies adopted by fishing households, and the resulting welfare outcomes along Shiroro and Kainji dams in Nigeria. The findings indicate that artisanal fishers face multidimensional challenges, with economic constraints including high costs of fishing gear, limited access to credit, and inadequate operating capital being the most severe. Institutional and technical factors, such as limited extension services and weak cooperative structures, alongside environmental and physical stressors like seasonal water-level fluctuations and climate variability, further constrain household livelihoods. Despite these challenges, households engage in highly diversified livelihood strategies (SDI = 0.955), combining agriculture, non-farm activities, and skill-based trades to mitigate risk and enhance welfare. The study underscores that livelihood diversification is a key adaptive mechanism that enables fishing households to sustain income, food security, and resilience in the face of structural and environmental constraints. Based on the findings of the study, the following recommendations were made

1. Policies and programs should focus on improving fishers' access to affordable credit, subsidies for fishing gear, and operational inputs. Microfinance schemes, cooperative-based lending, and low-interest credit facilities could significantly reduce economic

constraints and enable households to expand and optimize their livelihood activities.

2. Extension services, technical training, and cooperative strengthening should be prioritized to improve adoption of modern fishing technologies and sustainable resource management practices. Effective institutional frameworks will support diversified livelihood strategies and increase overall household welfare.
3. Interventions should combine market development, value-chain support, and environmental management to ensure sustainable incomes. Expanding access to local and regional markets, coupled with climate-adaptive fisheries management and ecological restoration measures, will enhance resilience, income stability, and long-term sustainability of artisanal fisheries.

Conflict of interest

The authors hereby declare that there is no conflict of interest.

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Authors' contributions

IDS: Conception, development of data collection instrument, interpretation of data, revised manuscript (50%)

TAM: Conception/design, data analysis, interpretation of data, and final draft (25%)

YJA: Conception/design, data collection, supervision, interpretation of data (25%)

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