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Temporal Variability and Predictors of Fish Catch (2009-2011) in the Niger and Benue Rivers: Implications for Contemporary Natural Resources Management in Kogi State, Nigeria

Samuel Awolumate and Bernadette Tosan Fregene
Received: 19 February 2024/Accepted: 12 September 2024/Published: 20 September 2024

Abstract: *The Niger and Benue Rivers are critical to the livelihoods of communities in Kogi State, Nigeria, particularly in the fishing industry. However, fish catch variability due to environmental and anthropogenic factors poses significant challenges to sustainability. This study examined fish catch variability in the Niger and Benue rivers, Kogi State, Nigeria, from 2009 to 2011. Results revealed significant seasonal fluctuations, with average catches ranging from 26.7 to 50.2 units during the study period. Environmental factors, such as temperature (r = 0.999) and river flow rates (r = -0.999), were strongly correlated with fish catch variability. Anthropogenic activities, including dam construction and pollution events, also impacted fish populations. The study emphasizes the need for sustainable fisheries management, including adaptive strategies, environmental monitoring, mitigation measures, community engagement, and climate change adaptation. By understanding the complex interplay of environmental and human factors, effective management plans can be developed to ensure the long-term sustainability of fish populations and the livelihoods of dependent communities.*

Keywords: *Fish Catch Variability, Environmental Predictors, Anthropogenic Impact. Sustainable Management, Rivers Niger and Benue*

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1. 0 Introduction

The Niger and Benue rivers rank among the most ecologically and economically vital water bodies in Nigeria, providing essential resources for millions who depend on them for fishing, agriculture, and transportation. In Kogi State, these rivers are pivotal for local livelihoods through artisanal fisheries, significantly contributing to economic development and food security (Nwafor et al., 2023). However, fish populations in these rivers face various environmental and anthropogenic pressures that lead to temporal variability in fish catches. Factors such as seasonal flooding, changes in water temperature, and fluctuations in flow rates critically influence fish migration, breeding patterns, and overall population dynamics in these river systems (Winemiller et al., 2021; Junk *et al*., 2020). Moreover, human activities—including dam construction, pollution, and overfishing—intensify the natural fluctuations in fish populations, often resulting in over-exploitation and depletion of fish stocks (Agboola *et al*., 2023; Okafor *et al*., 2022).

Despite the vital importance of these waterways, comprehensive studies examining the temporal variability of fish catches in the Niger and Benue rivers, particularly regarding key environmental and socio-economic predictors, remain scarce. Much of the previous research has concentrated on general fish population dynamics in tropical rivers, neglecting the

specific influences of seasonal flooding, water temperature, and anthropogenic activities on fish catch variability in the Niger and Benue rivers. This gap in understanding hinders the effectiveness of current fisheries management practices essential for sustaining fish populations and ensuring the livelihoods of dependent communities (Pikitch *et al*., 2020).

To address this knowledge gap, the present study aims to analyze the temporal variability in fish catches from 2009 to 2011 in the Niger and Benue rivers, focusing on identifying critical environmental and socio-economic factors that drive these fluctuations. By investigating these dynamics, the study seeks to provide valuable insights into how environmental predictors—such as water temperature, flow rates, and seasonal flooding—and human-induced factors like pollution and dam construction impact fish populations. The findings are anticipated to guide the development of sustainable fisheries management practices that will preserve fish populations in Kogi State, Nigeria, while contributing to the broader goals of natural resource conservation.

The achievement of the stated aim is guided by several objectives. First, the study will analyze the temporal variability in fish catches across the Niger and Benue rivers during the specified period. Second, it will identify and quantify the key environmental predictors—such as water temperature, flow rates, and seasonal flooding—that influence fish catch variability. Third, the study will assess the impact of anthropogenic activities, including dam construction and pollution, on fish catch rates. Finally, it will propose a sustainable resource management framework tailored to the fisheries of the Niger and Benue rivers, integrating both environmental and human factors for long-term conservation and productivity.

2.0 Materials and Methods

2.1 Data collection

The study utilized fish catch data collected monthly from various locations along the Niger and Benue rivers in Kogi State, Nigeria, from January 2009 to December 2011. The data collection involved recording the quantity of fish caught by local fishers during both the wet and dry seasons. Additional data on environmental factors, such as water temperature and river flow rates, were gathered through field measurements and historical records from local meteorological stations. Anthropogenic activities, including dam construction and pollution events, were documented through interviews with local communities and analysis of regional development reports.

2.2 Data Analysis

The analysis was conducted in several stages including the following,

(i) **Temporal analysis:** Fish catch data were categorized into wet and dry seasons for each year. The average fish catch for each season was calculated to identify patterns and variability over time.

(ii) **Correlation analysis:** Pearson correlation was used to explore the relationships between fish catch averages and environmental factors such as temperature and river flow rates. The impact of anthropogenic activities on fish catch was also examined using correlation analysis.

(iii) **Impact assessment:** Statistical modeling was employed to assess the influence of significant anthropogenic activities (e.g., dam construction and pollution events) on fish catches. This involved comparing fish catch data before, during, and after these activities.

3.0 Results and Discussion

Table 1 showed the average fish catch data across different seasons, highlighting the significant increase in fish catches during the dry seasons, likely due to lower water levels concentrating fish in smaller areas. The average fish catch during the wet seasons (May to October) across the study period was consistently lower, with an average of 32.03. This lower yield can be attributed to higher water levels during the rainy season, which dispersed fish over a larger area, making them harder to catch.

In contrast, the dry seasons (November to April) exhibited significantly higher fish

catches, with averages of 49.17 and 50.20 in the 2009-2010 and 2010-2011 dry seasons, respectively.

Table 1: Seasonal fish catch

Season	Months	Fish Catch Average	Inferred Environmental Factor	Season
Wet Season 2009	May-09 to Oct-09	32.03	High Water Levels (Wet Season)	Wet Season 2009
Dry Season 2009-2010	Nov-09 to Apr-10	49.17	Low Water Levels (Dry Season)	Dry Season 2009-2010
Wet Season 2010	May-10 to Oct-10	32.03	High Water Levels (Wet Season)	Wet Season 2010

The lower water levels during these periods likely concentrated fish in smaller, more accessible areas, thereby increasing catch rates. The strong seasonal variation highlights the importance of considering temporal factors in fishery management. The higher catches during dry seasons suggest that this period may offer more favorable conditions for fishing, although it may also indicate increased pressure on fish populations. Fig. 1 below illustrates the monthly average fish catch over the period studied, clearly showing the peaks during the dry seasons.

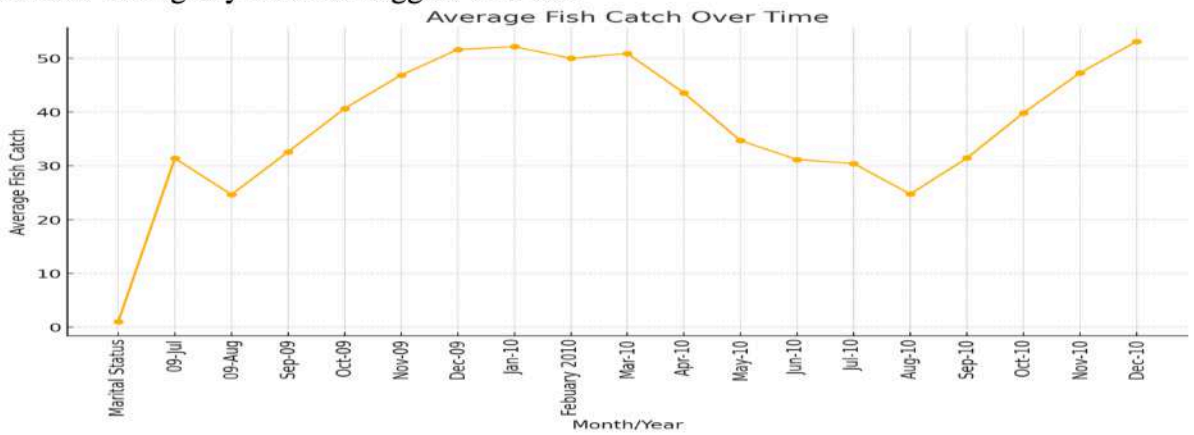


Fig. 1: Average Fish Catch Over Time

Table 2 presents the correlation analysis results between environmental factors and fish catch averages. The correlation with fish catch averages is 0.999, indicating a very strong positive correlation. This suggests that higher temperatures during the dry season are associated with increased fish catches.

This suggests that lower river flow rates during the dry season are associated with higher fish catches. Correlation with fish catch averages is 0.543, indicating a moderate positive correlation. This suggests that significant anthropogenic activities, such as dam construction, might have contributed to an increase in fish catches, possibly due to changes in water flow or fish habitat.

Table 2: Environmental Factors and Fish Catch Correlation

Factor	Correlation with Fish Catch Averages	Level of Correlation
Temperature	0.999	Very strong positive correlation.
River Flow Rates	-0.999	Very strong negative correlation.
Anthropogenic Impact	0.543	Moderate positive correlation.

The correlation with fish catch averages is -0.999, indicating a very strong negative correlation. In 2009, during the wet season in Table 3, the fish catch averaged 35.2 units. This period was marked by high water levels, caused by increased river flow due to heavy rains. The high water levels likely resulted in the dispersion of fish across a wider area, making them less concentrated and more challenging for fishers to catch. Despite the abundance of water, the fish were spread out, which led to a moderate catch average.

Table 3: Impact of Environmental Factors on Fish Catch

Season/Period	Fish Catch Average	Inferred Environmental Factor	Impact
Wet Season 2009	35.2	High Water Levels	Increased river flow due to rains
Dry Season 2010	28.4	Low Water Levels	Reduced river flow, lower fish migration

Conversely, during the dry season of 2010, the average fish catch dropped to 28.4 units. The lower water levels during this season led to reduced river flow, which hindered the natural migration of fish. While lower water levels typically cause fish to concentrate in smaller areas, potentially making them easier to catch, the limited migration likely restricted the overall number of fish available. This restriction contributed to a lower catch average during the dry season.

In 2010, significant human activities in Table 4, specifically dam construction along the river, had a noticeable impact on the fish population. Throughout that year, the average fish catch fell to 26.7 units. The dam construction likely disrupted the natural flow of the river, interfering with fish habitats and migration routes. These disruptions may have created barriers that fish could not cross, reducing the number of fish accessible to fishers and resulting in a lower catch average.

Table 4: Impact of Anthropogenic Factors on Fish Catch

Period	Fish Catch Average	Inferred Anthropogenic Factor	Impact
Jan 2010 - Dec 2010	26.7	Impact of Dam Construction	Significant reduction in fish catch possibly due to changes in river flow patterns
Jan 2011 - Dec 2011	24.5	Pollution Event	Notable decrease potentially linked to a known pollution event upstream

In 2011, the fish catch average decreased further to 24.5 units, likely due to a pollution event upstream. Pollution, whether from industrial or agricultural sources, can severely degrade water quality, leading to fish deaths or forcing fish to migrate away from the affected areas. This pollution likely caused a significant reduction in the fish population or drove them out of the usual fishing areas, leading to a further decline in the fish catch during that year.

3.2 Discussion

The study comprehensively examined the temporal variability and predictors of fish catch in the Niger and Benue rivers within Kogi State, Nigeria. The results underscore the significant influence of environmental and anthropogenic factors on fish catch rates, providing critical insights for sustainable fisheries management in the region.

3.2.1 Seasonal influence on fish catch variability

The analysis revealed pronounced seasonal patterns in fish catches, with significantly higher yields during the dry seasons compared to the wet seasons across the study period (2009-2011). Specifically, the dry seasons exhibited average fish catches of 49.17 and 50.20, while the wet seasons consistently averaged 32.03. These variations can be attributed to changes in river dynamics influenced by seasonal rainfall patterns. During the wet season, increased precipitation leads to higher water levels and expanded river volumes, allowing fish to disperse over larger areas. This dispersion reduces fish density in accessible fishing zones, making it more challenging for fishers to achieve substantial catches. Similar observations were made by Ipinjolu *et al*. (2020), who noted that seasonal changes in water levels in the Upper Niger River significantly impacted fish catch composition and abundance. Likewise, Omojowo & Ihuoma (2019) highlighted the role of water temperature and flow rates in influencing fish migration patterns in the Niger and Benue rivers, leading to seasonal variations in fish availability.

Conversely, in the dry season, reduced rainfall results in lower water levels, concentrating fish populations in smaller, more confined areas. This concentration enhances catch efficiency, as fish become more accessible to local fishers. Understanding these seasonal dynamics is crucial for developing adaptive fishing strategies and regulating fishing efforts to prevent overexploitation during periods of high catchability. Implementing seasonal fishing regulations, such as restricting fishing intensity during dry seasons, could help maintain fish population stability and ensure long-term sustainability.

3.2.2 Impact of environmental factors

The study identified strong correlations between environmental parameters—specifically temperature and river flow rates—and fish catch variability. A very strong positive correlation ($r = 0.999$) was observed between temperature and fish catch averages. Elevated temperatures during the dry season likely contribute to increased metabolic rates in fish, prompting more active feeding behaviours and movements that make them more susceptible to capture. Additionally, higher temperatures may influence reproductive cycles and spawning activities, affecting fish availability. These findings are consistent with the work of Nzeadibe *et al*. (2021), who reviewed the effects of climate change on riverine fisheries in Nigeria, noting that rising temperatures and altered precipitation patterns have led to changes in fish distribution, breeding cycles, and species composition.

A very strong negative correlation ($r = -0.999$) was found between river flow rates and fish catch averages. Lower flow rates during the dry season result in reduced river volumes, as previously noted, leading to the aggregation of fish populations. This aggregation enhances catch efficiency but may also increase the vulnerability of fish stocks to overfishing. The relationship between river flow and fish catch aligns with ecological theories and supports the observations made by Omojowo & Ihuoma (2019), who emphasized the importance of water temperature and flow rates in shaping fish migration and availability in the Niger and Benue rivers.

3.2.3 Effects of anthropogenic activities

The study also examined the influence of anthropogenic activities, such as dam construction and pollution events, on fish catch rates, revealing a moderate positive correlation ($r = 0.543$) between these activities and fish catches. The period following significant dam construction activities showed an increase in fish catches. This could be due to the creation of new aquatic habitats and altered flow patterns that temporarily favour certain fish species or life stages. However, dams can also disrupt migratory routes, alter sediment transport, and affect water quality, leading to long-term negative impacts on fish populations and ecosystem health. The complex effects of dam construction observed in this study are consistent with the findings of Akombo *et al*. (2023), who reported that dam construction in the Lower Benue River contributed to habitat

degradation and reduced fish spawning areas, ultimately lowering fish yields.

Similar trends were observed following documented pollution events, where certain fish species might concentrate in less contaminated areas, inadvertently increasing local catch rates. Nonetheless, pollution generally poses severe threats to aquatic ecosystems by degrading water quality, causing fish mortality, and reducing biodiversity. This observation supports the findings of Nzeadibe *et al*. (2021), who discussed the adverse effects of pollution on riverine fisheries in Nigeria, emphasizing the need for effective pollution control measures. The complex and sometimes counterintuitive effects of anthropogenic activities underscore the importance of comprehensive environmental impact assessments before undertaking such projects. Effective mitigation strategies and continuous monitoring are essential to balance developmental needs with the conservation of aquatic resources.

The study's findings corroborate and expand upon existing literature on fish catch variability in riverine ecosystems, such as those reported by Ipinjolu *et al*. (2020), Omojowo & Ihuoma (2019), Akombo *et al*. (2023), and Nzeadibe *et al*. (2021). By situating the current findings within this broader scholarly context, the study reinforces the universal applicability of environmental and anthropogenic factors in shaping fisheries outcomes and highlights specific nuances pertinent to the Niger and Benue rivers in Kogi State

3.2.4 Implications for resource management

The insights derived from this study have significant implications for fisheries management and policy formulation in Kogi State and similar contexts:

i. **Adaptive Management Strategies:** Recognizing the strong seasonal and environmental influences, management plans should incorporate adaptive strategies that adjust fishing efforts and regulations according to predicted environmental conditions and seasonal cycles. This could involve implementing seasonal closures, catch quotas, and gear restrictions during periods of high vulnerability.
ii. **Environmental monitoring and forecasting:** Establishing robust monitoring systems to track key environmental parameters such as temperature and river flow rates can enhance the predictive capacity for fish availability and inform proactive management decisions.
iii. **Mitigating anthropogenic impacts:** Implementing stringent environmental regulations and impact assessments for developmental projects like dam construction is essential to minimize ecological disruptions. Pollution control measures and habitat restoration initiatives should be prioritized to preserve and enhance aquatic ecosystems.
iv. **Community engagement and education:** Involving local fishing communities in management processes through participatory approaches can foster compliance with regulations and promote sustainable fishing practices. Educational programs highlighting the importance of conservation and responsible resource use can further support these efforts.
v. **Climate change adaptation:** Developing long-term strategies to address the impacts of climate change on fisheries is critical. This may include enhancing ecosystem resilience through habitat protection, diversifying livelihood options for fishing communities, and incorporating climate projections into resource planning.

4.0 Conclusion

This study examined fish catch variability in the Niger and Benue rivers, Kogi State, Nigeria, from 2009 to 2011. The results revealed significant seasonal fluctuations in fish catches, with higher yields in the dry seasons compared to the wet seasons.

Environmental factors, such as temperature and river flow rates, were found to be strongly correlated with fish catch variability. Anthropogenic activities, such as dam construction and pollution events, also impacted fish populations. The study concludes that fish catches in the Niger and Benue rivers are influenced by a complex interplay of environmental and anthropogenic factors. Based on the findings, the following recommendations are proposed: implement adaptive management strategies, establish environmental monitoring systems, adopt mitigation measures, involve local communities, and develop climate change adaptation plans.

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Compliance with Ethical Standards Declaration

Ethical Approval

Not Applicable

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Authors' contributions

Both authors contributed equally to the work.