Int. j. adv. multidisc. res. stud. 2026; 6(2):1350-1356

Received: 24-02-2026
Accepted: 04-04-2026

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Evaluating the Impacts of Climate Variations on Fish Production in Feira Area, Luangwa District, Zambia

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Abstract
Fishery-based livelihoods play a crucial role in the socio-economic fabric of communities in the Feira area of Luangwa District, Zambia. However, these livelihoods are increasingly vulnerable to the adverse impacts of climate variations, including erratic rainfall, rising temperatures, and extreme weather events. This study explored the complex relationship between climate variability and the sustainability of fishery-based livelihoods in the area, aiming to identify the factors that exacerbate vulnerability and potential strategies for resilience.
Using a mixed-methods approach, the research incorporated data from surveys, focus group discussions, and interviews with local fishers and stakeholders. The study also highlighted the limited adaptive capacity of the community, which is constrained by inadequate financial resources, lack of access to climate information, and weak institutional support. Despite these challenges, local fishers employ coping mechanisms such as diversifying livelihoods, utilizing traditional knowledge, and engaging in community-based resource management. However, these strategies are insufficient to address the scale of the challenges posed by climate variability.
The research concludes with recommendations for enhancing resilience, including the establishment of climate-resilient infrastructure, capacity-building programs, and improved access to early warning systems and alternative livelihoods. It calls for collaborative efforts among policymakers, local authorities, and development organizations to support sustainable fishery management and strengthen the adaptive capacity of vulnerable communities.
This study contributes to the understanding of climate change impacts on fisheries and underscores the urgency of proactive measures to safeguard fishery-based livelihoods in the Feira area and similar regions.

Keywords: Climate Variability, Fishery-Based Livelihoods, Vulnerability, Resilience, Adaptive Capacity, Climate Impacts, Community-Based Resource Management, Sustainable Fishery Management, Capacity-Building and Early Warning Systems, Climate Change Adaptation, Feira District

1. Introduction

Fishery-based livelihoods are fundamental to the food security and economic stability of communities in the Feira area of Luangwa District, Zambia. This region, situated along the Luangwa River, has a long history of dependence on small-scale fisheries. However, global climate change poses an unprecedented threat to these aquatic ecosystems and the communities they support. Southern Africa, and Zambia in particular, is experiencing heightened climatic variability, characterized by rising temperatures, increased frequency of extreme weather events, and altered precipitation patterns.

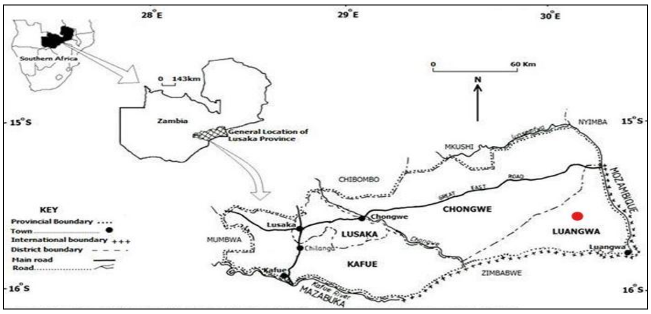
These changes directly impact freshwater systems, affecting water levels, temperature regimes, and habitat integrity all critical factors for fish survival, reproduction, and growth. While the global and regional impacts of climate change on fisheries are well-documented, there is a critical gap in localized, empirical studies that capture the specific perceptions and experiences of fishing communities. Such granular understanding is essential for developing effective, context-specific adaptation policies.

This article addresses this gap by presenting findings from a study conducted in Feira, Luangwa District. It focuses exclusively on the first research objective: to evaluate the impacts of climate variations on fish production. The study investigates local fishers' perceptions of climatic changes over the past decade and statistically analyses the association between these perceived changes and observed declines in fish populations.

2. Methodology

2.1 Location of the Study Area

The Feira area, located in the Luangwa District of Zambia, is situated within the eastern region of the country, characterized by its rich biodiversity and reliance on natural resources. The geographical coordinates of the Feira area are approximately 13.63° South latitude and 30.75° East longitude. This strategic location is marked by proximity to the Luangwa River, which serves as a vital resource for the local fisheries and supports the livelihoods of communities dependent on fishing and related activities.



Source: Google Maps

Fig 2: Map Showing Study Area Luangwa District

2.2 Research Design

The study utilized a Convergent Parallel Design, a specific mixed-methods research structure (Creswell, 2014). This design involved collecting and analysing quantitative and qualitative data concurrently but independently before merging the results to draw comprehensive conclusions. Quantitative data were gathered through structured surveys to measure variables like catch rates and income, capturing trends and conditions. Qualitative data were collected via interviews and focus group discussions to gain deeper insight into personal experiences, perceptions, and coping strategies. By integrating both datasets, the design addressed both the "what" of the current state and susceptibility of fisheries and the "why" behind underlying causes and adaptive responses. This concurrent approach also enabled triangulation, enhancing the study's validity and reliability by allowing quantitative data to substantiate qualitative findings and vice versa.

2.3 Sample Size

The sample size for the quantitative component was determined using Cochran's (1963) formula to ensure it accurately reflected the target population and minimized sampling error. With a population (N) of 36,047 and a 9% significance level, the calculation yielded a sample size of 123 respondents from the fishing community. For the qualitative component, 10 key informants were purposively selected, including government agricultural and fisheries officers and NGO representatives. Although the initial target was 133 total participants, data saturation was reached after surveying 90 community respondents, and thus the analysis was based on this achieved sample.

2.4 Sampling Techniques

A combination of sampling techniques was used to ensure both representativeness and depth. For the quantitative survey, stratified random sampling was employed. The community was divided into strata based on characteristics like age, gender, and occupation to ensure all key demographic groups within the fishery sector were proportionately represented, enhancing the generalizability of the findings (Salkind, 2010). For the qualitative component, expert purposive sampling was used to identify and select ten key informants who possessed specialized knowledge relevant to climate impacts and fisheries policy. This hybrid methodology minimized bias while maximizing both the representativeness of the community data and the richness of insights from experts.

2.5 Data Collection Tools

A variety of instruments were used to collect data, as the choice of tool significantly influences data quality and validity (Cohen *et al*., 2011). The primary tools were structured surveys, which provided quantitative data on income, fishing yields, and observed climate impacts, and semi-structured interviews and focus group discussions, which captured qualitative narratives on lived experiences and adaptation strategies. Secondary data, such as temperature charts from the meteorological department, were also analysed. The triangulation of these multiple sources enhanced data reliability and provided a multidimensional perspective on the research problem.

2.6 Methods of Analysing Data

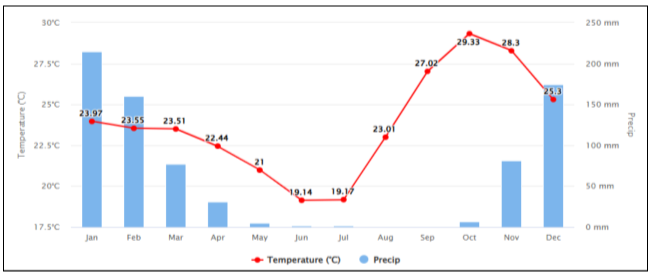
Data analysis employed techniques appropriate for each data type. Quantitative data were analyzed using statistical methods, including descriptive statistics and a Chi-Square test of independence, to identify relationships between climate variables and fishery productivity. Qualitative data from interviews and open-ended responses were analyzed using thematic analysis. This involved systematically coding the data to identify, analyze, and report patterns (themes) that reflected the underlying issues, experiences, and perceptions of the participants (Braun and Clarke, 2006) [11]. This combination of statistical rigor and qualitative depth ensured a balanced understanding of the vulnerabilities and adaptive capacities.

3. Results

3.1 Demographic Profile of Respondents

The respondent pool was predominantly experienced fishers, with 48.9% having 5-7 years of experience and 13.3% having over 10 years. The majority (57.8%) were male, reflecting the gender dynamics of active fishing. The largest age cohort was 36-45 years (43.3%), indicating a population of household heads in their prime productive years.

3.2 Evaluation of the impact of climate variations on fish production in Feira area of Luangwa District. The finding under this objective were as follows



Source: Meteorological Department of Zambia 2025

Picture 3.1.1: Showing monthly year temperature chart of Luangwa district for five years

Table 3.1.2: Showing the Major type of Fish Caught

FishType	Frequency	Percent	Valid Percent	Cumulative Percent	
Valid	Bream	77	85.6	85.6	85.6
	Tiger	13	14.4	14.4	100.0
	Total	**90**	**100.0**	**100.0**	
Missing	System	0	0.0		
Total		90	100.0		

Source: Field Data 2025

As shown above in table 5.3.2 above, an analysis of the fishing catch data (N=90) revealed a clear dominance of a single species. Bream was the predominant catch, constituting 85.6% (n=77) of all fish caught. Tiger fish was also present but was caught far less frequently, accounting for the remaining 14.4% (n=13) of the total catch. Notably, Nkolokolo was not recorded in this sample.

The mean value of the catch data (1.14) is much closer to the value assigned to Bream (1) than to Tiger fish (2), further underscoring its prevalence. The low standard deviation (0.35) confirms that the data is highly concentrated around this mean, indicating very consistent and uniform results dominated by the catch of Bream**.**

3.3 Quantitatively the following were the finding on the impact of climate variation on fish production.

Test 1: Chi-Square Test of Independence

Hypothesis:

- **H_0:** There is no association between observing climate change (Q2) and observing a change in fish population (Q4). (They are independent).
- **H_1:** There is an association between observing climate change and observing a change in fish population. (They are not independent).

	Q4: Fish Change = Yes	Q4: Fish Change = No	Row Total
Q2: Climate Ch. = Yes	70	4	74
Q2: Climate Ch. = No	12	4	16
Column Total	82	8	90

Expected Frequencies Table **(E)**

The formula for each cell is:

E = (Row Total × Column Total) / Grand Total

E (Yes, Yes) = (74 × 82) / 90 = 6068 / 90 = **67.422**

E (Yes, No) = (74 × 8) / 90 = 592 / 90 = **6.578**

E (No, Yes) = (16 × 82) / 90 = 1312 / 90 = **14.578**

E (No, No) = (16 × 8) / 90 = 128 / 90 = **1.422**

Expected Counts (E)	Fish: Yes	Fish: No
Climate: Yes	67.42	6.58
Climate: No	14.58	1.42

$(O - E)^2 / E$

1. $(70 - 67.422)^2 / 67.422 = (2.578)^2 / 67.422 = 6.646 / 67.422 =$ **0.0986**
2. $(4 - 6.578)^2 / 6.578 = (-2.578)^2 / 6.578 = 6.646 / 6.578 =$ **1.0103**
3. $(12 - 14.578)^2 / 14.578 = (-2.578)^2 / 14.578 = 6.646 / 14.578 =$ **0.4560**
4. $(4 - 1.422)^2 / 1.422 = (2.578)^2 / 1.422 = 6.646 / 1.422 =$ **4.674**

$$\chi^2 = 0.0986 + 1.0103 + 0.4560 + 4.674 = 6.2389$$

Degrees of Freedom

df = (number of rows - 1) x (number of columns - 1) df = (2 - 1) x (2 - 1) = 1

Critical Value and Decide

Using a Chi-Square distribution table, the critical value for α = 0.05 and df = 1 is **3.841**.

Calculated χ^2 = 6.24

Critical Value = 3.84

Decision: Since 6.24 > 3.84, we reject the null hypothesis and accept the alternative hypothesis that state there is an association between observing climate change and observing a change in fish population.

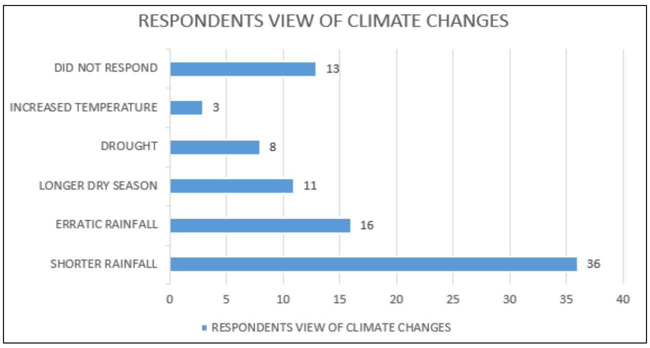
Table 3.1.4: Table Showing Respondents Perceptions of Variation Over Last Ten Years

	Frequency	Percent	Valid Percent	Cumulative Percent	
Valid	Yes (1)	78	86.7	88.6	88.6
	No (2)	10	11.1	11.4	100.0
	Total	**88**	**97.8**	**100.0**	
Missing	System (0)	2	2.2		
Total		90	100.0		

Source: Field Data 2025

As shown above, the vast majority of respondents (88.6% of valid responses) have observed changes in the climate over the last ten years. This was confirmed by one respondent who said that;

> *"The sun now burns differently. The river shrinks faster every dry season, leaving fish stranded in pools that turn to bath water."*



Source: Field Data 2025

Fig 3.1.5: Showing the Respondents View on Climate Change

Table 3.1.6: Showing Direction of Fish Abundance Change

	Frequency	Percent	Valid Percent	Cumulative Percent	
Valid	Decreased (1)	82	91.1	97.6	97.6
	Increased (2)	2	2.2	2.4	100.0
	Total	**84**	**93.3**	**100.0**	
Missing	System (Q3=No)	6	6.7		
Total		**90**	**100.0**		

Source: Field Data 2025

As shown above, many respondents saw a change in fish population, the experience is almost universally negative, with 97.6% reporting a decrease in fish abundance.

Table 3.1.7: Showing Respondents view on how Climate variation Affected Fish Habitat

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Reduced water levels (1)	75	83.3	83.3
	No change (3)	12	13.3	13.3
	Increased water level (2)	3	3.3	3.3
	Total	**90**	**100.0**	**100.0**
Missing	System	0	0.0	
Total		**90**	**100.0**	

Source: Field Data 2025

The data reveals a near-unanimous perception among respondents regarding the impact of climate variation on fish habitat. An overwhelming majority (**83.3%**) reported that the primary effect has been **reduced water levels**. This finding suggests that communities directly attribute habitat loss and degradation to climatic changes, likely linking it to observed patterns like longer dry seasons, drought, and erratic rainfall. A much smaller proportion of respondents (**13.3%**) perceived no change in the fish habitat, while only **3.3%** reported increased water levels.

One respondent said;

> *"The rains come late and leave early. They are fierce but shallow the water runs off the land rather than sinking in to feed the river through the dry months,"*

The assertion by a local that the rains arrive late and depart early each year. When they do come, they are intense and fierce, but their impact is limited because the water quickly runs off the land rather than soaking in. As a result, the soil remains dry, and the water does not sufficiently nourish the rivers that sustain the region during the dry months. This pattern of rainfall leads to prolonged dry spells and challenges for agriculture and local ecosystems, making water scarcity a persistent issue for the community.

4.Discussion

4.1 Quantitative Point of View

The findings under this objective present a unequivocal picture of significant impact. The Chi-Square test of independence ($\chi^2 = 6.24$, df=1, $p<.05$) provided a statistically robust rejection of the null hypothesis, confirming a perceived association between observed climate change and observed changes in fish population. This statistical finding is powerfully validated by the descriptive data: 88.6% of respondents observed climate changes over the past decade, and of those who saw a change in fish abundance, 97.6% reported a decrease. The overwhelming attribution (83.3%) of this decline to reduced water levels is a critical finding. This directly supports the work of Allison *et al.* (2009) [2], who identified freshwater fisheries in Africa as among the most vulnerable to climate change due to their dependence on water levels and temperature, which are highly susceptible to altered rainfall patterns and increased evaporation.

The dominance of Bream (85.6% of catch) and its acute vulnerability to the reported habitat changes further exacerbates the problem. Bream species (often Cichlids) typically rely on littoral zones and specific breeding grounds that are severely affected by receding water levels (Lynch *et al*., 2016). The near-disappearance of other species like Nkolokolo suggests a loss of biodiversity, which O'Reilly *et al*. (2003) link directly to increased ecosystem fragility and reduced resilience to climatic shocks. The community's perception aligns with scientific models that predict a decline in fishery yields in inland water bodies due to increased drought frequency and intensity.

4.2 Impact of Climate Variation on Fish Production

The findings from Luangwa District present a severe case of climate-induced fishery collapse. However, this crisis is not occurring in isolation. When compared and contrasted with other studies across Africa, a pattern of widespread vulnerability emerges, yet the specific manifestations and severity are deeply influenced by local ecological and socio-economic contexts.

4.3 Comparison with Broader African Studies

The general trend of declining fish catches due to climate variability observed in Luangwa is consistent with research across the continent. Studies on Lake Tanganyika, for instance, have directly linked **increased surface temperatures** to a reduction in the mixing of nutrient-rich waters, leading to a decline in phytoplankton production and, consequently, a decrease in fish yields by over 30% over the past century (O'Reilly *et al*., 2003). Similarly, in West African lagoons and estuaries, **altered rainfall patterns** and **rising sea levels** have been associated with salinity changes and habitat loss, impacting stock recruitment and artisanal catches (Béné *et al*., 2016) [6].

A key point of **contrast** lies in the primary driver of decline. While the Luangwa case is overwhelmingly defined by **reduced water levels (83.3%)** due to drought, studies in large lake systems like Victoria and Malawi often emphasize **overfishing** as the primary stressor, with climate change acting as a potent threat multiplier (Hecky *et al*., 2010) [29]. This suggests that for riverine systems like the Luangwa, which are more ephemeral and directly dependent on immediate rainfall, climate impacts may be more immediate and acute than in larger, deeper lacustrine systems that have a greater buffer capacity.

4.4 Convergence and Divergence in Southern Africa

The findings from Feira align tragically well with the predicted impacts of climate change on Southern African freshwater systems. The region is projected to experience increased temperatures and increased drought frequency, making it a hotspot for climate vulnerability (IPCC, 2022) [30].

This pattern of precipitation change is well-documented across Southern Africa, where climate models project increased rainfall intensity but reduced duration, particularly in the Zambezi basin (Usman and Reason, 2004). The specific issue of low water levels crippling fisheries is echoed in studies of the Zambezi River system. For example, research in the Barotse Floodplain has also documented how delayed and shortened rainfall seasons reduce the duration and extent of seasonal flooding, which is crucial for fish breeding and access to floodplain habitats (Lindley *et al*., 2020).

This observation aligns with scientific models projecting increased evaporation rates across Southern African river basins under climate warming scenarios (IPCC, 2022) [30]. Furthermore, a point of divergence, however, can be found in the response of fish species. The Luangwa study reports a near-total reliance on a diminished Bream population and the local extinction of Nkolokolo. In contrast, a study on the Okavango Delta, another dynamic floodplain system, found that while some species declined, others more tolerant to lower oxygen and higher temperatures (like certain catfish species) became more prevalent (Mosepele *et al*., 2017). This suggests that the ecological homogeneity of the Luangwa catch, dominated by a single vulnerable species, may have made the system particularly fragile and lacking the functional redundancy that provides resilience in more diverse ecosystems.

4.5 Localized Severity

Within Zambia, the Luangwa findings are part of a disturbing national pattern. Studies on the Lake Kariba fishery, shared with Zimbabwe, have consistently reported declining kapenta and bream catches, linked to rising lake surface temperatures and reduced nutrient upwelling (Lacoursière *et al.*, 2022). Similarly, communities on the Kafue Flats have reported declining fish stocks associated with changed flooding regimes, exacerbated by water abstraction for agriculture and hydropower (Sichilima *et al*., 2016).

The Luangwa case, however, appears to be an extreme example of this national trend. While other Zambian fisheries face combined pressures of climate change and human infrastructure (like dams on the Kafue), the Luangwa River is a relatively undammed system. This makes its sharp decline a starker indictment of the impacts of climate variation alone primarily increased temperature and drought on a natural river system.

Furthermore, the fact the river's flow is now so compromised to an extent that it can no longer sustain its historical ecological productivity, pushing a transboundary resource crisis. The crisis in the Luangwa River is both a confirmation of pan-African trends and a severe local manifestation of them. It converges with broader studies on the negative impacts of warming and drought on freshwater fisheries but highlights the acute vulnerability of riverine systems compared to larger lakes. It aligns with regional climate projections and patterns observed in other Zambezi basin floodplains but stands out due to the severity of the collapse and the lack of confounding factors like major dams. Within Zambia, it serves as a potent example of how climate change can single-handedly devastate a livelihood system. Therefore, the Luangwa fishery can be considered a "canary in the coalmine," providing an early and stark warning of the future that may await other artisanal fisheries across Southern Africa if warming trends and climatic variability continue unchecked.

5. Conclusion

This paper presents a focused investigation into the impacts of climate variation on fishery production in the Feira area of Luangwa District, Zambia. The central finding is that the local fishery, a critical source of food and income, is undergoing a severe and statistically demonstrable collapse directly linked to climatic changes. The research establishes that the community, comprised of experienced fishers, overwhelmingly observes key environmental shifts over the past decade, including increased temperatures, more erratic rainfall, and significantly reduced water levels in the Luangwa River. Crucially, a robust Chi-Square test confirms a significant statistical association between these perceived climate changes and a observed drastic decline in fish abundance and diversity. The study identifies reduced water levels as the primary mechanism of harm, degrading essential fish habitats and leading to a loss of biodiversity, with catches becoming dangerously reliant on a single declining species.

The importance of this paper lies in its transformation of local lived experience into validated, empirical evidence for policy and action. It moves the climate change discourse from global abstraction to a documented, localized crisis, providing Zambian policymakers with concrete data from a climate-impact hotspot. By methodically capturing and statistically corroborating community-based knowledge, the study offers a model for grounding environmental research in the perceptions of those most affected. Furthermore, the situation in Feira serves as a critical warning signal for similar riverine fisheries across Southern Africa, highlighting their acute vulnerability to hydrological changes. Ultimately, by pinpointing the root cause—climate-driven habitat loss through reduced water levels the paper establishes a vital foundation for designing targeted and effective resilience strategies, such as enhanced water management and community-led conservation, to address the crisis at its source.

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