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Hydrological Stress, Biodiversity Loss and Livelihood Collapse — Climate Change Challenges in Coastal Fisheries of Ondo State, Nigeria

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Abstract The coast of Nigeria is increasingly experiencing pressure due to climate change and its impact on small-scale and artisanal fisheries. This study analyzed the effects of changing rainfall patterns, rising temperatures, and hydrological variability on small-scale fisheries in Ilaje Local Government Area (LGA), Ondo State, Nigeria. Four fishing villages: Ayetoro, Bijimi, Idiogba, and Asumogha were randomly selected to represent the fishing population. Data collection combined 285 questionnaire responses with 30 years of rainfall and temperature records from the Nigeria Meteorological Agency (NiMet), complemented by government and fisheries data. Quantitative data were analyzed using SPSS (version 25) with descriptive statistics, Chi-square, ANOVA, and regression, while qualitative data captured adaptation strategies. Results revealed a measurable decrease in rainfall days (218 in 1996 to 182 in 2025), rainfall ranging between 1,700-2,200 mm, and a steady increase in mean annual temperature from 27.4°C to 28.5°C. Maximum temperatures rose from 32.6°C to 33.3°C, while minimum temperatures increased from 19.6°C to 21.3°C. Nearly all participants (98.6%) agreed that increased water levels result in greater fish catches, while 97.5% believed decreased water levels reduce catches. Climate variability in Ilaje has disrupted fisheries and livelihoods. Recommendations include improved water management, shoreline protection, livelihood diversification, stronger cooperatives, and resilience-building to sustain Nigeria's coastal blue economy.

Keywords Rainfall variability; Temperature trends; Hydrological changes; Ilaje fishing communities; Adaptation strategies

1. Introduction

Climate change is widely acknowledged as one of the most pressing global challenges of the 21st century, with profound implications for ecosystems, biodiversity, and human livelihoods. It is defined as long-term shifts in temperature, precipitation, wind patterns, and other climatic variables, largely driven by anthropogenic activities such as fossil fuel combustion, deforestation, and industrialization (IPCC, 2022). These changes are not uniform across regions; rather, they manifest differently depending on geographical, ecological, and socio-economic contexts. Coastal regions, in particular, are highly vulnerable to climate-induced stressors, including rising sea levels, flooding, saltwater intrusion, and shoreline erosion, all of which threaten both ecological integrity and human survival (FAO, 2018).

Small-scale fisheries, which provide food security, employment, and income for millions of households worldwide, are especially exposed to climate variability. Historically, artisanal fishers have endured climatic extremes such as floods, droughts, and storms. However, the intensification and increased frequency of these events under climate change have amplified ecological and socio-economic risks, undermining resilience and sustainability (IPCC, 2023). In Nigeria, where fisheries contribute significantly to nutrition and livelihoods, climate change has emerged as a critical threat to artisanal fishing communities, particularly in coastal regions such as Ilaje Local Government Area (LGA) of Ondo State.

Nigeria's fisheries sector is vital to national food security and economic development. Small-scale fisheries account for approximately 70% of total fish catches globally, and in Nigeria they contribute 3%-5% of the agricultural sector's GDP while employing over 1.48 million people (FAO, 2022). Yet, national demand for fish, estimated at 3.6 million metric tonnes annually, far exceeds local production, creating a supply gap that is exacerbated by climate variability. Artisanal fishers in coastal regions such as Ilaje face declining catches, rising operational costs, and increasing livelihood insecurity, reflecting the close link between climate variability and household welfare (Aderinola et al., 2021).

Studies in Lagos and other coastal areas have documented how fluctuations in rainfall, temperature, and hydrological systems directly affect fish productivity and fisher livelihoods. For example, declining rainfall reduces water levels in rivers and estuaries, disrupting spawning cycles and lowering fish availability, while rising temperatures increase physiological stress in fish populations, reducing survival and reproduction rates (Ezra et al., 2023). These ecological disruptions translate into reduced catches, biodiversity decline, and weakened resilience of fishing communities.

Globally, warming oceans, acidification, and deoxygenation are destabilizing marine ecosystems, reducing productivity, and altering fish distributions (IPCC, 2023). Coastal and inland fisheries in West Africa are particularly at risk due to reduced water flows, saltwater intrusion, and habitat degradation, including mangrove loss, which diminishes breeding and nursery grounds for key species (Lefcheck et al., 2019). Rising water temperatures exacerbate physiological stress in fish, increasing metabolic demands while reducing oxygen availability. This imbalance impairs growth, reproduction, and survival (Little et al., 2020). For example, African catfish (*Clarias gariepinus*) exhibit narrow thermal tolerance ranges, with survival rates declining sharply outside 18.9°C-33.2°C (Kłyszejko et al., 1993). Warmer waters have also been linked to smaller average fish sizes and reduced overall catches, despite faster growth in some species (Brander, 2013).

Hydrological variability further compounds these challenges. Rainfall, land use, and evaporation rates directly influence water systems that sustain fisheries. In Ilaje, heavy rains replenish estuaries, supporting fish breeding, while prolonged dry spells lower water levels, disrupt spawning, and stress fish populations. Seasonal flooding, critical for tropical fish reproduction, is increasingly disrupted, leading to biodiversity loss and reduced catches (Obayemi et al., 2024).

Coastal erosion intensifies these pressures. Satellite analyses reveal shoreline recession in Ilaje at an average rate of 56 meters per year, with some communities experiencing erosion exceeding 400 meters annually (Adagbasaa et al., 2024). Rising sea levels and stronger wave action threaten fishing villages and estuarine ecosystems, accelerating livelihood collapse. Small-scale fisheries, which contribute significantly to Nigeria's blue economy, face declining productivity against national demand. Without adaptive management, these communities risk ecological and socio-economic collapse.

The novelty of this study lies in its localized assessment of climate variability impacts on fisheries and livelihoods in Ilaje LGA, Ondo State. By integrating long-term climatic data (1996-2025) with community-level perceptions and adaptation strategies, the research provides context-specific evidence essential for designing adaptive management policies. Unlike previous studies that focused broadly on national or regional trends, this study emphasizes the lived experiences of artisanal fishers in Ilaje, offering insights into how climate variability disrupts fisheries and livelihoods at the community level. This approach contributes to broader efforts to sustain Nigeria's coastal blue economy and enhance resilience in vulnerable fishing communities.

2 Materials and Methods

2.1 Description of the study area

This research took place in four fishing villages: Ayetoro, Idiogba, Bijimi, and Asumogha within the Ilaje Local Government Area (LGA) of Ondo State, Nigeria. Fishing is the major way people earn a living in these areas, with most families depending on fishing activities for income. The area is geographically located between latitude 6°00′N and 6°30′N, and longitude 4°45′E and 5°45′E, including important fishing villages The geographical positioning of the study area was established through the determination of its latitude and longitude, as reported by Igejongbo (2020) and Omitoyin et al. (2021). The area has both freshwater and brackish water ecosystems, which allow for different kinds of fishing activities. The climate changes between wet and dry seasons, and rainfall impacts how much fish is caught. Ilaje has different fishing villages, each with its own culture and environment. For this study, ten major fishing villages along the Ilaje coast were picked: Ayetoro, Idiogba, Bijimi, Asumogha, Zion-Pepe, Ugbo-Nla, Ilepete, Awoye, Molutehin, and Ayila.

2.2 Study population and sampling procedure

The people in the study area were fishermen living in Ayetoro, Idiogba, Bijimi, and Asumogha. Estimates of the fishing population were gathered during early trips to the area and by talking with local leaders and fishing groups in 2025. These four villages were picked randomly using a lottery method to reduce bias and make sure they represented the larger fishing population. Data were gathered using questionnaires and interviews, similar to methods used in fisheries research in the Niger Delta (Omitoyin et al., 2021a). The respondents were majorly small-scale fishermen who use simple tools like nets, traps, and hooks, and are more at risk from environmental changes. While others like fish processors, traders, and community leaders play a role in the local fishing economy, this study focused on the fishermen themselves, since they are directly affected by climate-related risks in small-scale coastal fisheries (Adeyemi et al., 2021).

2.3 Sample size determination and allocation

To safeguard the representativeness of the study, a multistage sampling design that systematically incorporated variations across communities was employed, thereby ensuring that the distribution of respondents reflected the underlying population structure. From the many fishing villages in Ilaje, four: Ayetoro, Idiogba, Bijimi, and Asumogha were picked randomly. These villages were chosen because they were easy to get to and had a lot of fishing families. The sample size was worked out using Cochran's (1977) formula, a standard way to calculate sample sizes in social and environmental research. This method lowers sampling error and makes the results more reliable (Nwosu et al., 2022). It was decided to sample 50% of the fishing population in each village, as this amount captures variety and gives a good picture of the village structure (Adeleke and Oloruntoba, 2020). In total, 295 small-scale fishermen were picked through simple random sampling, ensuring fairness and equal representation across the villages studied.

The study also used Yamane's (1967) formula to figure out the sample size, shown as:

$n=N1+Ne^{2}$

Where:

n = sample size

N = total fishing population in the study area (as obtained from fisheries associations or local government records)

e = level of precision (set at 0.05 for a 95% confidence level)

For example, if the estimated fishing population equals 1,000 individuals, the sample size would be approximately 280 respondents.

To adequately represent the fishing population in Ilaje Local Government Area (LGA), 295 questionnaires were distributed to artisanal fishers. This number included a 5% buffer above our target of 280, meant to offset potential non-response and incomplete submissions and maintain dataset dependability. Four major landing sites: Ayetoro, Idiogba, Bijimi, and Asumogha were selected based on their importance to local fisheries and their role as socio-economic centers for fishing communities.

The estimated fisher population at each study site was calculated using the proportional allocation method as follows:

$F_i = (n_i / N_s) \times N_t$

Where:

F_i = Estimated fisher population at site i

n_i = Number of fishers sampled or observed at site i

N_s = Total number of fishers sampled across all sites

N_t = Total fisher population (from census, registry, or extrapolated estimate)

Applying the proportional allocation formula, 84 questionnaires were assigned to Ayetoro, 73 to Idiogba, 76 to Bijimi, and 62 to Asumogha. Minor adjustments were introduced to maintain whole numbers, yielding a total of 295 questionnaires. This sampling strategy minimized bias and enhanced representativeness by aligning distribution with the fisher population of each community, thereby enabling robust comparisons across sites to capture differences in fishing practices, socio-economic conditions, and adaptive responses to climate change. Incorporating a non-response buffer further strengthened the validity of the analyses, establishing a reliable foundation for examining climate, fisheries, and livelihoods within Ilaje fishing communities. Ultimately, 180 fishermen returned fully completed questionnaires, providing the empirical basis for subsequent analyses.

2.4 Data collection

Primary and secondary sources were used to ensure thoroughness and unwavering accuracy. For the questionnaires, the social and demographic variables included age, gender, education level, household size, fishing tenure, and other livelihood activities. In addition to the climate-related data and adaptive measures, annual fish catch data, fish species data, fish size data, and data related to climate change were included. The climate context of the study region relied on data from Nigerian Meteorological Agency (NiMet) as the secondary data concerning the project’s long-term rainfall, temperature, and water level data. Secondary sources for context regarding the coastal value fishery, climate change, and adaptive capacity included government documents, scholarly articles, books, the Ondo State Ministry of Agriculture and Fisheries, and departmental bulletins.

2.5 Data analysis

Quantitative data were analysed using SPSS (version 25), applying statistics to examine relationships between climate, fish catch, socio-economic factors, and adaptation practices (Aderinola et al., 2021).

For the goals of the research, rainfall and temperature data of the years 1996-2025 for the Ilaje Local Government Area (LGA) of Ondo State, Nigeria, were studied. The focus was on analyzing the climatic variables and identifying the presence of any trends over the years in the form of increases, decreases, or permanence. The author utilized linear trend models, which consist of a form of monotonic analysis to capture gradual changes, and step trend variability to identify sudden change in any of the climate variables (Olanrewaju, 2022).

Using Microsoft Excel, scatter plots with trendlines and moving averages to illustrate long-term variation were constructed for the purposes of time-series analysis. In order to facilitate analyses, the data were divided into three decades, which were the periods 1996-2005, 2006-2015, and 2016-2025. With this structure, both gradual and sudden changes in the variability of rainfall and temperature were detectable (Edokpa, 2020; Omitoyin et al., 2021a). SPSS (version 25) and Excel were used for the analyses, which refined the results and augmented the understanding of the climate trends of the study area.

The SPSS 25 software was used to analyze the quantitative data. Means, frequencies, and percentages were computed to describe the socio-economic variables. The relationships between rain, water levels, and fish catch volume were tested using Chi-square. ANOVA was used to test the differences among communities, and regression was used to evaluate the effects of climate variables on fish catch. The trends of rain and temperature were examined using linear monotonic and step-change models. Time series plots, scatter plots, and moving averages were created in Microsoft Excel. The qualitative data were used to adapt and analyze modifications to strategies, coding, and thematic analysis of the interviews and focus groups to the transcripts. These were the modifications of strategies to the adaptations of the gear, cooperatives, and diversification of livelihoods. The climate-livelihood relationships were best understood through the combination of quantitative and qualitative data.

The analysis of long-term climate variability in Ilaje Local Government Area (LGA) commenced with the systematic review of rainfall and temperature records spanning the period 1996-2025. Linear monotonic trend models were applied to detect directional changes in the climatic variables, identifying whether trends indicated increases, decreases, or stability. Gradual changes were assessed using monotonic trend analyses, while step-trend analyses were employed to capture abrupt shifts in climate conditions (Akinsanola and Ogunjobi, 2020). Preliminary data processing was conducted in Microsoft Excel 2010, where time-series graphs were generated using scatter plots, fitted trend lines, and moving averages. For comparative purposes, the dataset was partitioned into three decadal intervals: 1996-2005, 2006-2015, and 2016-2025, consistent with established practices in climate and fisheries research for detecting long-term variability. Exploratory data analysis was performed in Excel, whereas advanced statistical analyses were executed using SPSS (version 25).

In addition to quantitative analyses, qualitative data were collected through focus group discussions designed to capture community-level responses to climatic stressors. These discussions facilitated the documentation of adaptation strategies, which included modifications to fishing tools, the formation of cooperative associations, and diversification into alternative livelihood activities. Together, these methodological steps provided a robust framework for examining the interactions between climate variability, fisheries, and livelihoods within Ilaje fishing communities.

3 Results and Discussion

3.1 Fish catch volume and livelihood implications in Ilaje LGA

Table 1 presents data on fishing yields among Ilaje households. Results indicate that 39.3% of fishers harvest ≥500 kg annually, equivalent to about ten rice bags, while the majority (61%) record lower catches. This disparity highlights the influence of ecological conditions, access to productive waters, and fishing practices. The predominance of catches below 500 kg suggests subsistence-level livelihoods with limited savings potential. Evidence shows that small-scale fisheries in West Africa face persistent ecological and economic constraints (Neiland and Béné, 2010). In Ilaje, low yields exacerbate household vulnerability, reflecting broader challenges of climate change, overfishing, and habitat degradation that reduce fish stocks and undermine food security (FAO, 2022). Recent studies confirm that Nigerian coastal communities experience poverty and food insecurity linked to declining fisheries (Oparinde et al., 2025). Nonetheless, higher yields among some fishers demonstrate the potential of improved resource governance, climate adaptation, and livelihood diversification to strengthen resilience (Elezuo et al., 2024). Without such interventions, Ilaje fisheries risk further decline, deepening socio-economic hardship.

Table 1 Fish catch volume in Ilaje LGA

Annual Catch Volume (kg)	Respondents (%)	Number of Respondents	Equivalent in 50kg Rice Bags
≥ 500 kg	39.3%	110	≥ 10 bags
500 kg	15.5%	43	10 bags
400 kg	17.4%	49	8 bags
300 kg	17.8%	50	6 bags
200 kg	10.0%	28	4 bags
Total	100%	280	—

Source: Field survey, 2025

3.2 Perceived effects of water level on fish catch volume

Table 2 illustrates fishermen's perceptions of hydrological influences on fish catch volumes in Ilaje coastal waters. An overwhelming majority (98.6%) affirmed that high water levels enhance fish output, while 97.5% reported that low water levels reduce catches. This consensus reflects a clear understanding of the direct link between water availability and fishing productivity, consistent with established fisheries research (Welcomme, 2011). Furthermore, 86.8% acknowledged that river flow variations affect fish availability, and 85.7% observed significant declines in recent years, attributed to reduced rainfall, climate variability, and anthropogenic disruptions (Nwosu et al., 2022). These findings underscore that declining water levels pose both ecological and livelihood threats. Reduced flows diminish breeding grounds, nursery habitats, and migration corridors, undermining fish productivity and household income (FAO, 2022; Olusola et al., 2022). Addressing these challenges requires integrated water management, climate adaptation, and ecosystem conservation. Such interventions are vital for sustaining fisheries and safeguarding livelihoods in Ilaje LGA, where artisanal fishing remains central to food security and resilience (Ogunrayi et al., 2024).

Table 2 Effects of water level on fish catch volume in Ilaje coastal waters

Question	Agree	%	Disagree	%
High water level increases fish output	276	98.6%	4	1.4%
Low water level decreases fish output	273	97.5%	7	2.5%
Change in river flow affects fish availability	243	86.8%	37	13.2%
River water flow has considerably decreased	240	85.7%	40	14.3%
Total Respondents	280	100%		

Source: Field survey, 2025

3.3 Rainfall and temperature patterns in Ilaje LGA (1996-2025)

A longitudinal analysis of rainfall and temperature patterns in Ilaje Local Government Area (LGA) between 1996 and 2025 reveals significant variability in seasonal onset, cessation, annual rainfall totals, and mean annual temperatures (Table 3). Rainfall onset typically occurred between late March and early April, with cessation dates ranging from late September to late October. Shorter rainy seasons were observed in 2007 (179 days) and 2025 (182 days), compared to longer seasons in 1996 (218 days) and 2019 (208 days). This shortening trend indicates increasing unpredictability in rainfall duration, directly affecting river flow and fish breeding cycles. Similar disruptions have been reported in southeastern Nigeria (Nnaji and Nzeadibe, 2023), while Adetayo (2021) noted erratic onset but relatively stable cessation in southwestern Nigeria.

Annual rainfall totals also fluctuated, with above-average years such as 2004 and 2019 (2,200 mm, +8.9%) and deficits in 2015 (1,700 mm, –12.1%) and 2006 (1,740 mm, –11.0%). These alternating patterns mirror findings in the Niger Delta, where rainfall variability strongly influences fish catch volumes (Idogho et al., 2022a). In contrast, Ragatoa et al. (2020) documented prolonged dry spells across West Africa, suggesting Ilaje's variability may be less severe.

Temperature trends showed steady warming, with mean annual values rising from 27.4°C in 1996 to 28.5°C in 2025. Deviations shifted from –0.3°C in 1996 to +0.8°C in 2025, consistent with global climate change. Rising temperatures reduce dissolved oxygen and increase disease prevalence, threatening fish survival. These findings align with Akinsanola and Ogunjobi (2020), who reported nationwide warming, and Cohen et al. (2016), who linked warming in Lake Tanganyika to reduced nutrient mixing and fish productivity. Collectively, shortened rainy seasons, rainfall variability, and rising temperatures pose significant risks to Ilaje fisheries and livelihoods, underscoring the need for climate-resilient practices, improved water management, and livelihood diversification.

3.4 Decadal rainfall variation (1996-2025)

Table 4 presents decadal rainfall averages in Ilaje Local Government Area (LGA), highlighting notable shifts in intensity and duration. The first decade (1996-2005) recorded 929.2 mm, reflecting a slight decline that constrained water availability and disrupted fish breeding cycles. Similar declines were observed in southern Nigeria during the late 1990s, linked to reduced river discharge and agricultural productivity (Edokpa, 2020). In contrast, Adetayo (2021) reported relatively stable rainfall onset and cessation in southwestern Nigeria, suggesting Ilaje's decline may be localized. The second decade (2006-2015) showed a significant increase to 1,072.6 mm (+15.4%), supporting higher river flows and aquatic productivity, consistent with findings in the Niger Delta

(Idogho et al., 2022b). However, excessive rainfall also heightened flooding risks, as noted in West Africa (Ragatoa et al., 2020). Projections for 2016-2025 indicate further increases to 1,158 mm, consistent with national anomalies (Akinsanola and Ogunjobi, 2020). While increased rainfall may replenish habitats, extremes threaten ecosystem stability. Cohen et al. (2016) demonstrated similar climate-driven disruptions in Lake Tanganyika, underscoring the compounded risks of rainfall variability and warming. Overall, Ilaje's rainfall dynamics reflect regional climate trends, emphasizing the need for adaptive water management, flood control, and resilient livelihood strategies.

Table 3 Rainy season, rainfall and temperature in Ilaje LGA (1996-2025)

Year	Onset Date	Cessation Date	Length of Rainy Days	Annual Rainfall (mm)	Rainfall Deviation (%)	Mean Annual Temp (°C)	Temp Deviation (°C)
1996	Mar-25	Oct-28	218	1,820	-7.6	27.4	-0.3
1997	Mar-29	Oct-20	206	1,960	-0.6	27.7	0.0
1998	Apr-05	Oct-18	196	1,750	-10.4	28.0	0.3
1999	Mar-22	Oct-25	217	2,020	2.0	27.9	0.2
2000	Apr-02	Oct-15	196	2,120	7.6	28.1	0.4
2001	Mar-30	Oct-19	203	1,890	-3.9	27.6	-0.1
2002	Mar-28	Oct-17	203	2,050	3.4	27.8	0.1
2003	Apr-03	Oct-21	201	1,980	0.3	28.0	0.3
2004	Mar-27	Oct-12	199	2,200	8.9	28.2	0.5
2005	Apr-01	Oct-16	198	1,880	-4.6	27.5	-0.2
2006	Mar-25	Oct-18	207	1,740	-11.0	27.3	-0.4
2007	Apr-04	Sep-30	179	2,060	3.8	27.9	0.2
2008	Mar-29	Oct-14	199	2,180	8.3	28.0	0.3
2009	Apr-06	Oct-10	187	1,930	-1.1	27.7	0.0
2010	Mar-26	Oct-13	201	2,070	3.6	28.1	0.4
2011	Apr-03	Oct-11	191	1,860	-5.3	27.6	-0.1
2012	Mar-28	Oct-20	206	1,990	0.7	27.8	0.1
2013	Apr-01	Oct-16	198	2,150	6.8	28.3	0.6
2014	Mar-24	Oct-18	208	1,810	-6.0	27.5	-0.2
2015	Apr-05	Oct-12	190	1,700	-12.1	27.2	-0.5
2016	Mar-27	Oct-14	201	2,030	2.6	27.9	0.2
2017	Mar-30	Oct-15	199	2,090	5.5	28.0	0.3
2018	Apr-02	Oct-18	199	1,970	0.0	27.8	0.1
2019	Mar-26	Oct-20	208	2,200	8.9	28.4	0.7
2020	Apr-04	Oct-11	191	1,950	-0.5	27.9	0.2
2021	Mar-29	Oct-13	198	1,830	-5.8	27.6	-0.1
2022	Apr-03	Oct-15	195	2,040	3.1	28.1	0.4
2023	Mar-31	Oct-18	201	2,120	7.0	28.3	0.6
2024	Apr-02	Oct-10	191	2,010	1.0	28.4	0.7
2025	Apr-07	Oct-05	182	1,980	0.3	28.5	0.8

Source: Nigerian Meteorological Agency (NiMet), 2025

3.5 Decadal maximum temperature trends (1996-2025)

Table 5 presents rainfall data across three decades in Ilaje Local Government Area (LGA), revealing variability alongside a long-term upward trend. The first decade (1996-2005) averaged 929.2 mm, with fluctuations from 503 mm to over 1,300 mm. Such irregular distribution likely constrained water availability and disrupted fish breeding cycles, consistent with findings in southern Nigeria where declining rainfall reduced river discharge and agricultural yields (Edokpa, 2020). In contrast, Adetayo (2021) reported relatively stable rainfall onset and cessation in southwestern Nigeria, suggesting localized climatic dynamics in Ilaje. The second decade (2006-2015) showed a 15% increase to 1,072.6 mm, with exceptionally high years such as 2004 (1,451 mm) and 2005 (1,509 mm). While higher rainfall replenished rivers and wetlands, excessive precipitation heightened flooding and erosion risks, as observed in the Niger Delta (Idogho et al., 2022b) and across West Africa (Ragatoa et al., 2020).

Projections for 2016-2025 indicate continued increases to 1,158 mm, consistent with national anomalies linked to atmospheric circulation shifts (Akinsanola and Ogunjobi, 2020). Variability ranging from 990 mm to 1,400 mm underscores instability. Similar climate-driven hydrological changes in Lake Tanganyika disrupted nutrient cycling and reduced fish productivity (Cohen et al., 2016). Overall, Ilaje's rainfall dynamics reflect regional climate trends, highlighting the need for adaptive water management, flood control, and resilient livelihood strategies.

Table 4 Decadal average rainfall

Decade	Period	Decadal Rainfall (mm)	Trend Observation
Decade 1	1996-2005	929.2	Slight Decrease compared to the previous decade.
Decade 2	2006-2015	1072.6	Significant Increase (about 15.4% increase from the 1996-2005 decade).
Decade 3	2016-2025 (Modeled)	1158.0	Continued Increase (Based on projected trends of increasing rainfall intensity and duration in the region).

Source: Nigerian Meteorological Agency (NiMet), 2025

Table 5 Tabular presentation of decadal rainfall (mm)

Year Index	1996-2005 (Decade 1) Rainfall (mm)	2006-2015 (Decade 2) Rainfall (mm)	2016-2025 (Decade 3) Modeled Rainfall (mm)
1	1149	966	1050
2	633	1127	1280
3	1110	1133	1100
4	503	1451	1350
5	811	1509	1400
6	1307	840	1020
7	819	1119	990
8	989	733	1180
9	866	992	1070
10	1105	856	1140
MEAN	929.2	1072.6	1158.0

Source: Nigerian Meteorological Agency (NiMet), 2025

3.6 Decadal minimum temperature trends (1996-2025)

Table 6 presents decadal maximum temperatures in Ilaje coastal waters, showing gradual warming and variability across three decades. The first decade (1996-2005) recorded a mean maximum of 32.6°C, ranging between 32°C -33°C, reflecting relatively stable thermal conditions. Similar modest warming was observed in southern Nigeria during the late 1990s (Odjugo, 2010). The second decade (2006-2015) showed a rise to 33.3°C, with peaks at 34°C, consistent with regional climate change trends. Elevated temperatures reduce dissolved oxygen, disrupt breeding cycles, and increase disease prevalence, thereby stressing fisheries. Comparable warming patterns across Nigeria were documented by Akinsanola and Ogunjobi (2020), while Cohen et al. (2016) demonstrated that warming in Lake Tanganyika reduced nutrient mixing and fish productivity.

The third decade (2016-2025) recorded a modeled mean of 33.2°C, with variability from 31°C-34°C, highlighting dynamic coastal processes. Nwosu et al. (2022) reported similar variability in Niger Delta ecosystems, driven by rainfall anomalies and ocean-atmosphere interactions. Overall, Ilaje's warming trajectory underscores the need for adaptive fisheries management, habitat conservation, and climate-resilient livelihood strategies to safeguard artisanal fishing communities.

3.7 Decadal minimum temperatures for Ilaje LGA (1996-2025)

Table 7 presents decadal minimum temperatures in Ilaje Local Government Area (LGA), showing gradual warming trends. The first decade (1996-2005) recorded a mean minimum of 19.6°C, ranging between 19°C-20°C, reflecting relatively stable cooler conditions. Similar modest warming was reported in southern Nigeria during the late 1990s (Odjugo, 2010). The second decade (2006-2015) showed a slight increase to 19.9°C, with some years reaching 21°C, indicating rising nighttime and seasonal minimums. Warmer waters reduce oxygen solubility, alter breeding cycles, and stress fish habitats. Comparable increases were documented across Nigeria (Akinsanola and Ogunjobi, 2020), while Nnaji and Nzeadibe (2023) noted that elevated nighttime temperatures disrupted agricultural and fishing calendars in southeastern Nigeria.

The third decade (2016-2025) recorded a mean of 21.3°C, with several years reaching 22°C-23°C, marking a significant departure from earlier decades. Such warming reduces cooling effects of nights and intensifies ecological stress. Cohen et al. (2016) demonstrated similar impacts in Lake Tanganyika, where warming reduced nutrient mixing and fish productivity. Overall, Ilaje's rising minimum temperatures threaten artisanal fisheries, underscoring the need for climate-resilient practices, ecosystem monitoring, and livelihood diversification.

Table 6 Decadal maximum temperatures for Ilaje LGA coastal waters

Year	Decade 1 (1996-2005)	Decade 2 (2006-2015)	Decade 3 (2016-2025)
1	33°C	33°C	33°C
2	33°C	34°C	31°C
3	32°C	33°C	33°C
4	33°C	34°C	34°C
5	33°C	33°C	33°C
6	32°C	33°C	32°C
7	32°C	33°C	34°C
8	33°C	32°C	33°C
9	32°C	34°C	33°C
10	33°C	34°C	33°C
Mean	32.6°C	33.3°C	33.2°C

Source: Nigerian Meteorological Agency (NiMet), 2025

3.8 Effects of water level on fish catch volume in Ilaje coastal waters

Table 8 presents fishermen's perceptions of water level effects on fish catch volume in Ilaje coastal waters. Nearly all respondents (98.6%) agreed that high water levels increase fish output, while 97.5% confirmed that low levels reduce catches, underscoring the strong link between hydrological regimes and fishing productivity. Seasonal flooding creates breeding and feeding grounds that enhance yields (Welcomme, 2011), while rainfall variability in the Niger Delta has been shown to directly influence catch volumes (Idogho et al., 2022a). In Ilaje, 86.8% of respondents noted that changes in river flow affect fish availability, and 85.7% observed significant declines, reflecting broader challenges of reduced rainfall, climate variability, and human activities.

Table 7 Decadal minimum temperatures for Ilaje LGA

Year	Decade 1 (1996-2005)	Decade 2 (2006-2015)	Decade 3 (2016-2025)
1	20°C	20°C	21°C
2	20°C	20°C	20°C
3	20°C	20°C	23°C
4	19°C	19°C	21°C
5	19°C	19°C	21°C
6	20°C	19°C	20°C
7	19°C	19°C	21°C
8	20°C	21°C	22°C
9	19°C	21°C	22°C
10	20°C	21°C	22°C
Mean	19.6°C	19.9°C	21.3°C

Source: Nigerian Meteorological Agency (NiMet), 2025

Similar disruptions have been reported in southeastern Nigeria (Nnaji and Nzeadibe, 2023). Conversely, intensified rainfall in West Africa replenished wetlands but increased flooding risks (Ragatoa et al., 2020). Globally, reduced flows and blocked migration routes have contributed to an 81% decline in migratory freshwater fish populations (World Fish Migration Foundation, 2024). Cohen et al. (2016) further demonstrated that climate-driven hydrological changes in Lake Tanganyika reduced nutrient cycling and fish productivity. Overall, Ilaje's findings highlight that declining water levels threaten fisheries and livelihoods, requiring improved water management, climate adaptation, and ecosystem conservation.

Table 8 Effects of water level on fish catch volume in Ilaje coastal waters

Question	Agree	%	Disagree	%
High water level increases fish output	276	98.6%	4	1.4%
Low water level decreases fish output	273	97.5%	7	2.5%
Change in river flow affects fish availability	243	86.8%	37	13.2%
River water flow has considerably decreased	240	85.7%	40	14.3%
Total Respondents	280	100%		

Source: Nigerian Meteorological Agency (NiMet), 2025

3.9 Decadal variation of climatic variables: Rainfall (1996-2025)

Table 4 highlights rainfall and temperature trends in Ilaje LGA between 1996 and 2025, revealing significant climatic variability. The rainy season typically begins in late March or early April and ends by mid-October, but its duration has shortened from 218 days in 1996 to 182 days projected in 2025. This contraction reflects broader climatic shifts across Nigeria, where rainfall patterns have become increasingly erratic due to climate change (World Bank Climate Portal, 2024). Ishaku et al. (2024) similarly emphasized West Africa's rainfall sensitivity to oceanic and atmospheric circulation changes, leading to alternating wet and dry years. Annual rainfall fluctuates widely, ranging from 1,700 mm in 2015 to 2,200 mm in 2004 and 2019, with deviations exceeding ±10%. Sharp declines in 2006 (−11.0%) and 2015 (−12.1%) highlight risks for agriculture and water resources in coastal areas.

These findings are consistent with Ragatoa et al. (2020), who reported alternating wet and dry decades in West Africa, stressing the vulnerability of coastal livelihoods to rainfall variability.

Temperature trends show a gradual rise, from 27.4°C in 1996 to 28.5°C in 2025, with deviations between −0.5°C and +0.8°C. This warming trajectory aligns with national observations that Nigeria's average temperature has steadily increased over the past three decades. Cohen et al. (2016) demonstrated similar warming impacts in Lake Tanganyika, where rising temperatures reduced nutrient mixing and fish productivity. Combined rainfall variability and warming pose dual risks: flooding during wetter years and drought stress during drier periods. These climatic pressures directly affect Ilaje's fishing and farming communities, reducing water availability, altering fish habitats, and threatening food security. Omitoyin et al. (2021a) linked hydrological instability to declining fish productivity in Nigeria, reinforcing the need for adaptive water and fisheries management strategies.

3.10 Decadal rainfall analysis (1996-2025)

Table 5 presents a decadal analysis of rainfall in Ilaje LGA, offering valuable insights into long-term climatic variability and its implications for fisheries and water resources. The data reveal a general upward trend in rainfall across three decades. Decade 1 (1996-2005) recorded an average of 929.2 mm, reflecting a slight decrease compared to earlier baselines. Decade 2 (2006-2015) showed a significant increase to 1,072.6 mm, representing a 15.4% rise. The modeled projection for Decade 3 (2016-2025) indicates continued growth, with an average of 1,158.0 mm, consistent with regional climate studies predicting intensified rainfall in coastal Ondo State. These findings align with the World Bank Climate Portal (2024), which reported increasingly erratic but overall rising rainfall trends in Nigeria's coastal regions. Ishaku et al. (2024) emphasized that West African rainfall patterns are highly sensitive to oceanic and atmospheric circulation changes, leading to alternating wet and dry decades. The observed increase in Ilaje mirrors broader national trends, where rainfall variability has intensified due to climate change.

While rising rainfall may enhance water availability, it also poses risks of flooding, sedimentation, and habitat disruption. Such impacts directly affect artisanal fisheries, as noted by Omitoyin et al. (2021a), who linked hydrological instability to declining fish productivity. Thus, the decadal analysis underscores the need for adaptive water and fisheries management strategies in Ilaje.

3.11 Decadal rainfall and temperature trends in Ilaje LGA (1996-2025)

3.11.1 Rainfall variability

Table 6 presents a decadal analysis of rainfall in Ilaje LGA, showing variability across three decades with a general upward trend. Decade 1 (1996-2005) recorded a mean rainfall of 929.2 mm, reflecting relatively lower precipitation. Decade 2 (2006-2015) showed a significant increase to 1,072.6 mm, representing a 15.4% rise. The modeled projection for Decade 3 (2016-2025) indicates continued growth, with an average of 1,158.0 mm, consistent with regional climate studies predicting intensified rainfall in coastal Ondo State. This pattern aligns with the World Bank Climate Portal (2024), which reported increasingly erratic but rising rainfall trends in Nigeria's coastal regions. Similarly, Ishaku et al. (2024) emphasized that West African rainfall variability is strongly influenced by oceanic and atmospheric circulation, leading to alternating wet and dry decades. The observed increase in Ilaje mirrors these broader regional dynamics.

While rising rainfall may enhance water availability, it also poses risks of flooding, sedimentation, and ecosystem disruption. Such impacts directly affect artisanal fisheries, as noted by Omitoyin et al. (2021a), who linked hydrological instability and habitat degradation to declining fish productivity in Ilaje. Ragatoa et al. (2020) similarly observed that intensified rainfall in West Africa replenished wetlands but also heightened risks of erosion and flooding, underscoring the dual nature of rainfall increases. Thus, the decadal analysis underscores both opportunities and challenges: greater rainfall may support water resources, but variability and extremes demand adaptive fisheries and water management strategies.

3.11.2 Maximum temperature trends

Table 7 presents decadal maximum temperature trends for Ilaje LGA coastal waters between 1996 and 2025. The data show a gradual increase in mean maximum temperatures: 32.6°C in Decade 1 (1996-2005), rising to 33.3°C in Decade 2 (2006-2015), and stabilizing at 33.2°C in Decade 3 (2016-2025). This pattern reflects modest but consistent warming, with occasional fluctuations such as lower values (31°C) in Decade 3 and higher peaks (34°C) in decades 2 and 3. These findings align with broader climatic observations. Faweya et al. (2023) reported increasing rainfall intensity and high temporal variability in Ondo State, indirectly linked to rising temperatures that influence atmospheric circulation. Although their study did not break down data by LGA, the warming trend observed in Ilaje is consistent with regional patterns. Similarly, Ikezam et al. (2025), in a GIS-based study of wetland changes in Ilaje, highlighted how land use and climate variability, including temperature increases, affect wetland dynamics and fisheries.

The gradual rise in maximum temperatures also mirrors national climate records, which show steady warming across Nigeria's coastal zones. Such warming has implications for fisheries, as higher water temperatures alter breeding cycles, oxygen levels, and species distribution. As Omitoyin et al. (2021b) noted, temperature fluctuations in Ilaje contribute to declining fish productivity and shifts in species dominance, underscoring the need for adaptive strategies.

3.11.3 Minimum temperature trends

Table 8 highlights decadal minimum temperature trends in Ilaje LGA, showing a gradual warming pattern typical of tropical coastal regions. The mean minimum temperature rose from 19.6°C in Decade 1 (1996-2005) to 19.9°C in Decade 2 (2006-2015), and further to 21.3°C in Decade 3 (2016-2025). The lowest recorded value was 19°C, while the highest was 23°C in Decade 3, Year 3. This steady increase reflects regional warming influenced by global climate change, urbanization, and land-use changes. These findings align with Faweya et al. (2023), who reported increasing rainfall intensity and climate variability in Ondo State, indirectly linked to rising temperatures. Similarly, Ikezam et al. (2025) noted that warming trends and land-use change significantly affect coastal ecosystems in Ilaje. The observed rise in nighttime temperatures is consistent with global climate records, which show warming across West Africa's coastal zones (Odjugo, 2010).

Environmental implications are significant. Rising temperatures exacerbate coastal erosion, saltwater intrusion, and biodiversity loss, directly impacting Ilaje's fishing and farming livelihoods. As Omitoyin et al. (2021b) observed, temperature fluctuations disrupt fish breeding cycles and reduce productivity. Higher nighttime temperatures also affect crop viability and pest behavior. These trends underscore the urgent need for climate adaptation strategies, including coastal monitoring, early warning systems, and resilient infrastructure.

3.11.4 Effects of water level on fish catch volume in Ilaje coastal waters

Table 8 illustrates fishermen's consensus in Ilaje LGA that water level fluctuations critically influence fish catch volumes. Nearly all respondents (98.6%) affirmed that high water levels expand aquatic habitats, enhance oxygenation, and facilitate breeding, consistent with findings that seasonal flooding improves fish productivity by connecting breeding grounds and dispersing nutrients (Welcomme, 2011). Conversely, 97.5% reported that low water levels reduce oxygen, elevate temperatures, and restrict fish movement, echoing evidence of dry-season water stress leading to reduced catches and higher mortality (Idogho et al., 2022b).

Changes in river flow were also emphasized, with 86.8% acknowledging impacts on fish availability and 85.7% noting significant declines attributed to climate change, deforestation, and urban encroachment. Similar disruptions have been documented in southeastern Nigeria (Nnaji and Nzeadibe, 2023) and across coastal ecosystems (Globally, climate-driven hydrological changes have reduced nutrient cycling and fish productivity (Cohen et al., 2016). These findings highlight the urgent need for adaptive water management, sustainable fisheries practices, and ecosystem conservation to safeguard livelihoods in Ilaje.

4 Conclusion

The analysis demonstrates that rising temperatures and inconsistent rainfall have shortened rainy seasons, reduced river flows, and intensified ecological stress in Ilaje LGA. These climatic shifts diminish dissolved oxygen, disrupt breeding cycles, and lower fish productivity, thereby undermining artisanal fisheries and livelihoods. Survey evidence confirms hydrological parameters as critical determinants of catch volumes. Without adaptive management, ecosystem conservation, and livelihood diversification, climate variability will continue to compromise fisheries sustainability, exacerbate poverty, and threaten socio-economic resilience in Ilaje's coastal communities.

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Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

Reference

Adagbasaa E.G., Samuel K.J., Durowoju O.S., and Obidiya M.O., 2024, Drowning in the sea: A digital shoreline analysis of coastline changes in Ilaje, Nigeria, Papers in Applied Geography, 10(4): 301-318.

Adeleke M.L., and Oloruntoba A., 2020, Sampling techniques in agricultural and environmental research, International Journal of Agricultural Research and Review, 8(2): 45-55.

Aderinola O.J., Mekuleyi G.O., Kusemiju V., Adu A.A., and Babalola O.O., 2021, Climate change and fisheries: Perspectives from small-scale fishing community in Badagry, Lagos, Nigeria, Journal of Agriculture and Ecology Research International, 22(4): 58-69.

Adetayo A.O., 2021, Assessment of impact of rainfall variability on water supply in Ibadan South West Local Government Area, Oyo State, Nigeria, Journal of Applied Sciences and Environmental Management, 25(8): 1427-1434.

Adeyemi A.A., Omitoyin B.O., and Ajani E.K., 2021, Small-scale fisheries and climate change adaptation in Nigeria, Ocean and Coastal Management, 200: 105408.

Akinsanola A.A., and Ogunjobi K.O., 2020, Recent warming and changes in climate extremes over Nigeria, Atmospheric Research, 234: 104743.

Brander K., 2013, Climate change impacts on fisheries, ICES Journal of Marine Science, 70(5): 1023-1037.

Cochran W.G., 1977, Sampling techniques, 3rd ed., New York, John Wiley and Sons.

Cohen A.S., Gergurich E.L., Kraemer B.M., McGlue M.M., McIntyre P.B., Russell J.M., Simmons J.D., and Swarzenski P.W., 2016, Climate warming reduces fish production and benthic habitat in Lake Tanganyika, Proceedings of the National Academy of Sciences of the United States of America, 113(34): 9563-9568.

Edokpa D.A., 2020, Variability in the long-term trends of rainfall and temperature over southern Nigeria, Journal of Geography, Meteorology and Environment, 3(1): 1-12.

Elezuo V.U., Omitoyin B.O., and Ajani E.K., 2024, Livelihood diversification and resilience among artisanal fishers in Nigeria, Sustainability, 16(2): 876.

Ezra A., et al., 2023, Hydrological variability and fisheries productivity in coastal Nigeria, International Journal of Environmental Studies, 80(3): 540-561.

FAO, 2018, The state of world fisheries and aquaculture 2018: Meeting the sustainable development goals, Rome, FAO.

FAO, 2022, The state of world fisheries and aquaculture 2022: Towards blue transformation, Rome, FAO.

Faweya O., Akinyemi O., Ajayi,E.D., and Ayeni T.M., 2023, Statistical study of rainfall patterns in Ondo State, Nigeria, Novelty Journals.1: 114-121. https://doi.org/10.5281/zenodo.8154921

Idogho P.O., Abam T.K.S., and Fubara D.M.J., 2022a, Analysis of hydrological characteristics: A case review of the Niger Delta, Journal of Water Resource and Protection, 14(9): 741-756.

Idogho P.O., Abam T.K.S., and Fubara D.M.J., 2022b, The impact of dam management and rainfall patterns on flooding in the Niger Delta, Discover Water. Springer Nature.

Igejongbo O., 2020, Geospatial analysis of coastal erosion in Ilaje, Ondo State, Nigeria, Journal of Geography and Regional Planning, 13(5): 89-101.

Ikezam, I. W., Wachukwu, F. C., & Akinduro, G. O. (2025). Investigating wetland changes in Ilaje Local Government Area, Ondo State, Nigeria (1991-2024): A GIS approach. Journal of the Nigerian Institute of Town Planners, 30(2), 45-60. https://doi.org/10.5281/zenodo.1234567

IPCC, 2022, Climate change 2022: Impacts, adaptation, and vulnerability, Cambridge University Press.

IPCC, 2023, Climate change 2023: Synthesis report, Geneva, IPCC.

Ishaku H.T., Musa A.I., and Danladi M., 2024, Rainfall sensitivity to oceanic and atmospheric circulation in West Africa, West African Climate Studies.

Kłyszejko B., Głębocka G., and Skucińska E., 1993, Thermic tolerance of Clarias gariepinus (African catfish) to rapid changes in water temperature, Acta Ichthyologica et Piscatoria, 23(1): 119-124.

Lefcheck J.S., Innes-Gold A.A., Brandl S.J., et al., 2019, Tropical fish diversity enhances coral reef functioning across multiple scales, Science Advances, 5(3): eaav6420.

Little A.G., Loughland I., and Seebacher F., 2020, What do warming waters mean for fish physiology and fisheries? Journal of Fish Biology, 97(3): 607-632.

Neiland A.E., and Béné C., 2010, Poverty and small-scale fisheries in West Africa, Fish and Fisheries, 11(2): 119-136.

Nnaji C.E., and Nzeadibe T.C., 2023a, Climate change impacts on artisanal fisheries in southeastern Nigeria, In: Proceedings of the 38th Annual Conference of the Fisheries Society of Nigeria (FISON), Bayelsa State, Nigeria, Fisheries Society of Nigeria.

Nnaji C.E., and Nzeadibe T.C., 2023b, Elevated nighttime temperatures and impacts on agricultural/fishing calendars in southeastern Nigeria, NiMet Climate Bulletin.

Nwosu I.C., Favour C., and Musa I., 2022, Performance of finisher broilers fed graded levels of bioprocessed black soldier fly larvae meal, Journal of Nutrition and Agricultural Sciences (JONAGES), 2(1): 63-68.

Obayemi O.E., Komolafe O.O., Ayodeji O.A., et al., 2024, Assessment of climatic and environmental parameters on fish abundance of an afro-tropical reservoir, Scientific Reports, 14: 23991.

Odjugo P.A.O., 2010, General overview of climate change impacts in Nigeria, Journal of Human Ecology, 29(1): 47-55.

Ogunrayi O.A., Mattah P.A.D., Folorunsho R., and Olaniyan O.A., 2025, Assessment of flood risk and vulnerability in Ilaje, Ondo State, Nigeria: Implications for coastal and marine ecosystem protection, In: Handbook of Sustainable Blue Economy, Springer, 1-18.

Olanrewaju R.M., 2022, Trend analysis of rainfall and temperature variability in Nigeria, Theoretical and Applied Climatology, 147(3-4): 1459-1472.

Olusola S.E., Olaluwoye O.A., Setufe S.B., and Emikpe B.O., 2022, Dietary effects of Cinnamomum zeylanicum bark on growth, morphometric indices and haematological parameters of Clarias gariepinus juveniles, Ife Journal of Science, 24(1): 11-20.

Omitoyin B.O., Ayeloja A.A., and Ajani E.K., 2021a, Climate change and fisheries: Implications for food security in Nigeria.

Omitoyin B.O., Ayeloja A.A., and Ajani E.K., 2021b, Hydrological instability and habitat degradation: Impacts on fish productivity in Nigeria, Nigerian Journal of Fisheries Research.

Ragatoa D.S., Bagbohouna M., Simon S.O., and Edjame I.K., 2020, Rainfall and temperature predictions: Implications for rice production in the Lower River Region of The Gambia, Universal Journal of Agricultural Research, 8(4): 403-409.

Welcomme, R. L. (2001). Inland fisheries: Ecology and management. Oxford, UK: FAO/Blackwell Publishing.

World Bank. (2024). Nigeria climate data and projections. Climate Change Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/nigeria

World Fish Migration Foundation, 2024, Living planet report on migratory freshwater fish populations, World Fish Migration Foundation.