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Climate Change Adaptation Strategies Used by Fish Farmers in Niger State, Nigeria

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Abstract

The objectives were to determine factors influencing fish farmers' adoption of climate change adaptation strategies; identify the adaptation strategies used, and; identify the constraints affecting fish production in the area study area. A multi-stage sampling procedure was used to select 215 respondents. Primary data were obtained through questionnaire complemented by structured interview schedules and analysed using Poisson regression, mean, and percentages. Findings revealed that household size (−0.0558), sex (0.0587), fishing experience (0.1389), distance to market (−0.0100), perception of climate change effects (0.0185), extension contact (0.2233), and household income (0.0000) significantly influenced adoption of adaptation strategies. Commonly adopted adaptation strategies were installation of shading structures over ponds (88.4%), use of weather forecast information for planning (87.4%), and management of water temperature (86.0%). Furthermore, age (0.0044), years of education (−0.0039), access to credit (0.0006), cooperative membership (0.00002), and household income (0.00000) were significantly related to the response measures adopted by the farmers. In conclusion, fish farmers employed multiple strategies to mitigate climate change impacts and the study recommends that government and research institutions should develop an integrated adaptation frameworks combining environmental, technological and managerial approaches to enhance resilience and sustainability in aquaculture systems.

Keywords: Climate change, Adaptation strategies, fish farming

Introduction

Climate change remains a pressing global issue, bringing significant challenges for both our economies and the environment. While its impacts vary from one region to another, it undeniably influences development outcomes around the globe. Essentially, climate change involves long-term shifts in average weather patterns and atmospheric conditions, driven by both natural processes and human actions, most notably the greenhouse gas emissions resulting from industrial activities, agriculture, deforestation and the burning of fossil fuels (Australian Academy of Science, 2021).

As temperatures increase, rainfall patterns change and extreme weather events like floods and droughts become more common, agriculture faces significant challenges, particularly in Africa. These shifts threaten food systems, water supplies and the livelihoods of rural

communities. Additionally, climate-related hazards encompass issues like water shortages, rising sea levels, the spread of diseases and conflicts over resources (United Nations Framework Convention on Climate Change, 2022). The risks tied to climate change also include increasing temperatures, dwindling water resources, escalating resource-based conflicts, and the rise of both environmental and vector-borne diseases (Tologbonse et al., 2020).

Fisheries and aquaculture face similar threats from climate change. Changes in temperature, humidity and rainfall can negatively impact productivity in pond systems, which means fish farmers might see lower yields and face greater risks (George, 2022). In marine habitats, rising water temperatures and acidification can throw habitats and breeding cycles out of balance, leading to dwindling fish stocks, slower growth rates and increased mortality (Sumaila and William, 2020).

Aletan et al. (2022) highlighted that in Niger State, many families living in riverine areas rely heavily on fishing and farming for their income and daily needs. Women play a vital role too, significantly contributing through fish processing and sales. Since these livelihoods are so closely tied to water resources, any changes in climate can put a lot of economic strain on households involved in aquaculture. Unfortunately, there's still a lack of solid evidence on how fish farmers in the region are adapting to climate change. This gap in knowledge makes it tough to create effective policies and support programs. That's why this study was conducted to:

i. identified the adaptation practices in place;

ii. determined the factors influencing their adoption; and

iii. examined the major challenges faced in production.

Methodology

The study took place in Niger State, Nigeria, which is nestled between latitudes 8°22'N and 11°30'N, and longitudes 3°30'E and 7°20'E. This state covers an area of about 76,469.903 square kilometres, making up roughly 9.3% of Nigeria's total land area (Kolapo and Adeyera, 2021). As of 2021, the estimated population was around 5,644,139 according to the National Bureau of Statistics (NBS) (2022). The region experiences an average annual rainfall of about 1,219 mm, with temperatures typically ranging from 26.1°C to 30.3°C (Kolapo and Adeyera, 2021).

A three-stage multilevel sampling approach was employed. First, two extension blocks with fish farming activities were randomly selected from each of the three agricultural zones in the state (total of six extension blocks were selected). Second, two extension cells were randomly selected from each of the chosen extension blocks (total of six extension cells were selected). Third, 50% of the registered fish farmers within the selected cells were sampled, giving a total of 215 respondents from a sampling frame of 450 farmers. Information was collected through questionnaire (used for respondents who can independently read and understand) and structured interview schedules (administered to respondents that have reading difficulties). Data were analysed using Poisson regression (objective 1), percentages (objective 2), mean and standard deviation (objective 3).

Poisson Regression Model

Poisson regression model was used to determine factors influencing the response measures used by fish farmers to cope with changing climate conditions. Thus, the Poisson regression model Is expressed in implicit form as:

$Y = f (X_1, X_2, X_3, X_4, X_5, X_6, X_7, \ldots\ldots\ldots\ldots\ldots\ldots\ldots Xn$
The model is expressed in the explicit form as:
$Y=b_0 + b_1X_1+ b_2X_2+ b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_{12}X_{12} + U$
Where:
Y = Adaptation strategies (number of strategies adopted)
X_1 =Age (Years);
X_2 = Sex (dummy),
X_3 = fishing experience (years)
X_4 = Extension contacts (Number of visits in the last fishing season)
X_5 = Trainings received on climate change (Number)
X_5 = Cooperative membership (No of cooperatives)
X_7 = Access to storage facilities (Dummy)
X_8 = Education status (Years)
X_9 = Distance to market (Km)
X_{10} = Household income (Naira)
X_{11}= Perception on climate effects (Score generated from likert rating)
X_{12} = Access to credit (Naira)
β_0 = Constant term
$\beta_1 – \beta_{12}$ = Regression parameters to be estimated
ln = natural logarithm

Results and Discussion

Factors Influencing Fish Farmer's Adoption of Climate Change Adaptation Strategies

Table 1 shows the findings of the regression analysis on factors influencing the response measures used by fish farmers to cope with changing climate conditions. The estimated model result showed that a number of the socio-economic and institutional factors significantly affected the likelihood of farmers adopting adaptive practices. Significant variables included household size, sex, fishing experience, distance to market, perception of climate effects, extension contact and household income.

Household size (-0.0558225; $p < 0.01$) had a negative and significant relationship with the utilization of adaptation strategy, suggesting that larger households were less likely to implement adaptation measures. This may be due to competing household expenses that reduce funds available for investment in improved practices like improved pond management, climate-resilient fingerlings and water storage facilities.

Sex (0.0587) showed a positive significant effect, implying that male farmers were more likely to adopt adaptation measures. This may reflect greater access to productive resources such as land, finance, and extension services. These advantages increase their capacity to implement adaptation measures (Bello et al. (2021).

Fishing experience (0.1389; $p < 0.05$) positively influenced farmers utilization of climate change adaptation strategies. Experienced farmers often possess better knowledge of climatic trends, production risks, and farm management practices, which improves their ability to make informed adaptation decisions. Their past exposure to climate-related challenges may also increase confidence in trying new practices and investing in long-term adaptive measures.

Distance to market (-0.0100) had a negative effect, indicating that fish farmers located farther away from markets were less likely to utilize climate change adaptation strategies. Greater distance often increases transport costs and limits access to inputs, technologies, market information, and extension services. Similarly, Onyekwelu et al. (2021), also reported a similar negative effect of market distance on farmers' climate adaptation.

Perception of climate change effects (0.0185) positively affected farmers utilization of adaptation strategies. Farmers who recognized threats such as floods, irregular rainfall and heat stress were more inclined to implement measures like improved water management and pond reinforcement. Eta et al. (2022) also reported that perception of climate effects significantly influenced farmers' adaptation decisions.

Extension contact (0.2233) also had a positive influence, indicating that regular interaction with extension agents enhanced climate change adaptation decisions. Extension services help close information gaps, promote improved technologies, and provide technical guidance, thereby strengthening farmers' confidence in adaptation measures through training and practical demonstrations.

Household income (0.00000214) positively influenced farmers' decision on the utilization of climate change adaptation strategies. This reflects fish farmers' financial capacity in enabling investment in adaptation measures. Financially stronger households were better able to invest in adaptation measures and absorb associated risks.

Table 1: Factors influencing fish farmers' adoption of climate change adaptation strategies

Variable	Coefficient	Std. Error	z-value
Age	0.0043871	0.0052682	0.83
Years of education	-0.0038759	0.0045753	-0.85
Household size	-0.0558225	0.0116534	-4.79**
Sex	0.0587843	0.0160287	3.67***
Training received	0.0632605	0.0118298	5.35**
Fishing experience	0.1389624	0.0604253	2.30*
Distance to market	-0.0100250	0.0040328	-2.49***
Access to credit	0.0006325	0.0007354	0.86
Perception of climate change effects	0.0184642	0.0031067	5.94**
Membership cooperative	0.0000216	0.0000218	0.99
Extension contact	0.2232578	0.0754688	2.96*
Household income	0.00000214	0.00000486	4.41***
Constant	1.6408970	0.2353678	6.97
LR chi2(12)	148.51		
Prob> chi2	0.0000		
Pseudo R2	0.6733		

Source: Field survey, 2025 P ≤ 0.05 ***, **

Adaptation Strategies Utilized by Fish Farmers

Table 2 shows the commonly reported practices were provision of pond shade (88.4%), consultation of weather information for planning decisions (87.4%), regular monitoring of water temperature (86.0%), participation in farmer groups for knowledge sharing (84.7%), and adjusting feeding schedules to cope with temperature variations (81.4%) amongst others.

The installation of shading structures over ponds (88.4%) emerged as the most commonly adopted adaptation strategy. This reflects farmers' efforts to minimize excessive solar radiation, reduce water temperature, limit evaporation, and maintain favourable environmental conditions for fish growth. Elevated water temperatures can lower dissolved oxygen levels, increase fish stress, and reduce productivity; therefore, shading provides an effective means of protecting fish from heat stress. Similar observations have been reported

in recent aquaculture studies, where physical modifications of fish ponds were identified as important climate adaptation measures (Onyeneke, et al., 2020).

The use of weather forecast updates for planning (87.4%) demonstrates that farmers recognize the importance of climate information in making informed management decisions. Access to reliable weather forecasts enables fish farmers to schedule pond management activities, feeding, stocking, harvesting, and water management in anticipation of extreme weather events, thereby reducing production risks. This finding supports recent evidence that timely weather information significantly improves climate resilience and adaptive decision-making among fishers and fish farmers (Okeke-Ogbuafor et al., 2020).

Regular monitoring and management of water temperature (86.0%) was another highly adopted strategy. Since fish are highly sensitive to changes in water temperature, continuous monitoring enables farmers to respond promptly to unfavourable conditions through water exchange, aeration, or other management practices. Maintaining optimal water temperature contributes to improved fish health, feed utilization, survival, and overall production efficiency. Recent studies emphasize that effective water quality monitoring is fundamental to climate-resilient aquaculture systems (Aljehani et al., 2023).

Membership in cooperatives for knowledge sharing (84.7%) also ranked among the leading adaptation strategies. Cooperatives provide farmers with opportunities to exchange experiences, access climate-related information, receive technical training, and obtain financial or institutional support. Through collective action, farmers are better positioned to adopt innovative adaptation practices and strengthen their capacity to cope with climate change. Similar findings have shown that institutional support and social networks significantly influence the adoption of climate-smart aquaculture practices (Onyeneke, et al., 2020).

Adjusting feeding schedules to cope with temperature variations (81.4%) further indicates that farmers are modifying routine management practices to suit changing environmental conditions. Fish feeding behaviour is strongly influenced by water temperature; therefore, adjusting feeding times and frequencies during periods of high or low temperatures helps improve feed conversion efficiency, reduce feed wastage, and maintain fish growth. Recent aquaculture research similarly highlights adaptive feeding management as an effective strategy for minimizing climate-induced production losses (Aljehani et al., 2023).

The popularity of these practices reflects farmers' responses to increasing temperatures and declining water quality caused by evaporation and reduced dissolved oxygen. Many producers preferred relatively affordable measures suitable for small-scale and semi-commercial operations. Similarly, Akinrotimi et al. (2020), reported that shading helps reduce pond temperature and improve fish survival in West African systems.

Table 2. Climate change adaptation strategies adopted by fish farmers

Adaptation Strategies	Percentage (%) (n = 215)
Provision of pond shade	88.37
Consultation of weather information for planning	87.44
Regular monitoring and management of water temperature	86.05
Membership in cooperatives for knowledge sharing	84.65
Adjusting feeding schedules to cope with temperature variations	81.40
Using organic materials to improve water quality	79.98
Receiving training on climate change adaptation	76.74
Accessing financial/government support for adaptation	72.09
Collection of rainwater for fish farming	69.77
Using alternative locally available fish feed sources	67.44
Increasing pond depth to reduce evaporation	55.81
Use of improved fish species tolerant to climate change	51.16
Practicing integrated fish farming (e.g., fish–crop–livestock)	44.19
Use of aerators to increase dissolved oxygen	37.21
Use of floating cages or pens for fluctuating water levels	34.88
Stocking climate-resilient fish species	33.49
Modifying stocking density based on climate conditions	32.56
Water recycling or reuse	31.63
Adoption of biofloc or recirculating aquaculture systems	27.91
Seasonal adjustment in fish stocking	18.60

Source: Field survey, 2025

Constraints Associated with Fish Farming

Key limitations associated with fish farming as presented in Table 3 included deteriorating pond water quality, insufficient financing opportunities, rising feed expenses, and the high cost of pond establishment and maintenance.

Poor water quality ($\bar{x}$= 3.8) was a leading challenge because it affects oxygen levels, temperature balance, pH, and toxic accumulation, thereby reducing fish growth and survival.

Smallholder farmers are particularly vulnerable, as they often rely on water sources that are easily affected by seasonal changes and contamination. Oyinlola et al. (2021), similarly identified poor water quality as a major determinant of fish health in Nigeria's Niger Delta.

Limited access to credit ($\bar{x}$= 3.8) constrained farmers' ability to purchase fingerlings, feed, equipment, and improved technologies. Many relied on personal savings or informal loans, which were often inadequate. Many farmers reported difficulties in securing affordable loans, limiting their ability to purchase inputs such as fingerlings, feed, and improved technologies. Most rely on personal savings or informal borrowing, which is insufficient for expansion. Most financial institutions exhibited reluctance to lend due to perceived risks and lack of collateral. Akinwande et al. (2022) similarly noted that limited credit access restricts the adoption of improved aquaculture practices and reduces profitability.

High feed costs ($\bar{x}$ = 3.8) also ranked among the most serious challenges. Feed accounts for approximately 50–70% of the total cost of fish production, and rising prices of key ingredients such as maize, soybean meal, and groundnut cake have significantly increased production expenses. Competition for these ingredients from human food consumption and the livestock industry has further escalated feed prices, making both locally formulated and commercially manufactured feeds increasingly unaffordable for many smallholder fish

farmers. Consequently, high feed costs continue to reduce profitability and limit expansion of aquaculture enterprises in Nigeria. This finding agrees with Olagunju et al. (2024), who reported that feed remains the largest cost component in African catfish production in Nigeria and constitutes a major factor affecting the technical and economic performance of fish farms.

Similarly, high costs of pond construction and maintenance ($\bar{x}$ = 3.8) were widely reported. Establishing ponds requires substantial investment in land preparation, materials, and infrastructure, while ongoing maintenance adds further costs. Limited finances often lead farmers to adopt poor construction practices, resulting in seepage, flooding risks, and reduced productivity. Abiona et al. (2022) and Olaoye et al. (2022) also noted that high infrastructure costs remain a major barrier to aquaculture expansion in developing countries, a situation worsened by inflation and rising material prices in Nigeria.

Table 4.8. Constraints associated with fish farming

Constraints	Mean	SD
Poor water quality in ponds reduces fish growth and survival	3.84	1.10
Limited access to credit or financing	3.82	1.10
High cost of fish feed ingredients (e.g., maize, soybeans)	3.79	1.10
High cost of pond construction and maintenance	3.76	1.10
High cost of fish feed	3.72	1.12
Frequent disease outbreaks	3.69	1.12
High cost of fish farming equipment (e.g., aerators, nets)	3.67	1.12
Limited access to modern fish farming technologies	3.64	1.12
Poor transportation infrastructure increases post-harvest losses	3.58	1.21
Limited access to quality fingerlings	2.74	1.30
Poor market access and low fish prices reduce profitability	2.71	1.30
Inadequate technical knowledge and training	2.63	1.33
Inadequate extension services and technical support	2.54	1.39
Limited availability of land for pond construction	2.47	1.38
Limited access to reliable water sources	2.45	1.38
Predation by birds and other animals reduces fish yields	2.42	1.38
Lack of government support and policies	2.38	1.38
Lack of storage and preservation facilities	2.31	1.32
Competition with wild-caught fish reduces market opportunities	2.28	1.32

Decision rule: Mean scores ≥ 3= Constraint, Mean scores < 3= Not a constraint disagreed
Source: Field survey, 2025

Conclusion and Recommendations

Based on the findings of the study, the widely practiced adaptation measures included shading ponds, use of weather forecasts and early warning information, and regular monitoring of pond water temperature. Household size, sex, training received, distance to market, perception of climate change, cooperative membership, extension contact, and household income all significantly influenced fish farmers' decision to adoption climate change adaptation strategies. Key production constraints were poor water quality, inadequate credit access, high infrastructure costs, and expensive feed. Key production constraints were poor water quality, inadequate credit access, high infrastructure costs, and expensive feed. Overall, the findings suggest that government and research institutions should develop an integrated adaptation approach combining environmental, technological, and managerial strategies would strengthen resilience and promote sustainability in aquaculture systems.

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