EFFECT OF CHANGE IN CLIMATE ON FOOD SECURITY OF CATFISH FARMERS IN ONDO STATE, NIGERIA

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ABSTRACT
Climate change is an established reality, prompting nations worldwide to implement measures aimed at reducing anthropogenic carbon emissions and preparing for its impacts. Multistage sampling technique was employed in selecting the 231 catfish farmers for the study. Results revealed the mean age of catfish farmers to be 42 years (±10.69). Catfish production enterprise was male dominated (76%). The average number of years spent in school was 13 years (±4.89). The analysis revealed that catfish farmers, on average, had 11 years of farming experience, with a standard deviation of 7.74. Food secure households were estimated to be 42.86% while 57.14% of catfish farmers were food insecure. Factors contributing to rise in food insecurity among the catfish farmers in the study area were education ($p<0.01$), experience ($p<0.05$), household size ($p<0.1$) and climatic index ($p<0.05$). The study recommends that targeted education and training programs in catfish farming, along with strengthened extension services, are essential to improve management practices, climate resilience, and financial literacy among farmers. Additionally, promoting family planning and household resource management can help address food insecurity linked to larger household sizes and limited farming experience.

Keyword: Climate change, Catfish, Food Security, Logistic.

INTRODUCTION

Change in climate is a worldwide trend that affects various sectors and regions of the world, but especially agriculture, which is highly dependent on weather conditions, (Sirba & Chimdessa, 2021; Adeyeye, *et al., .,* 2023). Because catfish farmers are of higher susceptibility to the climate change effects, adaptation is especially important for developing countries like Africa, and particularly Nigeria. Africa is one of the most susceptible continents to climate change where it is estimated that by 2050, 6% of the population will experience chronic hunger or undernourishment, (Iruo, *et al., .,* 2019). Food and Agriculture Organization, (FAO, 2022) revealed that the effects of climate variability over the past 30 years are extreme and devastating. Although West Africa is widely recognized as one of the regions most vulnerable to climate change, there remains insufficient awareness among key stakeholders, such as catfish farmers, about the full extent of this phenomenon and the associated threats it poses to the region, (Sirba and Chimdessa 2021). Nigeria is a nation of remarkable climatic diversity and rich biological variety, influenced significantly by the southward progression of desertification. Iruo, *et al., .,* (2019) reported that the nation is susceptible to the climate change effects.

Change in climate poses a menace to all aspects of human existence, not just the socioeconomic and agricultural development of any one country (He, *et al.,* ., 2019). The Intergovernmental Panel on Climate Change (IPCC) in 2007 defined climate change as a variation in the average weather conditions observed over a specific period, (IPPC, 2007; Oyebola, 2021). It refers to the statistical characterization of relevant parameters over a range of time scales, spanning from months to thousands or even millions of years, typically expressed in terms of mean values and their associated variability. Variability in rainfall, temperature, air quality, and humidity significantly disrupt aquaculture systems by affecting water availability, quality, and the health of aquatic species. Fluctuating temperatures and humidity alter dissolved oxygen levels, salinity, and create conditions conducive to disease outbreaks, causing stress and reduced productivity. Together, these climatic factors compromise the balance required for efficient aquaculture, leading to lower yields and economic losses, (Yahaya *et al.,* ., 2024). These problems have caused large productivity losses and increased socioeconomic and financial vulnerability among farmers. Kim, Brown, and Kim (2019), along with Oladapo (2019), identified several climate change impacts on fish production, including heightened rainfall intensity, excessive wind, earlier seasonal onset, increased frequency and severity of droughts, farm area flooding, prolonged harmattan seasons, expansion of pond sizes, and elevated precipitation levels. According to Oladapo & Aladejebi (2022), climate change negatively affects catfish production in Nigeria, leading to a general decline in both productivity and the quality of produce. This decline is caused by various factors, such as temperature fluctuations that disrupt breeding cycles, reduce feed conversion efficiency, and increase stress and mortality rates among catfish. Additionally, extreme weather events like droughts and floods degrade water quality and alter pond ecosystems, further hindering growth and survival rates. These combined effects jeopardize food security at both the national and household levels by reducing the availability and affordability of a key protein source. Habitat degradation, overfishing, pollution, parasites, diseases, and more recently, due to the increased variability brought on by climate change have threatened fisheries resources. The uneven and worsening impacts of climate change, particularly since the late 20th century (Ajayi *et al.,* ., 2022), have not received as much attention as other pressing global challenges. Drought, flooding, and silt deposition have an impact on fish production because they cause fish mortality and significant changes in water quality (Oyebola, 2021). Since catfish farmers rely on high-quality water to achieve a plentiful harvest, their livelihoods are invariably impacted. Effective adaptation methods are required for catfish farmers to be capable of dealing with the effects of change in climate. Measure, recognized by FAO, 2022 as one of the strategy choices was adaptation which can lessen the negative effects of climate change. According to the Emmanuel and Olaniran (2022), "climate change adaptation" refers to the capacity to modify a human or natural system in reaction to present or predictable climatic stimuli or their effects in a way to minimize damage or takes benefit of beneficial chances.

One of the most important aquaculture activities in many countries is catfish farming, providing food and income for millions of people. However, catfish farming is susceptible to the climate change impacts as rising temperatures, water scarcity, water quality degradation, diseases and pests. These impacts can reduce catfish growth, survival, quality and profitability, and threaten the livelihood and food security of catfish farmers and consumers. Therefore, it is essential for catfish farmers to adjust to the changing climate by adopting various approaches that can boost their productivity and resilience. Some of these strategies include changing the species or breeds of catfish, using water-saving technologies, improving water quality management, diversifying income sources, accessing credit, extension services, information and markets. However, the adoption of these strategies depends on various factors, such as socio-economic variables of farmers, farm size, resources access, policies and institutions. Therefore, catfish producers can adjust to climate change by diversifying their sources of income, moving, switching to other species, or, in the worst case scenario, ceasing fish production (Xu & Findlay (2019). Catfish producers must therefore employ adaptation measures to lessen the effects of climate change in order to maximize the production of catfish needed to feed the world's expanding population.

The interrelationship between climate change and food security has garnered significant attention in recent years, particularly in sectors heavily reliant on environmental stability, such as aquaculture. Catfish farming, a vital component of food production and livelihood in many regions, is especially susceptible to the adverse effects of changing climatic conditions (Frona, *et al.,* ., 2021). Food security, defined as the availability, accessibility, and affordability of nutritious food for all (Oyebola, *et al.,* ., 2021), is intricately linked to stable environmental conditions. Iyiola, *et al.,* ., (2022) reported that climate-induced disruptions in food production systems compromise the four dimensions of food security namely availability, access, utilization, and stability. For catfish farmers, reduced yields due to environmental stressors translate into lower incomes, diminished purchasing power, and heightened vulnerability to food insecurity. Moreover, the effectiveness of these strategies in improving catfish production and food security is not well understood and documented. There is a need therefore to examine the food security status and the effect of change in climate on catfish farmers' food security in Ondo State, Nigeria. This study therefore seeks to fill this gap by analysing the socioeconomics variables of catfish farmers and the effects of change in climate on the food security of catfish farmers in Ondo State, Nigeria, a major catfish-producing State in the country Nigeria.

METHODOLOGY

Ondo State serves as the study area for this research, with geographic coordinates of 5°45'N latitude and 4°15'E longitude. The State covers an approximate land area of 14,793.723 square kilometres and is home to a population of about 3.441 million people. It is administratively divided into 18 Local Government Areas (LGAs), providing a diverse and relevant context for examining the impacts of climate change on catfish farming and its implications for food security. Its climate has two seasons that are distinct: the rainy season (April to October), and the dry season (November to March). It is in the tropics, (National Boundary Commission (NBC) of Nigeria 2020). The study employed multistage sampling technique. The first stage is the purposive selection of Ondo State. This is because it is among the States noted for catfish farming in Nigeria. The second stage involved the purposive selection of all the five (5) Agricultural Development Programme Zones (ADPs) in the State. This is because the fishpond ownership cu across all the ADPs, Table 1. Finally, using the list of the registered fish farmers (Table 1), a random and proportionate selection of two hundred and thirty-one (231) catfish farmers were selected for this study.

Both descriptive statistics such as percentages, means, frequency, percentages, Likert Scale, and inferential statistics such Food Security Index, Weighted Mean and Logistic Regression analytical tools were employed in analysing the data collection.

Likert Scale: Likert scale was used for ranking respondents' response to climate indicators in the study area. It is a type of rating scale used to assess perception or attitudes of individual concerning a particular topic or issue, (Likert, 1931 adapted by Onyeneke, et al., 2019). However, it can be used to collect data on how frequently or strongly respondent accept as true that change in climate has affected catfish production. Five-point rating scale was utilized and this ranged from: Strongly Agreed, Agreed, Undecided, Disagreed, and Strongly Disagreed on the scale of 5 to 1 respectively.

Weighted Mean (WM)

Simple, weighted and geometric average are the three approaches that are most frequently employed to calculate an average (or mean), (Yadlowsky, et al., 2024). When forecasting nonrecurring (NR) costs utilizing ratios of NR expenses to first unit production costs, analysts frequently employ averages as estimating guidance. The applicability of utilising simple and weighted averages has some scholarly critics. The "wrong mathematics," according to some observers, is how simple averages are created because it violates the fundamental principles of mathematics. According to Shu-Ping (2011); Gbode, et al., (2021), weighted averages are based on the "correct mathematics" and need to be used as such, therefore it was used in this study.

Given a set of n observations:

$$Z_1, Z_2 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots Z_n$$

WM is defined by the following formulae

$$WM = \frac{\sum_{i=1}^{n} w_i Z_i}{\sum_{i=1}^{n} w_i}$$

Where sample size = n and the weighting factor of the i^{th} observation $i = 1 \ldots\ldots\ldots n = w_i$.
Z is the observations or values.

Estimation of Food Security using Food Security Index (FSI): FSI was used to measure how the food secured catfish farmers were in the study area. The food security index has found wide application in literature (FAO, 2019; Adio & Olarinde, 2020, Ayeni & Adewumi 2023) was adopted. The Food Security Index (FSI) calculates households' per-capita food expenditure (including farm produce consumptions and cash) in Naira monetary terms. If a household spends at least two-thirds of the average food expenditure of the sampled households, it is regarded to be food secure; otherwise, it is deemed to be food insecure, (Ayeni & Adewumi 2023). Hence, the FSI according to (Adio & Olarinde, 2020) is given as:

$$F_i = \frac{\text{per capita food expenditure for the ith households}}{2/3 \text{ mean per capita food expenditure in all households}}$$

Where:

$$F_i = Food\ security\ index$$

When

$$F_i \geq 1 = food\ \mathrm{sec}ure - ithhousehold$$

$$F_i \leq 1 = foodin\ \mathrm{sec}ure - ith - household$$

Logit Regression (LR) Model: Logistic regression is a parametric method used for examining the relationship between a binary response variable (one that is categorical having only two categories) and a set of independent predictor variables that can be either continuous or categorical. It is models a relationship between predictor variables and a categorical response variable. Logistic regression helps us estimate a probability of falling into a certain level of the categorical response given a set of predictors. Each predictor in a logistic regression is assigned a coefficient that expresses how much of an independent contribution it makes to the variation in the dependent variable. If the response is "food secure," the dependent variable Y takes a value of 1, and if it is "food insecure," it takes a value of 0. The multiple binary logistic regression model is represented thus:

$$\pi(X) = \frac{\exp(\beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k)}{1 + \exp(\beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k)}$$

$$= \frac{\exp(X\beta)}{1 + \exp(X\beta)}$$

$$= \frac{1}{1 + \exp(-X\beta)}$$

Where π denotes a probability and not the irrational number. In this study, 1 represents food secure and 0 for food insecure. Since Logistic regression calculates the probability of success (p) over the probability of failure (q), the results of the analysis are in the form of an odds ratio (p/q).

$$X_1 = age\ of\ the\ respondents, X_2 = Education, X_3 = fishing\ experience, X_4 = labour, X_5 = member\ of\ association, X_6 = Climate\ index, X_7 = marital\ status, X_8 = household\ size$$

RESULT AND DISCUSSION

Table 2 presents the summary statistics of the socioeconomic characteristics of catfish farmers, categorized by factors such as sex, age, marital status, educational attainment, household size, years of fishing experience, and association membership. These characteristics are analysed and discussed in detail to provide insights into the demographic and professional profiles of the farmers. The distribution of the farmers by age showed that the mean age for farmers was 42 years with a standard deviation of 10.69. This implies that the catfish farmers are within their active and productive age range, enabling them to effectively engage in and sustain catfish production activities. Catfish farming is a labour-intensive occupation and exerts energy for pond maintenance, cleaning, fertilization, feeding and harvesting (Sarojini *et al., .,* 2022). The findings are similar to those of Olajide and Omonona (2019) who reported that the mean age of fish farmers in Osun State was 49 years. Results of the study on distribution of the fish farmers by sex revealed that male dominated the enterprise. This also shows that fish farming activities is carried out mostly by male gender, although women were also involved. The average years spent in school was thirteen (13) years. This result indicated that the fish farmers in Ondo State were open-minded and implies that the fish farmers will be more open to extension agents for information and embracing other best practices for improved species and harvesting techniques that would control the quality of fish.

Furthermore, catfish farmers in the State have considerable years of experience as revealed by the result of years of fishing experience. The average fishing experience was 11 years with 7.74 values for standard deviation. This is consistent with the findings of Iruo, *et al., .,* (2019). The result of the findings also revealed the perception of respondents on the effect of climate change on catfish farming in the study areas to be flooding (Mean 1.42, SD 0.90), long harmattan period leading to increase in fish production (3.03, 1.37), precipitation increase resulting to increase in fish production (2.47, 0.95), long period of hot season resulting to decrease in production of fish (2.13, 0.85), long period of hot season resulting to decrease in production of fish (2.03, 0.56), Situation of drought resulting to decrease in production of fish, decrease in fish farming, and decrease in quality of fish (2.03; 056). However, the Standard Deviations (SD) values of change in climate indicators on catfish production indicated that the catfish farmers varied in their responses. This aligns with Egwuonwu's (2022) findings, which identified climate change as being characterized by variations in rainfall patterns, irregular precipitation, shorter wet seasons, droughts, reduced river water volumes, and rising daytime and night-time temperatures.

The coping strategies as revealed by the respondents were: construct ponds near water sources (1.41; 0.52), digging bore hole and/or wells for alternative water source at dry seasons (1.74; 0.50), time of stocking adjustment (1.89; 0.78), sourcing climate change information (1.73; 0.70), stocking favoured climate change fish species (1.60; 0.68), avoidance leakage of pond (1.62; 0.61), ensuring good water circulating system (1.56; 0.70), purchase of weather monitoring kits (1.69; 0.72), erecting embankments to reduce/prevent flood water (1.64; 0.73), stocking of fingerlings that is healthy (1.72; 0.67), usage of better varieties of fish (1.81; 0.74), clearing pond regularly (1.72; 0.47), ensuring better inlet and outlet (1.75; 0.86), and diverting water ways (1.56; 0.56). The findings of this study were in consonance with Oyebola, *et al., .,* (2021)'s work on potential adaptation techniques for change in climate impact among flood-prone fish producers in Uganda climate hotspot who reported similar adaptation strategies.

Climatic effects and Adaptation Measures: The result of climatic indicators as revealed by the respondents in the study areas is in Table 2. Change in climate indicators were rated with Likert-type rating scale questions of 5-points rated as Strongly Agreed; Agreed; Undecided and Strongly Disagreed, Strongly Disagreed, with a scale from 5 to 1 respectively. Included among others flooding, long period of harmattan season leading to increase in fish production, precipitation increase resulting to increase in production of fish, long period of hot season resulting to decrease in production of fish, long period of hot season resulting to decrease in production of fish, situation of drought resulting to decrease in production of fish, decrease in fish farming, and decrease in quality of fish. In ranking, situation of drought resulting to decrease in production of fish rank first, followed by clearing pond regularly, avoidance of leakage of pond (Table 2).

The adaptation strategies used by catfish farmers in the study area according to Table 2 were construction of ponds near water sources, digging bore hole and/or wells for alternative water source at dry seasons, time of stocking adjustment, sourcing climate change information, stocking favoured climate change fish species, avoidance of leakage of pond, ensuring good water circulating system, purchase of weather monitoring kits, erecting embankments to reduce/prevent flooding, stocking of fingerlings that are healthy, stocking of better fish varieties, regular pond clearing, ensuring better inlet and outlet and diverting water ways. According to Table 2, digging bore hole and/or wells for alternative water source at dry seasons ranked first followed by clearing pond regularly, avoidance leakage of pond, stocking of healthy fingerling, diverting water ways, erecting embankments to reduce water, purchase of weather monitoring kits, stocking favoured climate change resistant fish species, construction of pond near water sources.

Food Security Status of Catfish Farmers: The food security index which explained as per capita food expenditure for the *ith* household over 2/3 mean per capital food expenditure of all households was applied to determine the food security status. Households with Food Security Index (FSI) greater or equal to one was considered food secure. The result in Table 3 showed the monthly mean per capita food expenditure for the total household was ₦59,065.03 as calculated by the total food expenditure divided by the household size of the respondents and the 2/3 mean per capital food expenditure for all the household was ₦39375.35. Using ₦39375.35 as the standard, 42.86% of the households were estimated to be food secure (Table 3) while 57.14% of the respondents were food insecure. This probably could be the adverse effects of climate on the catfish production. This is contrary with the study of FAO, (2019) and Gbode, *et al., .,* (2019) who used 2/3 of average mean per capita expenditure on food as the food secured line and reported that the respondents studied were food secure.

Effects of Change in Climate on Food Security of Catfish Farmers: Result in Table 4 showed the factors contributing to rise in food insecurity among catfish farmers in the study area. Results revealed that education ($p<0.01$) has the probability of decreasing food insecurity of respondents. Coefficient (0.857) of the education has a positive relationship with household's food insecurity status. The results indicate that food security improves with higher levels of formal education among household heads in the study area. This may be attributed to the fact that, in Nigeria, formal education significantly influences wage determination, while also enhancing human capacity and technical skills, which drive productivity and, consequently, improve food security. These findings align with the study by Olagunju, Adesiyan, & Ayinde (2012) on the economic viability of catfish production in Oyo State, Nigeria. The coefficient of the variable experience ($p<0.05$) indicates that greater experience in catfish farming significantly reduces the likelihood of food insecurity among farmers. This suggests that households with more experience in catfish farming have a lower probability of being food insecure, and vice versa. The coefficient for the climatic index (access to climate information) shows a positive relationship with household food security. This indicates that households with access to climate information are more likely to be food secure compared to those without, as such access equips them with valuable knowledge on climate variability, strategies for coping or mitigating its effects on catfish production, and other production-related incentives, ultimately improving their output and food security status. Finally, Table 4 also revealed that household size ($p<0.10$) is positively associated with increased food insecurity among catfish farmers in Ondo State. Each additional household member reduces the odds of being food secure by 0.77, as larger households require higher food expenditures, especially when many members rely solely on the household head for income. This finding aligns with Opaluwa *et al., .,* (2019), who highlighted the impact of household size on food security among rural farming households in Dekina Local Government, Kogi State, Nigeria

CONCLUSION

The study highlights the critical challenges of food insecurity among catfish farmers, with over half of the households in the study area identified as food insecure. Construction of ponds close to water sources, dig bore hole/wells to supply water during dry seasons, adjustment in the time of stocking, seeking/listening to information about climate change, stocking fish species that are more favoured by climate change, among others were the adaptation measures adopted by the catfish farmers.

Key factors influencing food insecurity include education, farming experience, and household size. These findings underscore the importance of targeted interventions, such as enhancing educational opportunities, providing technical training, and promoting family planning initiatives, to improve food security. Addressing these factors to help strengthen the livelihoods of catfish farmers and contribute to sustainable food production in the State is recommended.

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Table 1: Registered catfish farmers in Ondo State

LGAs	Fishpond Ownership						
	State Government	Local Government	Educational Institutions	Coop. Society	Company	Private Individual	Total
Akoko Northeast	3	2	10	0	3	56	74
Akoko Northwest	0	0	3	0	4	28	35
Akoko Southeast	0	0	1	0	0	3	4
Akoko Southwest	0	0	1	0	0	8	9
Akure North	0	0	2	0	2	15	9
Akure South	46	2	9	0	9	160	226
Ese Odo	0	0	2	1	0	18	21
Ilaje	0	0	4	0	0	121	125
Idanre	0	1	4	3	8	15	31
Ifedore	0	0	3	0	42	20	65
Ile-Oluji/Okeigbo	0	0	5	0	0	12	17
Irele	0	0	0	1	0	1	2
Odigbo	0	0	3	0	4	13	20
Okitipupa	0	0	1	0	0	42	43
Ondo East	0	0	1	0	1	6	8
Ondo West	2	0	6	0	3	84	95
Ose	0	0	0	0	2	5	7
Owo	4	0	4	0	11	89	108
Total	**55**	**5**	**59**	**5**	**89**	**696**	**909**

Source: Ondo State of Nigeria Digest of Agricultural Statistics (2017).

Table 2: Summary Statistics of the variables used

Variable	Obs.	Mean	SD
Sex	231	0.76	0.43
Age	231	42	10.69
Marital status	231	2.00	0.622
Education Level	231	4.02	1.06
Education	231	13.21	4.89
Household size	231	4.40	2.37
Experience	231	11.77	7.74
Fish association	231	0.59	0.49
Climatic effects			
Flooding	231	1.42	0.90
Long period of harmattan season leading to increase in fish production	231	3.03	1.37
Precipitation increases result in increase in production of fish	231	2.47	0.95
Long period of hot season results in decrease in production of fish	231	2.13	0.85
Situation of drought resulting to decrease in production of fish	231	2.03	0.56
Decrease in fish farming	231	2.11	0.64
Decrease in quality of fish	231	2.32	1.00
Adaptation strategies			
Construct ponds near water sources	231	1.41	0.52
Digging bore hole and/or wells for alternative water source at dry seasons	231	1.74	0.50
Time of stocking adjustment	231	1.89	0.78
Sourcing climate change information	231	1.73	0.70
Stocking favoured climate change fish species	231	1.60	0.68
Avoidance leakage of pond	231	1.62	0.61
Ensuring good water circulating system	231	1.56	0.70
Purchase of weather monitoring kits	231	1.69	0.72
Erecting embankments to reduce/prevent flood water	231	1.64	0.73
Stocking of fingerlings that is healthy	231	1.72	0.67
Usage of better varieties of fish	231	1.81	0.74
Clearing pond regularly	231	1.72	0.47
Ensuring better inlet and outlet	231	1.75	0.86
Diverting water ways	231	1.56	0.56

Source: Field Survey, 2023. Obs. = Observation, SD = Standard Deviation, Min. Minimum, Max. = Maximum

Table 3: Food security status of the catfish farmers

Food security status	Frequency	Percentage
Food secure	99	42.86
Food insecure	132	57.14
Total	**231**	**100**

Source: Field Survey, 2023

Table 4: Logistic regression result on effects of change in climate on food security of catfish farmers

Variables	Odd Ratio	Std. Err.	p-value
Age	0.991	0.027	0.733
Education	0.857	0.045	0.003***
Fishing experience	0.917	0.0348	0.022**
Labour	1.122	0.404	0.750
Association	1.452	0.699	0.439
Climate indicator	1.113	1.549	0.039**
Marital status	1.275	0.571	0.588
Household size	0.776	0.106	0.063*
Constant	28.54	67.16	0.154
Observation	231		
LR $chi^2(8)$	22.49		
Prob > chi^2	0.0041		
Pseudo R^2	0.1634		

*, ** and *** Represents 10%, 5% and 1% significant levels respectively (Source: Field Survey, 2023)