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Determinants of Household Fish Farmers' Vulnerability to Climatic Hazards in Southwest Nigeria

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Abstract **Original Research Article**

The study examined the determinants of fish farmers' household vulnerability to climatic hazards in Southwest Nigeria. A multi-stage sampling technique were used to select the respondents for this study. In the first stage, Ondo and Ogun States were purposively selected in the tropical rainforest zone of Southwest Nigeria. These States have coastlands; in addition, they are prominent in fishing activities and climatic hazards, as well as waterlogged areas are a common occurrence. In the second stage, stratified random sampling of two (2) Local Government Areas (LGAs), namely Ilaje LGA and Ese-Odo LGA in Ondo State, while Odogbolu LGA and Ijebu Waterside LGA were selected in Ogun State. The Selection of the LGA's was based on was based on the fact that these LGAs were the prominent ones where intensive fishing activities take place. In the third stage, four (4) fishing communities were randomly selected from each LGA, while in the final stage, sixteen (16) respondents were randomly selected from each of the communities. The respondents were expected to be 256, but only 220 questionnaires were returned. Therefore, a sample of 220 respondents was selected for this study. Data collected from 220 respondents were analyzed using frequency tables, descriptive statistics, charts, and an ordered logistic regression model. The average age of the respondents was 49 years, 56.36% of the respondents observed floods as the major climatic hazards in the study area, followed by erosion (19.55%) and change in rainfall pattern (12.27%), respectively. The most of the important adaptation strategies adopted is building embankments to prevent flooded water, planting of shaded crop to prevent erosion, improved fish managements, procurement of weather/water monitoring kits, insurance policies and diversification measures were adopted in the study area to cushion the effects of being vulnerable to various climatic hazards in the study area. The Ordered Logistic Regression result showed that flood, erosion, and heavy rainfall were the major production risks perceived by the fish farmers in the study area. It is concluded that fish farmers in the study area were vulnerable to various climatic hazards, notably floods, erosion, and changes in the rainfall pattern. Therefore, policy and local development practitioners should give priority to highly vulnerable households by encouraging them to practice climate-smart agriculture and improved fish farming management, as well as ensure their businesses to mitigate the effects of climate risks on their businesses.

Keywords: Determinants of Vulnerability, Vulnerability drivers, Climatic Hazards and Fish Farmers.

1. Introduction

Aquaculture is the fastest growing food producing sector globally, with production increasing from about four million tonnes in 1970 to 73.8million tonnes in 2014 (Food and Agriculture Organization, 2016). To date, 50% of the world's human fish consumption comes from aquaculture, and about 18 million people are engaged in fish farming, of which 94% are from Asia (FAO, 2016). Sub-Saharan Africa's aquaculture Production, estimated at 1.7 million metric tons (MT) of the global 76.6 million MT of production in 2015, continues to face fish feed shortages. Those shortages have dimmed hopes of the sector's growth in response to the region's increasing population-now estimated at one billion people. These ecosystems are already feeling the impact of climate change due to their high sensitivity to changes in temperature, salinity, and acidity. As a result, livelihoods dependent on fisheries and aquaculture are expected to be among the first to be significantly impacted by climate change. Particularly vulnerable are the livelihoods of small-scale fish farmers and fishers in Small Island developing states, drought-prone countries, and developing countries in South and South-East Asia and Sub-Saharan Africa (Allison et al., 2009). Millions of people, including many in developing countries, derive their livelihoods from fishing, while about 2.6 billion people get their protein from seafood. Fishing provides employment for up to ten million people in Africa and provides a vital source of protein to 200 million people (Adebo & Ayelari, 2011). The fisheries sector is a means of growing the economy, creating jobs, enhancing food security, and reducing poverty (Asiedu et al., 2017; Garlock et al., 2020). In sub-Saharan Africa, it plays a major role in people's livelihoods and food and nutrition security (Aheto et al., 2019). Fisheries account for about 20% of the global animal protein production and provide protein to one-fifth of the global population (Falola et al, 2022).

Climate change could have dramatic impacts on fish production, which would affect the supply of fishmeal and fish oils. Future aquaculture production could be limited by the supply of fishmeal or fish oils if stocks of species used in the production of fishmeal are negatively affected by climate change and live-fish production (Adebo & Ayelari, 2011). Freshwater systems are also strongly connected to climate, as they may influence climate-related atmospheric processes and serve as indicators of climate change.

The IPCC considered freshwater systems to be among the most threatened on the planet because of the multiple anthropogenic impacts that are common occurrences. Hydropower infrastructure, water use for irrigation, and agricultural land use result in the fragmentation of water bodies, modification of flow regimes, and a progressive disconnection of floodplains and wetlands from the rivers that sustain them. It is expected that these stressors will continue to dominate as human demand for water resources grows, together with the quest for development that leads to urbanization and agricultural expansion (Settele *et al.*,2014), in addition to climate change.

Human influence has been detected in the warming of the atmosphere and ocean, changes in the global water cycle, reductions in snow and ice, global mean sea level rise, and changes in some climate extremes. This evidence for human influence has grown since AR4. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century." (IPCC 2013) By damaging the natural environment and building in areas prone to earthquakes, floods, and extreme weather conditions, it has adversely affected fishing production as well as fishing communities. The life of the rural coastal communities' dwellers revolves around the water. Flooding is a regular experience and has been integrated effectively into everyday lives and activities. Consequently, over time, most of these communities have developed different Indigenous approaches, such as consultation with gods to appease water through sacrifices, construction of embankments, anticipation of flood occurrences from some local signs, etc., to mitigate the negative effects of flooding on the settlements.

The identified problems led to questions that are raised on the perceived effects of climatic hazards on aquaculture production, as prevalent in the coastal areas of Southwest Nigeria, and the extent of vulnerability of aquaculture fish farmers. Therefore, there is a need to assess the socioeconomic characteristics of fish farmers and determine the extent of their vulnerability to climatic hazards. The objectives of the study are to describe the socioeconomic characteristics of aquaculture fish farmers in the coastal communities of Southwest Nigeria and to determine the major determinants of fish farmers' vulnerability to climatic hazards in the study area.

2. Literature Review

Impacts of flood vary with location, age, sex, income level, diversification of economic activities, social participation, marital status, household size, education, ability to migrate, availability of efficient early warning systems, and governance (Oyekale *et al* 2013; Oyeleye & Adetunji, 2013). Poor people suffer higher negative impacts of disasters than rich people (Oyekale *et al* 2013), while the ability to migrate and the availability of assistance during flooding reduce the vulnerability to the impacts of flooding (Oyekale *et al*, 2013).

Flooding is known to create environmental problems. Environmental problems of flooding, such as inundation of homes with flood water and debris, are likely to reduce with increasing work experience (Oyekale *et al*, 2013). Even though educated people are expected to avoid water contamination and reduce the water-related problems of flooding, Oyekale *et al* (2013) found that education increases the probability of water contamination, and females were more susceptible to water contamination than males during flooding in Epe, Lagos State, Nigeria.

Disruption of economic activities and loss of livelihood are common economic impacts of flood disasters. The rate of disruption of economic activities, as a result of flood hazard, reduces with increasing age, work experience, availability of help during flooding, and the ability to migrate, while larger household sizes and early warnings tend to encourage economic disruption (Oyekale *et al* 2013). However, Orlove *et al* (2004) reported that rural people, especially fishermen, do not always make use of flood warnings, while Taiwo *et al* (2012) asserted that the effectiveness of a particular flood warning depended on the previous flood disaster experience of the people.

Flooding leads to property losses and livelihood insecurity. Probability of property losses and livelihood insecurity during flooding reduces with monthly income, economic diversification, ability to migrate and social networking (Oyekale *et al* 2013; Armah *et al*, 2010).

3. Materials and Methods

Study Area

This study was carried out in Ondo State and Ogun State in the Southwest part of Nigeria. The study area comprises Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti states. The area lies between longitudes 2°31' and 6°00' East and Latitudes 6°21' and 8° 37'N (Agboola, 1979) with a total land area of 77,818 KM^2. The study area is bounded in the East by Edo and Delta states, in the North by Kwara and Kogi states, in the West by the Republic of Benin and in the south by the Gulf of Guinea.

The climate of Southwest Nigeria is tropical in nature, and it is characterized by wet and dry seasons. The temperature ranges between 21 and 34°C while the annual rainfall ranges between 1500 and 3000 mm. The wet season is associated with the Southwest monsoon wind from the Atlantic Ocean, while the dry season is associated with the northeast trade wind from the Sahara Desert.

Sampling Techniques

A multi-stage sampling technique was used to select the respondents for this study. In the first stage, Ondo and Ogun States were purposively selected in the tropical rainforest zone of Southwest Nigeria. These States have coastlands; in addition, they are prone to fishing activities and climatic hazards, and waterlogged areas are a common occurrence.

In the second stage, stratified random sampling of two (2) Local Government Areas (LGAs), namely Ilaje LGA and Ese-Odo LGA in Ondo State, while Odogbolu LGA and Ijebu Waterside LGA were selected in Ogun State. The Selection of the LGA's was based on was based on the fact that these LGAs were the prominent ones where intensive fishing activities take place. In the third stage, four (4) fishing communities were randomly selected from each LGA, while in the final stage, sixteen (16) respondents were randomly selected from each of the communities. The respondents were expected to be 256, but only 220 questionnaires were returned. Therefore, a sample selection of 220 respondents was retrieved for this study.

Primary data were collected through a field survey at the rural household level through the use of a structured questionnaire among fishermen in the selected communities. Personal interviews with the fishermen and women who live in coastal areas were conducted to provide baseline information on the effects of exposure to climatic hazards and coping strategies common in the study area. Key Informant Interview (KII) and Focus Group Discussion (FGD) were conducted with men and women groups to ascertain the prevailing circumstances, such as the effects of salt water on their aquaculture business, among other salient issues

Method of Data Collection

Primary data were collected on farmers' perceptions on impacts, socioeconomic profiles and adaptation strategies) were collected using a well-structured questionnaire administered to rural households. Interviews and Focus Group Discussions (FGDs) were also used to collect a cross-section of perceptions and adaptations to climate change among respondents. Secondary data on Temperature and rainfall were collected from the Nigerian Meteorological Agency (NIMET).

4.4 Method of Data Analysis

The socioeconomic traits of aquaculture fish farmers and the major drivers of fish farmers' vulnerability to climatic hazards in the study area were analyzed through the use of descriptive statistics. The socioeconomic features of the respondents were analyzed and presented using statistical techniques such as frequency distributions, means, percentages, ranges, minimum, maximum, and cross-tabulation. The major drivers of fish farmers' vulnerability to climatic hazards in the study area were analyzed using ordered Logistic Regression.

Ordered logistic regression models were used to achieve objective 2, which is to determine the major drivers of vulnerability among aquaculture fish farmers to climatic hazards. Given that the dependent variable for this study which is major drivers of aquaculture fish farmers' vulnerability was ordered and coded as 1, 2, 3 or 4 (1 = very low; 2 = low; 3 = marginal, and 4 = high), this implies that multiple linear regression techniques is not suitable in this case as the assumption of normality is most likely violated, hence, the most appropriate technique for variable with more than two outcomes is ordinal logistic regression model (Liu, 2009).

Given the measurement model for Ordinal variables, it is assumed that category 4>3>2>1
$Y = f(Y^*)$

$Y^*=\alpha j +X\beta+\varepsilon$ Equation…. (1)

Where

Y is an observed ordinal variable which is a function of Y^* is unobserved or unmeasured variable.

X is the vector of independent variables

β is the vector of regression coefficients to be estimated

ε is the error term

αj is the threshold or cut points

Since our Y*is divided into some cut points or thresholds α1, α2, α3, α4, and α1<α2<α3<α4

Considering the observed food security status level as an ordinal outcome, Y ranging from1 to 4 the category in which each respondent falls is expressed as:

$$Y = \begin{cases} 1 & if\ Y^* \le \alpha_1 \\ 2 & if\ \alpha_1 < Y^* \le \alpha_2 \\ 3 & if\ \alpha_2 < Y^* \le \alpha_3 \\ 4 & if\ \alpha_3 < Y^* \le \infty \end{cases}$$ Equation….. (2)

Where Y=1, 2, 3, 4(1=very low fish farmer's vulnerability to 4=high fish farmer's vulnerability)

Therefore, the probability of a respondent to be at a particular level of major drivers of fish farmer's vulnerability can be expressed as follows:

$[Y \le j/X_1, X_2, X_3, X_4] = \alpha j + (-B_1X_1 - B_2X_2 - B_3X_3 - B_4X_4 - \ldots\ldots\ldots BnXn)$ Equation…(3)

Y-Major drivers of fish farmer's vulnerability

Xi- Income of the fish farmers

Xii-Literacy Rate

Xiii-Economic Status

Xiv-Source of drinking water

Xv-Climate information

Xvi-Membership of Cooperative Societies

Xvii-Membership of Trade Union

Xviii- Access to Credit facilities

Xix-Access to Inputs

Xx-Occurrences of Flood

Xxi-Occurrences of Erosion

Xxii-Change in rainfall pattern

Xxiii-Hot weather

Xxiv-Cool weather

Xxv-Distance to water source

Xxvi-Numbers of days it takes for the flood to disappear

Pr $[^{y\le j}/_{x}]$ $=\beta 0+\beta 1$income$+\beta 2$literacy rate$+\beta 3$economic status$+\beta 4$source of drinking water $+\beta 5$climate information$+\beta 6$cooperative societies$+\beta 7$trade union$+\beta 8$credit facilities $+\beta 9$access to inputs $+\beta 10$flood occurrences $+\beta 11$erosion $+\beta 12$ change in rainfall pattern $+\beta 13$ hot weather $+\beta 14$ cool weather $+\beta 15$ distance to water source $+\beta 16$ Numbers of days it takes for the flood to disappeared

4. Results and Discussion

4.1. Socio-economic Characteristics of the Respondents

The distribution in Table 1 indicates that 67.3% of the respondents are male, while 32.7% are female. This shows the dominance of male farmers in fish farming activities over female farmers in the study area. The production enterprise is male-dominated, and climate change adaptation decisions are likely to be favored and supported for action.

Table 1 further presents that 60.9% of the respondents have spent between 10 and 20 years in fish farming, another 13.6% have spent between 21 and 30 years in the fish farming business, while 22.3% of the sampled fish farmers have less than 10 years of farming experience in the fish farming business. The result also showed that 2.3% of the respondents have between 40 and 41 years of farming experience, and a few fish farmers, 0.9%, have more than 40 years of experience in fish production as a means of livelihood. This suggests the majority of the respondents have acquired farming experience of between 10 and 20 years. Experience plays a prominent role in agribusiness or farm enterprise. The sampled farmers are in a better position and frame of mind to accept innovations and knowledge of climate-related production technologies and adaptation strategies that will enable them to adjust their coping mechanisms. A sampled farmer has been in farming for an average of 14 years. A similar result was reported by Gega et al. (2018), who reported that 84% of the respondents were males and only 16% were females, and this indicates that farming is predominantly a male business, with males having a greater responsibility of providing food and other basic necessities to the family. 53.5% of the respondents fall within the age range of 41-59 years, and about 90.1% were found to be married. Moreover, the highest level of education among the respondents is secondary, with 56.4%.

Table 1: Distribution of Respondents by Selected Socio-Economic Characteristics

Sex	**Frequency**	**Percentage**
Male	148	67.3
Female	72	32.7
Total	220	100.0
Farming Experience(Years)	**Frequency**	**Percentage**
Less than 10	49	22.3
10-20	134	60.9
21-30	30	13.6
31-40	5	2.3
Above 40	2	0.9
Total	220	100.0

Source: Field data, 2023.

4.2 Climatic Hazards Experienced in the Study Area

Figure 1 shows that many of the respondents (56.36%) experienced flooding as the prevailing climatic hazard in the study area, some 19.55% of the respondents experienced erosion as the next major climatic hazard in the study area, 12.27% experienced change in rainfall pattern, 6.82% mentioned rise in sea level as a climatic hazard, 2.27% mentioned change in salinity as a treat to their fishing business. Few respondents (1.82%) and 0.91% respectively mentioned change in water quality and frequent storms as the climatic hazards experienced. The implications of being familiar with the various climatic hazards in the study areas are that it enables the fish farmers to be aware of various coping strategies available locally and around them that will improve their livelihood. According to Agboola and Olurin (2003) who reported that the World Bank ranked coastal erosion as needing moderate priority attention in the Niger Delta. The associated inundation will increase problems of floods, intrusion of seawater into freshwater sources, and destroy ecosystems, such as stabilizing systems such as mangroves, which affect agriculture, fisheries, and general livelihoods.

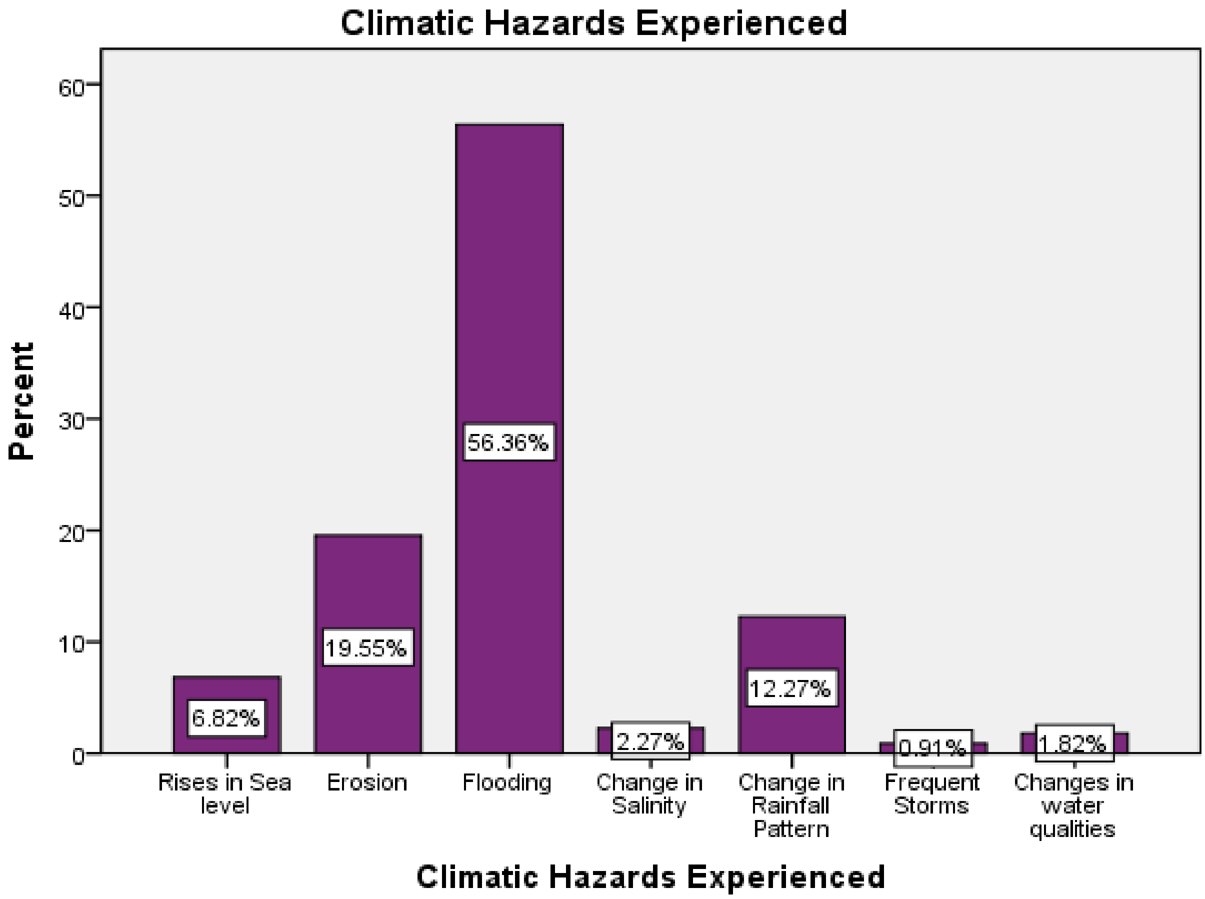

Figure 1: Climatic Hazards Experienced in the Study Area

Source: Field data, 2023.

4.3 Determinants of households' major drivers of fish farmers' vulnerability to climatic hazards

The result of the ordered logistic regression model in Table 2 revealed that the combined effect of all the variables in the model is different from zero, and the model as a whole is statistically significant compared to the null model with no predictors. Based on the results of z statistics, it is indicated that Economic status (β = 1.215, p = 0.040), hazard experienced (β = 0.577, p = 0.000), coping measures(β = 0.180, p = 0.027), climate information (β = -2.485, p = 0.017), erosion occurrences (β = 1.811, p = 0.000), and livelihood of the fish farmer's (β = 1.884, p = 0.000) were all found to be significant at 5% and 1% and positive, this indicates that they are major drivers of fish farmers vulnerability to climatic hazards while farmers association (β = -0.8060 p = 0.028), flood occurrences(β = -2.983, p = 0.000) and land mud (β = -1.942, p = 0.000) were found to be significant at 5% and negatively related to the major drivers of fish farmers vulnerability to climatic hazards which indicated that fish farmers losses as a result of climatic hazards would consequently affect the livelihood of the affected smallholder farmers since it is their major source of income. With regards to proportional odds ratios, the results from Table 2 further indicated that respondents' level of education, trade union, access to extension agents, input subsidies, economic status, climate change, cost of fish, and fish farmers' livelihood are all greater than one (>1), meaning that their odds of being drivers of vulnerability are greater.

However, explanatory variables such as size, education, cooperative societies, trade union, access to extension, credit facilities, ownership of a fish farm, input subsidies, social class, human activities, climate change, dry weather, loss of aquatic life, cost of fish, and climatic hazards were not significant. This result was consistent with the findings of Suharyanto et al. (2014), who found that farming households in Bali were positively and significantly related to food security. However, explanatory variables such as age, food prices, household size, flood occurrence, inundation depth, livestock, and farm assets losses were not significant but found to be consistent with the a priori expectation of a negative relationship with the dependent variable. Fluctuations in food prices have a negative effect on consumers' purchasing power, which in turn affects their accessibility to the adequate quantity and quality of food they require (Suharyanto *et al.*, 2014).

Table 2: The determinants of households' major drivers of aquaculture fish farmers' vulnerability to climatic hazards.

Explanatory Variables	Coefficient	Standard Error	Z Scores	P>|z|	[95% Conf. Interval]	
Size	.0765574	.0575143	1.33	0.183	-.036168	.1892834
Education	.6609573	1.321498	0.50	0.617	-1.92913	3.251046
Farmer Association	-.806002***	.3659388	-2.20	0.028	1.52322	-.0887752
Cooperative Societies	.3079231	.34465	0.89	0.372	-.367578	.9834246
Trade Union	.5115283	.3823437	1.34	0.181	-.237851	1.260908
Access to Extension	.840831	.4254016	1.98	0.048	.0070593	1.674603
Credit Facilities	-.1697337	.4005117	-0.42	0.672	-.954722	.6152548
Farm Ownership	-1.851179	1.078444	-1.72	0.086	-3.96489	.2625328
Inputs Subsidies	.4530869	.4799153	0.94	0.345	-.487529	1.393704
Economic Status	1.215017***	.5922083	2.05	0.040	.0543104	2.375724
Social class	-.3620773	.2948796	-1.23	0.219	-.9400307	.215876
Hazards Experienced	.5770642***	.110107	5.24	0.000	.3612584	.79287
Coping Measures	.1800916***	.0816577	2.21	0.027	.0200455	.3401377
Climate information	-2.485438***	1.041418	-2.39	0.017	4.52658	.4442964
Flood Occurrences	-2.983189***	.501117	-5.95	0.000	-3.96536	-2.001018
Erosion Occurrences	1.810666***	.4038811	4.48	0.000	1.019073	2.602258
Mud land Occurrences	-1.94221***	.5245622	-3.70	0.000	-2.97033	-.914087
Human Activities	-.3561558	.3197955	-1.11	0.265	-.982943	.2706318
Climate Changes	.5039101	.3224189	1.56	0.118	-.128019	1.135839
Dry Weather	.3663598	.2283018	1.60	0.109	-.0811035	.8138231
Loss Aquatic lives	-.6832779	.4651375	-1.47	0.142	1.594931	.2283749
Cost of fishes	.2472323	.5891952	0.42	0.675	-.907569	1.402034
Farmers Livelihood	1.883685***	.4601291	4.09	0.000	.9818483	2.785521

Climatic Hazards	.3182937	.1514465	2.10	0.036	.021464	.6151234

Field Survey, 2023

Likelihood ratio = -227.73924,

LR chi2 = 200.89. *** Significant at 5% and 1%

5. Conclusions and Policy Issues

The study showed that the majority of fish farmers have adopted various coping measures, such as building embankments around their ponds, planting cover/shade over their ponds, improved fishing management, procuring weather/water monitoring kits, clearing drainage and river course as a coping measure, insuring their fish farm, and various diversification measures in the study area. The study also showed that most fish farmers in the study area experienced floods as the most common climatic hazards in the study area, followed by erosion.

Government should encourage fish farmers to engage in climate-smart agriculture and insure their business against risks and eventualities. These outcomes will assist decision makers, donors, and government agencies in making decisions on interventions with regard to institutional supports for climate-smart developments, thereby reducing the overarching effect of climate-driven production changes on fish production in Southwest Nigeria.

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