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Assessing the impact of flood risk and associated factors on profitability of fish farming operations: evidence from South- South Nigeria

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Abstract

Fish farming plays a crucial role in food security and economic development in Nigeria. However, the country's susceptibility to floods due to its geographical location and climate change has raised concerns about the profitability and sustainability of fish farming operations. This study aims to assess the impact of flood risk and associated factors on the profitability and sustainability of fish farming operations in South-South, Nigeria. The research employs a purposive random sampling techniques to generate data on flood frequency and severity, associated factor affecting profitability fish farms locations in the three (3) states, and other associated factors affecting profitability of fish farmers, their production figures are collected and analyzed to identify areas prone to flooding and the extent of damage caused to fish farms. Additionally, two hundred and one (180) fish farmers were sampled for the study (Delta 96, Bayelsa45 and Rivers 60 fish farmers) to gather information on flood risk effects, perception and profitability during flood occurrence. Preliminary findings indicate that flood severity is statistically significant at a 5% level (t-ratio: -2.4806) with a negative coefficient (-0.4876). Flood frequency is statistically significant at a 1% level (t-ratio: -4.5934). with a negative coefficient of -3.8035. This suggests that more severe flood events are associated with lower profitability among fish farmers. The result also revealed that at a probability of 0.1%, fish farmers in Delta, Bayelsa and Rivers States were susceptible to flooding with about 92.9% experiencing flood events although at a probability of 0.2%, it was noticed that only 7.1% of fish farmers were facing flood events. The study recommends that adoption of climate- smart farming practices, such as choosing flood resistant fish species and diversifying income sources, can enhance resilience, prioritize conducting thorough risk assessments specific to each fish farming location. These assessments should consider historical flood data, local climate conditions, topography, and the vulnerability of infrastructure. These findings will inform farmers and policy makers about the level of risk and guide mitigation efforts.

Keywords: Flood Risk; Sustainability; Fish farms; Profitability; Associated Factors; South Nigeria

1. Introduction

Over the years, Nigeria has experienced a notable increase in the frequency and severity of flooding incidents. These events, attributed to changing rainfall patterns and rising sea levels, have not only led to substantial economic losses but have also raised significant questions about the long viability of aquaculture in flood prone areas. (Ayinde, Folorunsho and Oluwaseun, 2020). Fish farming which constitute a significant proportion of the Nigeria's agricultural sector, is particularly vulnerable to flood-related disruptions include the destruction of infrastructure, loss of fish stocks, and the compromise of water quality, all of which have far-reaching implications for the industry's profitability and environmental sustainability. (Muringai, Naidoo, Mafongoya, and Lottering, 2020).

Recognizing the urgent need to address these challenges, this study aims to assess the impact of flood risk on fish farming operations in the South- South Nigeria. It also seeks to look into the associated factors that contributes to this

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risk, ranging from farming experience, flood severity, frequency of extension contacts, age and climate patterns to management and mitigation strategies. By conducting an in-depth analysis, this study tends to provide valuable insights that can inform policy decisions, guide investment in resilient infrastructure, and enhance the adaptive capacity of fish farmers in Nigeria. Ultimately, the success of fish farming in south-south Nigeria is intrinsically linked to its ability to withstand and recover from the reoccurring threat of floods. This study sheds light on the multifaceted dimensions of this challenge, with the overreaching goal of ensuring the continued profitability and sustainability of fish farming operations in the face of evolving environmental risks. (Asiedu, Adetola& Odame-Kissi 2017).

Fisheries and aquaculture contribute immensely to food production and economic growth as the sector provides about 12% of global livelihoods (Alam & Guttormsen 2019; Lima et al. 2020) and essential nutrients for 3 billion people (Adhikari et al. 2018). Despite being affected by flooding and other climate change disaster, aquaculture supplies roughly 52% of the world's fish meals (FAO 2016; & Guttormsen 2019), and its production is still projected to reach about 109.4 million tons by 2030 (FAO 2018; Lima et al. 2020). Africa's contribution to world aquaculture production is still very low (2.7%) as of 2019 (Chan et al. 2021) but it has experienced a significant increase between 1995 and 2018 with a compound annual growth rate of about 16% (FAO 2016; Halwart 2020; Adeleke et al. 2020). According to Garlock et al. (2020), Africa's aquaculture production has tremendous potential to compete in the world's food industry. Nigeria's fish industry is the second largest in Africa with an estimate of 2.5 million tonnes of potential (FAO 2018). It is one of the fastest growing sub-sectors, making it an important source of livelihood, income generation, and job creation. Despite its economic relevance, the aquaculture in Nigeria is vulnerable to flooding and other climate extremes and variability as it applies to other developing countries. According to the Climate Scorecard (2019) and World Bank (2021), Nigeria is ranked among the ten most vulnerable countries in the world to receive the impact of flooding and natural disasters. Since 2012, the country has experienced severe floods that resulted to about $17 billion in damages in most affected areas (World Bank 2021). The Emergency Events Database (EM-DAT) reported that flood situations in Nigeria between 1900 and 2020 have accounted for 1440 deaths with an estimated $645 million in damages (World Bank 2021). Echendu (2020). The World Bank (2020), stated that over 40 million Nigerians are estimated to be living in high climate exposure areas, and the risk of flooding due to negative rainfall anomalies is expected to increase further.

The problem is multifaceted and demands immediate attention. Flood events, characterized by rising water levels, inundate farms, and disrupt sully chains, only result in substantial economic loses for fish farmers but also jeopardize the food security of a nation heavily reliant on fish as a primary source of protein. Furthermore, these floods affected the profitability, sustainability, affecting water quality degradation and damage to delicate aquatic ecosystems. Therefore, adoption of flood risk mitigation strategies all ply a key role in determining the extent of damage inflicted on fish farming operations. The agricultural sector in Nigeria must include fish farming since it is vital to both economic stability and food security. However, the profitability and sustainability of fish farming are seriously threatened by the rising frequency of floods in Nigeria. According to a number of studies, particularly those conducted in the study region (Abosede 2017, Mircetic 2020, Nwaobiala and Nwosu, 2017, Vukotic, Ivanic and Martin, 2018), families are more susceptible to the effects of flooding. (Achoja, Ogisi, and Okeke 2019) examined the causal and disseminating effects of extreme flooding on food, including fish households, particularly in the study area, are vulnerable to the effect of flood. (Achoja, Ogisi and Okeke 2019), in their study, analyzed the causal and spread effects of extreme flood on food, including fish availability and affordability, as the two dimensions of food security and concluded that flood hazards directly lead to a fall in food supply in Delta state, this study intends to go beyond the previous literature by conducting a research on the associated factors affecting profitability and sustainability of fish farming in South- South, Nigeria. Households are particularly susceptible to the effects of flooding in the study area. This study aims to go beyond the previous literature by conducting research on the associated factors affecting profitability and sustainability of fish farming in South-South, Nigeria. This study also analyzes the causal and spread effects of extreme flood on food, including fish availability and affordability as the two dimensions of food security.

Understanding these factors and their interplay with flood risk is crucial to devising effective strategies that bolster the resilience of the aquaculture production in the face of these growing threats. This study tends to investigate the financial losses incurred by fish farmers due to flood related disruptions; key factor influencing the profitability and sustainability of fish farming in the study locations, assess the financial and environmental sustainability of fish farming operations. This article involves how floods risk and related factors affects the profitability of fish farming operations in South-South, Nigeria. It probably looks into how fish farming operations can be affected by floods, how they affect financial results, and how they endanger their long-term viability in the research area. In light of this, this study aims to close a knowledge gap by offering policy recommendations to the government about the crucial distribution of climatic information in order to lessen the impact of flooding on small-scale fish farmers.

2. Literature Review

Fish farming plays a significant role in Nigeria's food security and economic development. However, the sector faces various challenges, including climate-related risks such as flooding. This literature review explores the existing research on flood risk and its associated factors, particularly in the context of Nigerian fish farming, focusing on its impact on profitability and sustainability.

2.1. Flood Risk in Nigeria

South-south Nigeria experiences seasonal rainfall and riverine flooding, making it susceptible to flooding events. Studies (Ajibade, 2019; Adunuga et al 2020) consistently highlight the increasing frequency and severity of floods in Nigeria due to climate change, deforestation and urbanization.

2.2. Impact on Fish Farming Operations

- **Production losses:** flooding events often leads to significant fish mortality, habitat destruction, and reduced growth rates. Research studies conducted by Adewoye et al (2018); and Nwabeze et al (2017) demonstrates the detrimental effects of floods on fish production.
- **Financial Stress:** Floods cause immediate financial losses for fish farmers, including the destruction of infrastructure and loss of investment. Olufayo et al (2018) highlight the economic burden floods impose on fish farmers, jeopardizing their livelihoods. Flooded roads and transportation routes disrupt the supply chain, making it difficult for fish farmers to access markets. This issue was underscored by Akindele et al, (2019) in their study on the impact of floods on market access for fish products

2.3. Frequency and Adaptive Capacity of fish farmers to Flood Risk

Onyeneke at al (2020), conducted a study on climate change adaptation actions by fish farmers in Delta state Nigeria. Ordinary least square regression as well as the multinomial probit model were used for data analysis in the study. The results showed that fish farmers in Delta state adopted the following; seeking early warning information about flood risk, sitting ponds far from flood prone-areas, improved fish breeds, insurance, livelihood diversification, sinking, consistently monitoring and changing pond water (50%). Some fish farmers in the study area also adopted the strategy of sitting fish ponds far away from flood prone areas (67%). The result further showed that agricultural extension significantly increased the uptake of all the adaptation strategies except insurance. An additional contract with agricultural extension workers significantly increased seeking early warning information by 13.8%, sitting fish ponds far from flood-prone by 7.3% and consistent monitoring of pond water by 0.5%. Agricultural extension provides information on flooding and other climate related issues. Farmers who have more access to extension services are in a better position to access climate risk management information and improved agricultural technologies and techniques.

Bassey et al (2015), investigates the key factors determining the flood risk-adaptive strategies adopted by catfish farmers in Osun State, Nigeria using cross-sectional data collected from 80 randomly sampled catfish producers. Results of the study showed that catfish farming is male-dominated (81.3%) and that respondents had access to different sources of capital and that all the farmers were constrained by one risk or the other, especially flood risk. The study also revealed that farmers employed different risk adaptive strategies of which the major ones were siting of fish pond away from flood prone areas (75.0%), strictly treating the pond before stocking (73.8%), using large-sized fingerlings (71.3%) and proper water and feed quality (70.0%). The multivariate probit results revealed that age of respondents, years of education, household size, startup capital, and amount spent on monthly medication and years of experience were the significant factors that affected farmers' choice of risk-adaptive strategies.

2.4. Factors contributing to flood risk

- Climate change: multiple studies (Egberongbe et al 2020; Ezekiel et al 2016) emphasize the link between climate change and increased rainfall, which elevates the risk of floods in Nigeria.
- Mitigation and adaptation Strategies: Research (Onyeneke et al 2021, 2020; Edeh *et al* 2021) suggests that fish farmers in Nigeria have adopted have adopted various strategies to mitigate flood risks. These include raising building and ponds above the flood level, or investing in improved infrastructure.

Summarily, the literature review revealed that flood risk poses a significant threat to profitability and sustainability of fish operations in Nigeria. Climate change, land use changes, and inadequate infrastructure are key drivers of this risk. While some adaptation strategies are being employed, there is a need for comprehensive policies and interventions to enhance the resilience of the fish farming sector in the face of increasing flood risk.

3. Material and methods

3.1. Location description

The south-south region of Nigeria is where the study was conducted. three States—Delta, Bayelsa, and Rivers States were captured for the study region. Nigeria's South-South is strategically located at the Atlantic Ocean's Y-junction with the Niger River through the Gulf of Guinea. Additionally, a dense rain forest zone that supports agricultural operations makes up the research region. According to National Bureau of Statistics (NBS) (2012), it comprises 66.6 percent of the Niger Delta, where oil and gas are economically exploited, and consequently dominates Nigeria's economy.

The South South Nigeria is located at latitude 4^0N and longitude 6^0E, with an area of 84,587km^2 and has a coastline spread of over 540 km^2. The area is bordered to the South by the Atlantic Ocean and to the East by Cameroun with a population of 17.6 million people (National Population Commission, (2022). The area is majorly occupied by the Izons, Urhobo, Isoko, Ikwerre, Ika, Ukwuani, Abua, Itsekiri, Ogoni, Efik, Ibibio, and Bini. It has a rich historical and cultural heritage with major attractions like the Ibenu sand beach, Oron Museum, Asaba beach, Abraka River Resort Model, etc with traditional festival called Ishe festival of peace, Odemimon festival etc. (Ibaba, 2005, Etekpe, 2007).

Over half of the region is covered by tropical rain forests making it favourable for fish and aquaculture production. People in the zone engage in fish farming, trading, lumbering, crop farming, palm wine tapping, palm oil milling, and livestock rearing, weaving and carving. The zone is blessed with water resources that supports fish production, and aquaculture. It is also suitable for fish production due to its unique ecological zone.

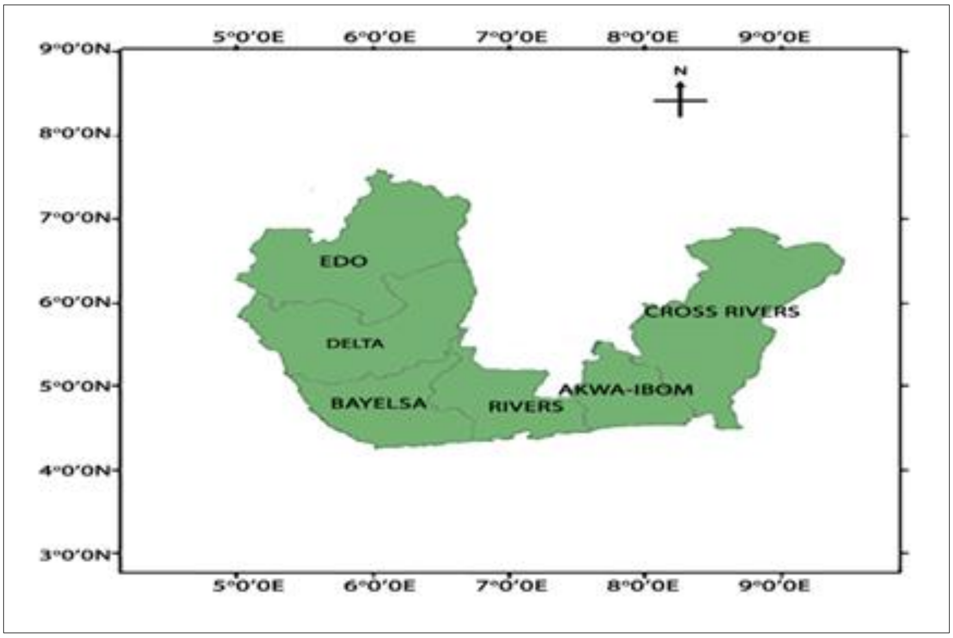

Figure 1 Map of South- South Nigeria

3.2. Data and sampling procedure

The population for the study was made up of fish farmers in South-South, Nigeria. A Multi-stage sampling technique was used for this study. The first stage involves the purposive selection of 3 south-south states which includes: Bayelsa, Delta and Rivers states. The reason for the selection is because of the proximity of the states to each other, due to consistent flood events, dominance of fish farms and the researcher's familiarity with the terrain. The second stage involves the selection of fish farmers in the selected states. The sampling in the third and subsequent stages was done on state-case-basis as plausible in each of the selected states as described below;

Bayelsa State is made up of eight Local Government Areas (LGAs) which are demarcated into three (3) ecological zones. Two (2) agro-ecological zones was purposively selected due to the preponderance of fish farming. The two selected zones consist of six LGAs (Ekeremor, Sagbama, Kolukoma-Opokuma, Yenagoa, Ogbia and Southern Ijaw). This was followed by a purposive selection of three LGAs out of the six (6) and another purposive selection of three (3) communities from each of three LGAs making a total of nine (9) communities. Five (5) fish farmers were randomly selected from the nine communities making a total of 45 respondents for Bayelsa State.

Delta State is made up of 25 LGAs which is further demarcated into three (3) ecological zones namely Delta North, Delta South and Delta Central agro-ecological zone. Delta Central consists of nine (9) LGAs which includes Ethiope East, Ethiope West, Okpe, Sapele, Udu, Ughelli South, Ughelli North, and Uvwie. Delta North consists of eight LGAs which includes Aniocha North, Aniocha South, Ika North –East, Ika South, Ndokwa East, Ndokwa West, Oshimili North, Oshimili South and Ukwuani. Delta South consists of eight LGAs which includes Bomadi, Burutu, Isoko North, Isoko South, Patani, Warri North, Warri South and Warri South-West (NBS, 2012; NPC, 2016). In Delta State, there was a purposive selection of two (2) LGAs from the three (3) agro ecological zones making a total of six LGAs. This was followed by a purposive selection of two (2) communities from each of the LGAs making a total of 12 communities. The final stage was a random selection of eight (8) fish farmers 12 communities making a total of 96 respondents for Delta State

Rivers State is made up of 23 LGAs demarcated into three agro-ecological zones namely Rivers West, Rivers East and Rivers South-East. Two (2) riverine LGAs was purposively selected from each of the agro-ecological zones due to the preponderance of fish farming activities in those LGAs. These LGAs includes Ahoada West and Abua/Odua in Rivers West agro-ecological zone, Ikwerre and Etche in Rivers East agro-ecological zone and Tai and Gokana in Rivers South-East Agro-ecological zone. This was followed by a purposive selection of (2) two communities from each of the previously selected six LGAs to give a total of 12 communities, and finally a random selection of five (5) fish farmers in the 11 communities giving a total of 58 fish farmers in Rivers State.

Probability was used to identify the frequency and severity of fish farming in the study area while multiple regression analysis was used evaluate the associated factors affecting the profitability of fish farmers in the study area.

3.3. Model Specification

3.3.1. Assessment of flood frequency was achieved using probability,

$$Ƥ\ (ƑɆ) = ɸ/Ɣ$$

Where:
Ƥ(ƑɆ) = Probability of flooding event
ɸ = Number of times flooding event occurred
Ɣ = Total number of years (i.e. 10years)

3.3.2. Assessment of flood severity will be achieved using expected value (ƐV).

$$\textbf{Flood severity} = (ƐV) = \sum_{i=1}^{n} \textbf{RLi.}\ (Ƥ(ƑɆ)$$

Where:
(ƐV) = Expected value
RL = Revenue lost to flooding (₦)
Ƥ(ƑɆ) = Probability of flooding
n = Number of flood cases for the past 10 years

3.4. Multiple Regression

The regression model is specified as follows:

$$Y= bo + b_1X_1 +b_2 X_2 + X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9 X_9 +ei$$

Where:
Y = Profitability (profitability index)
X1 = age of farmers (in years);
X2 = educational level (years in formal school);
X3 = feeds (kg);
X4 = farmers experience (in years);
X5= frequency of extension contact (number);
X5= membership of association (cluster) (dummy: yes=1; 0 otherwise);

X6= flood severity (revenue lost due to flood risk (₦));
X7= flood frequency (number of flood events in the past 10years)
ei = error term

4. Results and discussion

Table 1 Flood frequency and severity experienced by fish farmers in South- South (Delta, Bayelsa and River States) Nigeria

Probability of flooding event	Fish farmers (n = 196)	
	Frequency	Percent
0.1	182	92.9
0.2	14	7.1
Flood severity		
<250,000	128	65.3
250,000 – 499,999	32	16.3
500,000 – 749,999	23	11.7
750,000 – 999,999	6	3.1
Above 999,999	7	3.6
Mean	283,950.76	

(Source: Field Survey, 2023)

The table offers valuable insights into the flood frequency and severity experienced by fish farmers in South-South Nigeria. At a probability of 0.1, it is evident that fish farmers in the region are susceptible to flooding events, with 92.9% experiencing such events. However, the risk diminishes as the probability increases to 0.2, with only 7.1% of respondents facing flooding events. Notably, all fish farmers were faced with flooding events, suggesting that fish farmers were consistently exposed to flooding at this higher probability level. In terms of flood severity, lower-severity floods below ₦250,000 are commonly experienced by fish farmers. Conversely, fish farmers in each states experienced relatively higher-severity floods in the ₦250,000 – ₦499,999, ₦500,000 – ₦749,999, ₦750,000 – ₦999,999, and above ₦999,999 categories.

The mean flood severity further confirms this trend, with farmers in the study area facing slightly higher average financial losses (₦283,950.76). These findings underscore the need for tailored flood mitigation and support strategies for both groups, acknowledging their distinct vulnerabilities and challenges in the South-South region, to enhance the resilience of the fish farming sector. (Eagles, 2014).

Table 2 Profitability of fish farms in Delta, Bayelsa and Rivers States (South-South) Nigeria

Items			
Variable cost	**Quantity**	**Price**	**Amount (₦)**
Fingerlings/ juveniles	7,510 fishes	55.01	413,118.40
Feeds	135 bags	12,511.87	1,682,846.52
Water			36,859.81
Fuel			60,249.54
Labour			32,357.02
Medication			75,894.72

Veterinary services			67,412.53
Miscellaneous			142,361.39
Total variable cost			**2,511,099.94**
Fixed cost			
Rent	1 year		109,783.92
Pond construction	6 ponds	187,604.01	1,063,089.39
Depreciation			106,308.94
Total fixed cost			**1,279,182.25**
Total cost			**3,790,282.19**
Revenue	5,303.47 Kg	1,128.16	5,983,141.28
Gross margin			**3,472,041.34**
Net revenue			**2,192,859.09**
Net Return on Investment			**0.58**

Source:(Field Survey, 2023)

Table 2. Presents an overall analysis of the profitability of fish farms in the Delta Bayelsa and Rivers States (South-South) Nigeria.

4.1. Variable Costs

All expenditures incurred during production are included in the category of variable costs. The following expenses are incurred: fingerlings/juveniles, food, water, fuel, labor, medication, veterinary services, and other charges. Costs for fish farmers came to 2,511,099.94. The variable costs can be explained by elements including the quantity and cost of supplies, pond size, fish stocking levels, and differences in farming techniques.

4.2. Fixed Costs and Profitability

Fixed costs include expenses that remain relatively constant regardless of production levels, such as rent, pond construction, bore hole pumps and depreciation. fish farmers incurred fixed cost, with a total of ₦1,279,182.25. However, when it comes to profitability, fish farmers also exhibit significantly higher gross margins, generating ₦3,472,041.34. Gross margin represents the profit after deducting variable costs from revenue. Furthermore, when considering net revenue (which factors in both variable and fixed costs), the difference remains substantial. Fish farmers in the study area achieve a net revenue of ₦2,192,859.09. This showed that fish farming in South-South Nigeria is financially rewarding, with a net return on investment (ROI) of 0.58.

This indicates that fish farming operations are economically viable in this region. In summary, the profitability analysis underscores that fish farmers in the South-South region, despite incurring higher variable and fixed costs, achieve significantly higher profitability. This result corroborates with the study of Umesh et al (2010), in their study, it was revealed that shrimps farmers operating in cluster had a higher profit margin of Rs530 ($16) during the period of study.

Table 3 Influence of flood risk and associated factors on the profitability of fish farmers in South-South (Delta, Bayelsa and Rivers State) Nigeria

Variables			
	Coefficient	**Standard error**	**t-ratio**
Constant	2.7501	0.5265	5.2235
Age	-2.2798**	1.1237	-2.0289
Educational level	2.5693***	0.7098	3.6197
Feeds	-1.4405	0.7400	-1.9468
Farmers experience	0.4943	0.9252	0.5343
Sex	2.2441***	0.6830	3.2856
Frequency of extension contact	0.4916	2.3618	0.2081
Membership of association	1.4378	3.5572	0.4042
Flood severity	-0.4876**	0.1966	-2.4806
Flood frequency	-2.3141**	0.8372	-2.7641
Amount of money spent during flooding	-2.5025***	0.5902	-4.2401
Model summary	**R^2**	**Adj. R^2**	**F**
	0.5996	0.5422	6.8265

Where: *** and ** are statistically significant at 1% and 5% level respectively; **(Source: Field Survey 2023)**

The results from the regression analysis investigating the influence of flood risk and associated factors on the profitability of fish farmers in South-South Nigeria, the following significant variables were observed:

- **Age:** Age is statistically significant at a 5% level with a t-ratio: of -2.0289 and has a negative coefficient (-2.2798). This implies that older fish farmers have lower profitability.
- **Educational Level:** Educational level is statistically significant at a 1% level (t-ratio: 3.6197) with a positive coefficient. This suggests that fish farmers with higher educational levels tend to have higher profitability in cluster fish farms.
- **Sex:** Sex is statistically significant at a 1% level (t-ratio: 3.2856) with a positive coefficient (2.2441). This suggests that being male is associated with higher profitability.
- **Flood Severity:** Flood Severity is statistically significant at a 5% level (t-ratio: -2.4806) with a negative coefficient (-0.4876). This suggests that more severe flood events are associated with lower profitability among fish farmers. The finding of this study is consistent with a study by Ehiakpor et al. (2016) who reported a negative relationship between climate change and income level/profitability. The result also showed that flooding shows that positively and significantly income of farmers
- **Flood Frequency:** Flood frequency is statistically significant at a 1% level (t-ratios: -2.7641 and -2.5078). The negative coefficients (-2.3141 and -1.2802) indicate that a higher frequency of floods leads to lower profitability in the study.

4.3. Model Summary

The model explains approximately 59.96% of the variability in profitability (R2). This suggests that a substantial portion of the variance in profitability can be attributed to the independent variables included in the model. The adjusted R-squared (Adj. R2) is 0.5422, indicating that after accounting for the number of predictors, the model retains moderate explanatory power. The F-statistic is 6.8265, which is statistically significant ($p < 0.05$), indicating that the overall model has a significant impact on explaining profitability.

Overall, the analysis reveals that several factors, including age, educational level, sex, flood severity, flood frequency, and spending during flooding, have varying degrees of influence on the profitability of fish farmers in South-South Nigeria. These findings underscore the importance of considering these factors in policies and interventions aimed at enhancing the profitability of fish farming and encourage small scale farmers to delve into fish farming/production.

Summarily, these results indicate that several factors, flood frequency and severity have varying impacts on the profitability and is also an additional factors affecting the profitability of fish farm agribusiness in the south- south region. This result is consistent with previous findings that access the impact of membership of an association as having a significant factor on profitability and efficiency of crop farmers. (Adeoye et al (2009).

Table 4 Influence of flood risk and associated factors on the profitability of fish farmers in South-South Nigeria (Semi-log, Double –log, Exponential and Linear)

Variables	**Linear**	**Double log**	**Exponential**	**Semi-log**
Constant	2.7501	1.7296	-0.4371	3.6335
	(5.2235)	(0.8675)	(-5.5925)	(5.3658)
Age	-2.2798**	0.0249	1.9505	-0.1739
	(-2.0289)	(0.0890)	(0.1648)	(-0.6584)
Educational level	2.5693***	-1.8693**	1.4817	0.0205
	(3.6197)	(-2.3968)	(0.9582)	(0.4662)
Feeds	-1.4405	0.6450	-6.6505	0.0476
	(-1.9468)	(1.2555)	(-0.0443)	(0.5668)
Farmers experience	0.4943	-0.0289	-1.2270	-0.0312
	(0.5343)	(-0.2831)	(-0.4769)	(-0.2511)
Sex	2.2441***	1.5747***	1.9260	-0.0716
	(3.2856)	(4.3415)	(0.1639)	(-0.2226)
Frequency of extension contact	0.4916	0.9199***	7.4500	0.0613
	(0.2081)	(3.3019)	(0.2669)	(0.7880)
Membership of association	1.4378	0.7851***	1.2765***	1.7462
	(0.4042)	(14.6442)	(3.9688)	(0.2143)
Flood severity	-0.4876**	1.4002***	3.7772***	2.8118
	(-2.4806)	(4.8061)	(6.7441)	(0.8917)
Flood frequency	-2.3141**	0.4103	5.6402***	0.1353***
	(-2.7641)	(0.8596)	(2.5630)	(4.4598)
Amount of money spent during flooding	-2.5025***	8.9710	1.8829	110.1262
	(-4.2401)	(0.4163)	(0.7579)	(0.0737)
R^2	0.5996	0.6152	0.5424	0.3153
Adjusted R^2	0.5422	0.5905	0.5092	0.2832
F-ratio	6.8265***	16.9452***	7.4607***	2.6241***

Figures in parenthesis () are t-values; Where: *** and ** are statistically significant at 1% and 5% level respectively

The table presents the results from the regression analysis investigating the influence of flood risk and associated factors on the profitability of fish farmers in South-South Nigeria. The multiple linear model was chosen as the lead equation and the results as presented in the table. The coefficient of determination, R2 value was 0.5996 indicating that 59.96% of the variation in profitability is explained by the explanatory variables while the Adjusted R-squared (Adj. R2) is 0.5422, indicating that after accounting for the number of predictors, the model retains moderate explanatory power. The F-statistic is 6.8265, which is statistically significant ($p < 0.05$), indicating that the overall model has a significant impact on explaining profitability in cluster fish farms. The coefficient ((-2.2798) for age showed that age is statistically at 5%. this implies that as the age of the clustered fish farmer's increases, their profit level decreases. This finding agrees with the study of Gbigbi and Achoja (2020) who reported that age had a negative influence on fish output in Delta State.

Educational Level is statistically significant at a 1% level (t-ratio: 3.6197) in cluster fish farms, with a positive coefficient (2.5693).

This suggests that fish farmers with higher educational levels tend to have higher profitability in cluster fish farms. This study agreed with the work by Inoni and Oyaide (2007) study on the effect of productive inputs of pond fish production on the output of fish in Imo State, Nigeria. Sex is statistically significant at a 1% level (t-ratio: 3.2856) with a positive coefficient (2.2441). This suggests that being male is associated with higher profitability in cluster fish farms. The coefficient for flood frequency and severity (-0.4876 and -2.3141) showed that Flood Severity is statistically significant at a 5% level while flood severity is statistically at 1%. Which implies that that more severe flood events are associated with lower profitability in cluster fish farms. The finding of this study is consistent with a study Ezeh et al (2008) who also obtained similar results although their study did not consider cluster fish farmers.

Summarily, the model explains approximately 59.96% of the variability in profitability (R2). This suggests that a substantial portion of the variance in profitability can be attributed to the independent variables included in the model. The adjusted R-squared (Adj. R2) is 0.5422, indicating that after accounting for the number of predictors, the model retains moderate explanatory power. The F-statistic is 6.8265, which is statistically significant ($p < 0.05$), indicating that the overall model has a significant impact on explaining profitability in cluster fish farms.

5. Conclusion and Recommendation

Fish farming is a critical components of Nigeria’s agriculture sector, contributing significantly to food security and economic development. However, the profitability and sustainability of fish farming operations in Nigeria are increasingly threatened by flood risk and associated factors. This study explores the key findings and implication of assessing the impact of flood risk on fish farming in South-South Nigeria. The study revealed that flood risk is a substantial challenge for fish farmers in the study area, with both direct and indirect consequences. Direct impacts include damage to fish ponds, loss of fish stock, and infrastructure damage. Indirect effects involve increased operational costs, reduced market access, and decreased fish production. The severities of these impacts varies regionally, with coastal and riverine areas being more vulnerable. These impact and associated factors on profitability and sustainability of fish farming operations in Nigeria is a pressing concern. While fish farming has the potential to address food security and boost the economy, addressing these challenges is essential to realize its full potential.

To mitigate these risks and enhance the sustainability of fish farming, policy makers, stakeholders and farmers must take concerted actions. These actions may include(Recommendations)

- Climate resilience: adoption of climate- smart farming practices, such as choosing flood resistant fish species and diversifying income sources, can enhance resilience.
- Infrastructure development: investment in improved pond design, flood control mechanisms, and drainage systems can help minimize flood related losses.
- Land use planning: proper land use planning can prevent the construction of fish farms in flood prone areas, reducing vulnerability.
- Conduct comprehensive risk assessment: prioritize conducting thorough risk assessments specific to each fish farming location. These assessments should consider historical flood data, local climate conditions, topography, and the vulnerability of infrastructure. These findings will inform farmers and policy makers about the level of risk and guide mitigation efforts.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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