EMPIRICAL ANALYSIS OF FLOOD IMPACT ON FOOD SECURITY IN NIGERIA`S COASTAL REGIONS

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Abstract

One common and recurrent natural disaster associated with the coastal region of Nigeria is flooding. The disaster created by flooding is exacerbated by climate change and rising sea levels with huge consequences such as food availability, accessibility, stability and utilization. The impact of flood is profound and multifaceted in the region. Therefore, this study seeks to empirically explore and examine the impact of flooding on food security in the coastal region of Nigeria. Mixed statistical methods of Multiple Regression Analysis (MRA) and Geographically Weight Regression (GWR) were utilized to assess the relationship between flooding and food security indicators. Data for the study was collected from the coastal communities in Nigeria affected by flooding over the years. The analysis demonstrated a significant negative impact of flooding on food security in the coastal region of Nigeria. GWR analysis reveals that the severity of food insecurity is more pronounced in communities with lower social economic status and limited adaptive capacities. The study established that the quantitative independent variables are statistically significant using the fitted model. Thus, the study underscores the critical need for targeted intervention to enhance food security in flood affected coastal regions of Nigeria.

KEYWORDS: Flooding, Food security, Coastal region, Food prices, Climate change, Empirical study, Agricultural productivity.

Sub-theme of the abstract: Climate **change, sea level raise and coastal hazards.**

1 Introduction

0ne common natural event that often characterized the coastal region of Nigeria is flooding with its attendant consequences on the environment, properties and human survival. Flooding is the overflow of water into normally dry land due to heavy rain fall, storm surges (dam failure), rising sea-levels such that oceans, rivers, lakes cannot accommodate the water and not easily absorbed by the ground or contained by artificial barriers. Therefore, flooding occurs in the coastal region when excessive volume of water from heavy rainfall or ocean surges inundates normally dry land with excessive water. This region is characterized by the low-lying areas and proximity to large bodies of water hence vulnerable to flooding.

Zewdie (2014) reviewed the impacts and implications of climate change on food security. The findings averred that climate change has enormous impact on food security as result of excessive rainfall and rising sea levels leading to disastrous flooding of farmland, crops and communities.

The coastal region comprises of inshore waters, coastal lagoons, estuaries and mangroves especially in the Niger Delta states of Nigeria. Floods are recurrent natural disaster in this region that impact negatively on the environment including the available farmland and growing crops in the farmland, thereby affecting and altering food availability, stability and perhaps utilization. Floods depending on the intensity and severity submerge farmland and destroy crops with large scale consequences on crop yields, food availability, food prices and household food consumption patterns. Ahmed et al. (2015) empirically reported the effects of flood and general insecurity on food security among farming households. The study further asserts the huge consequences of flooding on crop yields among household farmers affected by massive flooding.

Nkeme (2017) examined the impact of recurrent flooding on staple crops farming in the Niger Delta. The findings indicated a substantial drop in crop yields due to flood-induced soil erosion and water logging which severely affect the growth conditions of the crops, thus affecting availability and prices. Food security is an intentional process of ensuring that the entire population has adequate access to sufficient, safe, healthy and nutritious food all year round. Floods impact on food security through direct and indirect pathways affecting agricultural productivity, food supply chains and socio-economic conditions of the entire region and beyond.

Eze (2019) focused on cassava farms in the coastal areas of Lagos State. The study revealed that flooding resulting in 30% decrease in cassava yields, primarily due to root rot and delayed planting season. The disaster created by floods on a yearly cycle is enormous as practically all crops are affected from the planting point to the harvest period. Flood events resulted in huge financial losses, induced poverty on smallholder farmers and reduced farmer capacity to reinvest in agricultural inputs and technology (Ebele & Emodi, 2018).

Chikezie et al. (2019) explored the broader economic impacts of flooding on rural livelihoods, demonstrating how the destruction of farmlands and farm related infrastructure led to increased poverty and food insecurity among coastal communities. Floods continue to ravage and wreck unimaginable havoc on the coastal towns and villages destroying buildings, roads, farmlands, animals and crops resulting in abysmally poor crop yields and the consequent short fall in food supply and food availability. The consequences of the foregoing are drop in food supply, sever hunger, increased in prices of food items and insecurity in the land.

Ayodele (2018) empirically investigated the impact of flooding on market access for farmers in Bayelsa state. The study revealed that poor transport infrastructure, massive flooding, limited farmer's ability to access market resulting in lower sales prices and huge post-harvest losses. Nkeme (2021) assessed the food security status of household affected by flooding in Delta state. The findings revealed that households ravage by massive flood experienced higher levels of food insecurity, with reduced food intake and dietary diversity. The general level of food insecurity in the coastal regions and beyond are direct impact of flooding on farmland, road networks and residential areas within the coastal communities.

Weeks and Wizor (2020) reported sharp price fluctuations of fish and other essential seafood in the Niger Delta where flooding significantly affected the availability of these products, causing remarkable price increases during and after flood event. Empirical literature underpins the significant impact of flooding on food security indicators in Nigeria's coastal regions and other parts of Nigeria. Floods lead to reduced agricultural productivity, increased food prices and greater economic vulnerability and insecurity.

Dominic and Benjamin (2023) examined the impact of flooding on food security and the findings revealed that there is always a gross inadequacy of food supply during the years of devastating floods compared to years of normal annual rainfall. Consequently, food security indicators such as prices of agricultural product increased by almost 200% and household income declined significantly during the flood disaster years.

Scientific studies and existing literature revealed that flooding has profound effect on food security by reducing crop yields, food supply, farmers' income, food availability, accessibility, utilization. In the light of above, food insecurity created by massive flooding is stark reality confronting our nation demanding urgent and all encompassing proactive interventions by all stakeholders

1.1 Conceptual Framework

Nigeria's coastal regions are essentially important for the nation's food security due to their rich fertile soil, huge agricultural resources and significant contributions to the national food production. The large volume of water bodies such ocean, lakes, river, lagoons; estuaries are large reservoir of sea food that can contribute immediately to food production. However these areas are increasingly vulnerable to flooding, a natural disaster exacerbated by climate change, rising sea levels and inadequate infrastructure resilience. Flooding poses a severe threat to food security through its devastating effects on farmland, crops yields, farm infrastructure, and access road thereby affecting food availability, accessibility and utilization.

Thus, the coastal regions face recurrent flooding which has profound implications for agricultural productivity, farmer's livelihoods and overall food security. This empirical study seeks to understand the extent of these impacts and identity key factors contributing to food insecurity in flood-prone areas. The study therefore in aim to provide evidence based actionable insights that can inform and direct policy making and strategic interventions to enhance the resilience of coastal communities.

1.2 Statement of the Problem

Flooding, a recurrent natural disaster in the coastal region, disrupt agricultural activities by inundating farm lands with excessive water, destroying crops and eroding soil quality with greater consequences on crop yields and food availability. Additionally, flooding affects food supply chain through destruction of farm facilities and road infrastructure. The cumulative effects of these disruptions contribute immensely to food insecurity, particularly in areas with high poverty rates and limited adaptive capacities. Consequent upon the foregoing, the study therefore is intended to address the following main issues:

1. Empirically assess the impact of flooding on food security indicators in Nigeria" coastal regions
2. Evaluate the frequency and severity of floods and their direct effects on crop yields and agricultural productivity
3. Analyze the relationship between flood events and food security indicators like crop yields
4. Providing policy recommendations to mitigate the adverse effects of flooding on flood security

2.0 Methodology

Floods pose significant environmental challenges that disproportionately affect agricultural regions, especially the coastal areas. The impact of flooding on food security in Nigeria coastal regions is diverse and multifaceted in nature. Therefore, mixed statistical methods will be employed in this study integrating quantitative data with qualitative field observations. Data were collected from the coastal communities through interview, survey and secondary sources. Multiple Regression Analysis (MRA) and Geographically Weighted Regression (GWR) were employed to assess the relationship between flooding and food security indicators. This empirical analysis is aim to provide actionable insights that will enhance food security, community resilience in the face of the recurrent floods.

2.1 Model Specification

In further search for the relationship between crop yields and food insecurity indicators created by flooding, a quantitative technique is adopted to determine the influence of the selected variables on crop yields.

The MRA model is specified as follows:

$$Y=\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon \quad (1)$$

Where

Y= Crop yield

X_1 = Number of flood event in a year

X_2 = Duration of flood events (days)

X_3 = Total area covered by flood (ha)

X_4 = Total annual rainfall (mm)

X_5 = farm size

X_6 = Soil PH level

X_7 = Farm input expenditure (#)

Also, Geographically Weighted Regression (GWR) model is specified as follows:

$Y_i = \beta_0 (u_i v_i) + \sum_{k=1}^{p} \beta_k (u_i v_i), X_{ik} + \varepsilon$ (2)

Where:

Y_i = crop yield
β_1 $(u_i v_i)$. Number of flood event in a year, β_2 $(u_i v_i)$. Duration of flood events (days), β_3 $(u_i v_i)$. Total area covered by flood (ha), β_4 $(u_i v_i)$. Total annual rainfall (mm), β_5 $(u_i v_i)$. Farm size, β_6 $(u_i v_i)$. Soil PH, β_7 $(u_i v_i)$. Farm input expenditure (₦).

β_1 $(u_i v_i)$, β_2 $(u_i v_i)$, β_3 $(u_i v_i)$, β_4 $(u_i v_i)$, β_5 $(u_i v_i)$, β_6 $(u_i v_i)$ and β_7 $(u_i v_i)$ are the vary across, reflecting the impact of independent variables on crop yields

3. Results and Discussion

In this section of the study, the researcher presents the results of the data analysis that was accomplished through R. code Statistical software. The study primary interest lies in empirically determining the influence of selected food insecurity indicators (independent variables) on crop yields in coastal region of Nigeria. The results were presented in **Table 1, Table 2, Table 3 and Table 4 respectively.**

Table 1
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	1.192	1.204		.990	.332
	Number of Floods per Year	-.019	.197	-.048	-.097	.002
	Duration of Flood Events (Days)	-.003	.043	-.022	-.058	.003
	Total Area Covered by Flood (ha)	-.005	.004	.601	-1.134	.002
	Total Annual Rainfall (mm)	-.001	.000	-.814	-3.203	.004
	Farm Size (ha)	.039	.009	.346	4.181	.000
	Soil pH Level	.567	.170	.574	3.346	.062
	Farm Input Expenditure (₦)	-1.502E-6	.000	-.108	-1.070	.029

a. Dependent Variable: Crop Yield per Hectare (tons/ha)

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.995[a]	.990	.987	136.36594

Table 3: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	42898391.417	7	6128341.631	329.557	.000[b]
	Residual	446296.083	24	18595.670		
	Total	43344687.500	31			

a. Dependent Variable: Average Price of Yam (₦ per tuber)

b. Predictors: (Constant), Farm Input Expenditure (₦), Soil pH Level, Farm Size (ha), Total Annual Rainfall (mm), Number of Floods per Year, Duration of Flood Events (Days), Total Area Covered by Flood (ha)

Considering **Table 1,** the fitted multiple regression model yields:

$\hat{y}$ =1.192-0.019x_1-0.03x_2-0.005x_3-0.001x_4+0.39x_5+0.56x_6-1.502x_7

(1.24) (0.197) (0.043) (0.004) (0.000) (0.009) (0.170) (0.000)

Where, the values in parenthesis are the respective standard errors of the estimates. The standard errors are relatively close to the parameter estimates, inevitable consequences of non-collinearity inherent in the structure of the data. The estimated regression parameters have negative signs except for x_5 and x_6. The negative signs clearly suggests that the number of flood in a year, duration of flood events (days), total area covered by flood(ha), total annual rainfall and total expenditure on farm inputs (₦) induces reduction in crop yields, thus creating food shortages and food insecurity.

Additionally, **Table 2** revealed the Adj R^2 (0.987). The value reaffirmed the adequacy of the model that 98.7% of the variability associated with crop yields and perhaps food insecurity are explained by the changes in selected flood induce independent variables. The **ANOVA** output presented in **Table 3** provides the F variance ratio. The relatively large value of the F ratio is an indicative of the adequacy of the model revealing the negative influence of flood induce independents on crop yields.

Table 4: Model Summary Based on Geographic Locations

Location	Intercept	Rainfall Coefficient	Soil pH Coefficient	GWR Estimate	Prediction	Local R^2
Edo	3.0287	-0.001070	0.3148	-0.3215 to 0.5604	4.0287 to 4.3328	0.7592
Bayelsa	2.6066	-0.001013	0.3727	-0.2934 to 0.2104	2.2320 to 3.9896	0.8309
Delta	2.8514	-0.001048	0.3394	-0.4963 to 0.5472	2.5912 to 4.3649	0.7976

Considering **Table 4**, the intercepts vary slightly across the locations, with Edo having the highest intercept (3.0287) and Bayelsa the lowest (2.6066). This suggests that when other variables are held constant, the base level of the dependent variable (likely related to crop yield or a similar metric) is highest in Edo. The coefficients for rainfall are consistently negative across all locations, indicating that an increase in rainfall slightly decreases the dependent variable. This impact is relatively small, with the largest magnitude in Edo (-0.001070).The soil pH coefficient is positive in all locations, indicating that an increase in soil pH tends to increase the dependent variable. Bayelsa has the highest coefficient (0.3727), suggesting that soil pH has a slightly more substantial effect on the dependent variable in Bayelsa than in Edo or Delta.

The geographically weighted regression (GWR) estimate varies significantly across the locations and within the locations themselves, reflecting the spatial variability of the relationship. In Edo, for example, the GWR estimate ranges from -0.3215 to 0.5604, indicating that the effect of the variables varies within Edo itself.The prediction values, which are likely estimates of the dependent variable (CROP YIELD), also vary across locations. Edo tends to have the highest predicted values (up to 4.3328), while Bayelsa shows a broader range, reflecting the higher variability in this region. The local R^2 values are relatively high across all locations, indicating that the model explains a significant portion of the variability in the dependent variable in each location. Bayelsa has the highest local R^2 (0.8309), suggesting that the model fits the data best in this region.

Fig 1: GWR Coefficient for rainfall

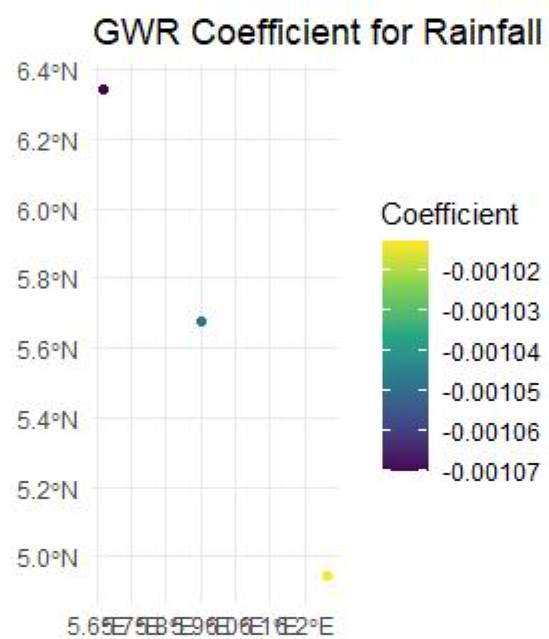
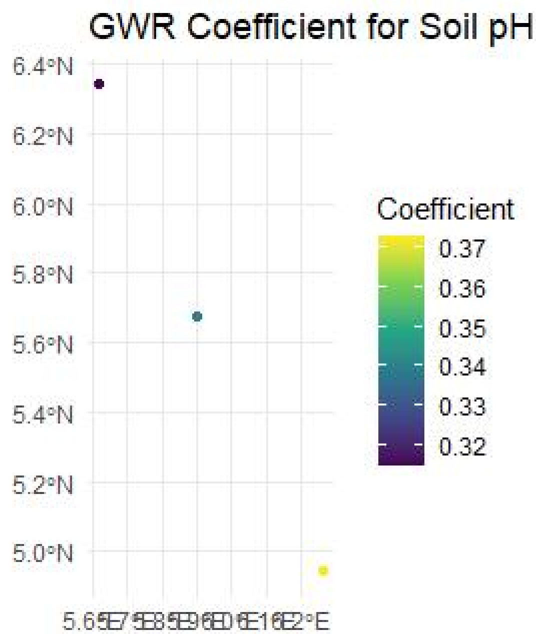


Fig 2: GWR Coefficient for Soil pH



The model results reveal significant geographic variability in the relationships between the dependent variable and the predictors across Edo, Bayelsa, and Delta. While the intercepts are similar, indicating a comparable baseline level of the dependent variable across locations, the coefficients for rainfall and soil pH show notable differences. Rainfall consistently has a slight negative effect on the dependent variable across all regions, but its impact is most pronounced in Edo. Conversely, soil pH has a positive effect, with the strongest influence observed in Bayelsa, suggesting that soil quality may play a more crucial role in this area.

The geographically weighted regression (GWR) estimates and predictions further emphasize the spatial differences, particularly within each location. Edo exhibits the widest range in GWR estimates, highlighting the variability in the relationships within the region itself. Bayelsa has the highest local R^2, indicating the model's strong explanatory power there, while the other regions also show substantial but slightly lower model fit. These findings underscore the importance of considering geographic context in environmental data analysis, as the impact of factors like rainfall and soil pH can vary significantly from one location to another.

4. Conclusion and Recommendations

4.1 Conclusion

Flooding in the coastal regions of Nigeria poses a significant threat to food security by damaging agricultural lands, disrupting food supply chains and causing economic hardship. Thus, the study comprehensively and empirically investigated and assesses the impact of flood induce independent variables on crop yields on coastal region of Nigeria with the following conclusions:

- Five of the selected flood induce independents variables (x_1, x_2, x_3, x_4 and x_7), in the study revealed substantial negative impact of these independent variables on crop yields and thus food insecurity.

- Adj-R^2 revealed the enormous negative influences of flood induce indicators on crop yields with great consequence on food supply, availability and accessibility.
- Additionally, GWR model provides and account for spatial heterogeneity revealing the influence of geographical location on food insecurity. The tool offered insight on the nuanced and localized effect of flood induces food security indicators on crop yields.

4.2 Recommendations

Based on the findings, the following are recommended.

- Construction and maintenance of flood control structures like levees, dikes, drainage systems, sea walls, coastal barriers and dams.
- Encourage and promote climate smart agricultural and resilience practices such as resistant crops varieties, crops with early maturity, and diversify livelihood.
- Early warning structure and disaster preparedness should be inculcated into the resident of the coastal communities.

The strategies embedded in the recommendations can provide immediate and long-term flood secure future for the coastal communities thereby mitigating the adverse effects of flood on food security.

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