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Effects of changing climate on livelihood option of farmers in south east Nigeria

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Abstract

Climate change has increasingly altered the livelihoods of smallholder farmers across Nigeria, with Southeast Nigeria being among the most affected regions. This study assessed the effects of changing climate on the livelihood options of farmers in the region. A multistage sampling technique was employed to select 360 respondents across three states Anambra, Abia, and Ebonyi. Primary data were collected through structured questionnaires and interview schedules, while secondary climatic data (2001-2020) were sourced from the Nigerian Meteorological Agency (NiMet) and relevant research institutes. Data were analyzed using multinomial logit regression and principal component factor analysis. The results revealed that climatic variables such as increased temperature, rainfall variability, drought frequency, flooding, and pest outbreaks significantly influenced farmers' choice of livelihood options. The Nagelkerke R^2 value of 0.602 and a significant Chi-square ($p < 0.01$) indicated a strong relationship between climate variability and livelihood diversification. Farmers increasingly engaged in non-farm enterprises such as petty trading, agro-processing, transportation, and electronic repairs as adaptive strategies. Major constraints to livelihood diversification were grouped into environmental, institutional, and economic factors, including declining yields, long distances to financial institutions, inadequate farm inputs, and high credit interest rates. The study concludes that changing climate conditions significantly affect rural livelihoods and calls for strengthened policy support, enhanced access to finance, and improved extension services to build farmers' adaptive capacity.

Keywords: Climate change, livelihood diversification, southeast Nigeria, smallholder farmers, adaptation strategies

1. Introduction

Climatic conditions play a fundamental role in determining the livelihood systems of human societies. In agrarian economies, environmental factors such as rainfall, temperature, and soil fertility largely shape the dominant economic activities within particular regions (Sampson, Divine, Lawrence, & Felix, 2017; Onu & Onu, 2016) ^[20, 18]. For instance, riverine communities typically depend on fishing, while upland regions with fertile soils engage predominantly in crop cultivation and livestock production. These interrelationships demonstrate that livelihoods are deeply intertwined with the prevailing climatic conditions of an area.

Climate refers to the long-term average of weather patterns within a particular location usually measured over a period of 30 to 35 years (Morse & McNamara, 2013) ^[13]. It encompasses key atmospheric variables such as rainfall, humidity, temperature, wind, and sunshine hours that collectively determine the suitability of a given region for agricultural and other livelihood activities (FAO, 2014) ^[8]. However, the global climate system has been undergoing significant alterations due to anthropogenic activities such as deforestation, industrial emissions, and unsustainable agricultural practices. These changes have resulted in increased atmospheric temperatures, altered rainfall patterns, and the occurrence of extreme weather events, which collectively threaten agricultural productivity, food security, and the overall sustainability of rural livelihoods (Nasreen, Hossain, & Azad, 2015; FAO, 2014) ^[14, 8].

In Nigeria, agriculture remains the mainstay of the economy, employing more than 70% of the rural population. Yet, this sector is highly vulnerable to the adverse impacts of climate change.

The country has witnessed rising temperatures, irregular rainfall distribution, prolonged droughts, and recurrent flooding, all of which have significantly reduced soil fertility, lowered crop yields, and disrupted traditional farming calendars (Onu, 2013; Arslan *et al.*, 2015) ^[16, 3]. These climatic stresses have not only affected agricultural production but also the income and welfare of farm households, thereby heightening rural poverty and food insecurity. The increasing unpredictability of weather patterns has made traditional farming systems less reliable, compelling rural farmers to explore alternative livelihood options to sustain their households (Komba & Muchapondwa, 2015) ^[12]. Such livelihood diversification often includes non-farm activities like petty trading, agro-processing, commercial driving, tailoring, and artisanal work, which serve as adaptive strategies to mitigate income loss caused by climate variability.

Globally, several empirical studies have highlighted the nexus between climate change and livelihood adaptation. For example, Kamwi *et al.* (2018) ^[11] examined livelihood activities and skills in rural areas of the Zambezi Region of Namibia, emphasizing policy implications for poverty reduction. Similarly, Akudugu and Alhassan (2012) ^[1] explored climate change, food security, and social safety nets in Northern Ghana, while Branca, McCarthy, Lipper, and Jolejole (2013) ^[5] reviewed the relationships between food security, climate change, and sustainable land management practices. In Nigeria, Igwe and Mbam (2013) ^[10] investigated farmers' adaptation to climate change in Ebonyi State, identifying socioeconomic and institutional determinants of resilience. Despite these efforts, there remains a paucity of empirical evidence focusing specifically on how farmers in Southeast Nigeria a region characterized by dense population, intense agricultural activity, and increasing environmental degradation adjust their livelihood strategies in response to changing climatic conditions.

This knowledge gap underscores the need for a comprehensive analysis of the effects of climate variability on livelihood diversification in the region. Understanding these dynamics is crucial for guiding evidence-based policymaking aimed at enhancing farmers' adaptive capacity and promoting sustainable rural development.

Therefore, this study was designed to assess the effects of changing climate on livelihood options of farmers in Southeast Nigeria. The specific objectives were to:

1. Determine the effects of climate variability on the livelihood options of farmers in the study area; and
2. Identify the major constraints to livelihood diversification among farm households under changing climatic conditions.

To achieve these objectives, the following null hypothesis was tested:

H₀: Changing climate has no significant effect on the livelihood options of farmers in the study area.

2. Methodology

2.1 Study area

The study was carried out in Southeast Nigeria, one of the six geopolitical zones of the country. The region comprises five states Abia, Anambra, Ebonyi, Enugu, and Imo and is geographically located between latitudes 4°30' and 7°5' N and longitudes 6°50' and 8°30' E. It occupies an estimated

land area of 58,214.7 square kilometres and has a projected population of approximately 28.4 million people (National Population Commission [NPC], 2020). The zone is bordered to the north by Benue and Kogi States, to the south by Akwa Ibom State, to the east by Cross River State, and to the west by Delta and Rivers States.

Southeast Nigeria is predominantly inhabited by the Igbo ethnic group and lies within the rainforest and derived savannah ecological zones. The region experiences two distinct seasons: the rainy season, which spans from April to October with peak rainfall in July and September, and the dry season, which extends from November to March. The area enjoys a tropical climate with annual mean temperatures ranging from 18 °C to 34 °C (Onu & Ezech, 2015) ^[17].

Agriculture forms the backbone of the regional economy and remains the primary occupation of the rural populace. The major food and cash crops cultivated include rice, yam, cassava, cocoyam, and maize, while livestock such as poultry, goats, pigs, and fish contribute significantly to household income and nutrition. The combination of fertile soils, favorable rainfall patterns, and rich biodiversity supports diverse farming activities. However, increasing climatic variability manifested in erratic rainfall, flooding, and prolonged dry spells poses significant challenges to agricultural productivity and the sustainability of rural livelihoods in the region.

2.2 Sampling technique

A multistage sampling technique was adopted for selecting respondents across the study area to ensure adequate representation of the diverse climatic and socioeconomic conditions in Southeast Nigeria.

- **Stage I:** Three states Anambra, Abia, and Ebonyi were purposively selected from the five states in the region. The selection was based on the high level of climate change impacts observed in these states, such as flooding, irregular rainfall, and prolonged drought periods, as well as the predominance of smallholder farming activities.
- **Stage II:** Within each of the selected states, two senatorial zones were purposively chosen, giving a total of six senatorial zones. The criterion for selection was the relative vulnerability of the zones to climate-induced effects on agricultural production and livelihoods.
- **Stage III:** From each senatorial zone, two Local Government Areas (LGAs) were purposively selected, resulting in a total of 12 LGAs. Selection at this stage focused on LGAs with visible evidence of climate-related challenges such as erosion, flooding, and reduced crop productivity.
- **Stage IV:** Within each selected LGA, three communities were randomly chosen, giving a total of 36 communities for the study. This stage ensured representation of rural farming households most affected by climatic variability.
- **Stage V:** Finally, 360 respondents were proportionately selected from the 36 communities using probability proportionate to size (PPS) sampling. This approach ensured that the number of respondents selected from each community reflected its population size, thereby minimizing sampling bias.

This multistage framework provided a representative and spatially diverse sample of smallholder farmers whose livelihoods are influenced by changing climatic conditions in Southeast Nigeria.

2.3 Data collection

The study utilized both primary and secondary data sources to ensure comprehensive coverage of information relevant to the research objectives.

The primary data were collected through the administration of a structured questionnaire and interview schedule designed to obtain detailed information on farmers' socioeconomic characteristics, livelihood activities, perceptions of climate change, and adaptation responses. The questionnaire also captured data on the different livelihood options available to farm households, constraints to diversification, and coping mechanisms adopted under changing climatic conditions.

Data collection was carried out by a team of trained enumerators who were selected from the study areas to facilitate effective communication with respondents and ensure accurate data recording. The interviews were conducted in the local dialects of the communities where necessary to enhance understanding and response accuracy. The secondary data were obtained from reliable institutional sources, including the Nigerian Meteorological Agency (NiMet) and research institutes such as the National Root Crops Research Institute (NRCRI), Umudike, and Ugwachara Meteorological Station, Abakaliki. These data covered a 20-year period (2001-2020) and included key climatic variables such as annual rainfall, minimum and maximum temperature, relative humidity, evaporation rate, sunshine hours, and solar radiation.

Combining both primary and secondary sources provided a robust dataset that allowed for the analysis of how changing climatic conditions influence farmers' livelihood decisions and adaptation strategies in Southeast Nigeria.

2.4 Nature of data collected

The nature of data collected for this study was guided by the specific objectives outlined in the research. The data encompassed both qualitative and quantitative variables that captured the diverse aspects of farmers' livelihood systems under changing climatic conditions.

Firstly, data were collected on the various livelihood options available to rural farmers as alternatives or complements to agricultural production. These included both farm-based activities such as crop and livestock production and non-farm-based activities, including petty trading, agro-processing, transportation, tailoring, and artisanal work. Information on the scale of engagement, income contribution, and reasons for diversification into these activities was also obtained.

Secondly, data were gathered on the constraints limiting farmers' ability to diversify their livelihoods in response to climatic challenges. The identified constraint variables included:

- Poor access to credit facilities and financial institutions
- Limited extension services and inadequate access to agricultural information
- High cost and limited availability of farm inputs
- Poor policy implementation and excessive bureaucratic procedures
- Low technical know-how and limited education

- Inadequate market access and poor marketing infrastructure
- High interest rates on agricultural loans
- Long distance to meteorological and credit institutions

Additionally, socioeconomic data were collected on respondents' characteristics such as age, gender, educational level, household size, farm size, income level, and years of farming experience. These variables provided a broader context for understanding the relationship between climate variability and livelihood decisions among rural farmers. The comprehensive dataset generated through this process enabled detailed analysis of both the effects of changing climate and the constraints to livelihood diversification among farm households in Southeast Nigeria.

2.5 Analytical techniques

Both descriptive and inferential statistical techniques were employed to analyze the data in line with the study's objectives. The combination of these methods provided both a general understanding of the data and rigorous testing of the relationships among variables.

2.5.1 Descriptive statistics

Descriptive statistics such as means, frequencies, and percentages were used to summarize the socioeconomic characteristics of respondents and identify the various livelihood options pursued by farm households under changing climatic conditions. This technique was also employed to describe the major constraints faced by farmers in diversifying their livelihood activities.

2.5.2 Multinomial Logit Regression Model (MNL)

To determine the effects of changing climate on the livelihood options of farmers, a multinomial logit regression model (MNL) was used. This model is appropriate when the dependent variable is categorical with more than two outcomes and allows the estimation of the probability of selecting one livelihood option relative to others.

The implicit form of the model is expressed as:

$$Y_i = f(X_i)$$

The explicit form is given as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \mu_i$$

Where:

Y = Livelihood option chosen by the farmer (Farming = 1; Petty Trading = 2; Agro-processing = 3; Driving = 4; Electronic Repairing = 5)

X_1 = Increase in rainfall amount (dummy: Yes = 1, No = 0)

X_2 = Increase in temperature (dummy: Yes = 1, No = 0)

X_3 = Increased drought frequency (dummy: Yes = 1, No = 0)

X_4 = Increased flood frequency (dummy: Yes = 1, No = 0)

X_5 = Increase in climate-induced pests and diseases (dummy: Yes = 1, No = 0)

μ_i = Stochastic error term

$\beta_0 - \beta_5$ = Estimated coefficients

The a priori expectations were that climatic variables such as rainfall, temperature, droughts, floods, and pest outbreaks would significantly influence farmers' livelihood decisions

($\beta_1 - \beta_5 > 0$). The model parameters were estimated using the Maximum Likelihood Estimation (MLE) procedure, and significance was evaluated at 1%, 5%, and 10% probability levels.

Model validity was tested using the Nagelkerke R^2 , Cox and Snell R^2 , and McFadden pseudo- R^2 , while the Chi-square (χ^2) statistic was used to test the overall significance of the model.

2.5.3 Principal Component Factor Analysis (PCA)

To identify and categorize the constraints affecting livelihood diversification under changing climatic conditions, Principal Component Factor Analysis (PCA) was employed. The PCA method reduces a large set of correlated variables into smaller, uncorrelated components that explain the maximum variance in the data.

The model is represented as:

$$Y_i = \beta_{i0} + \beta_{i1}F_1 + \beta_{i2}F_2 + \beta_{i3}F_3 + \dots + \beta_{in}F_n + e_i$$

Where:

Y_i = Observed variable

$F_1 - F_n$ = Extracted factors

$\beta_{i0} - \beta_{in}$ = Factor loadings (coefficients showing the correlation between variables and factors)

e_i = Error term

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were conducted to

assess data suitability for factor analysis. Following Kaiser's criterion, only factors with eigenvalues ≥ 1.0 and factor loadings ≥ 0.40 were retained and interpreted.

This analytical technique enabled the identification of three major groups of constraints environmental, institutional, and economic that limit farmers' ability to diversify livelihoods in response to climate variability.

2.6 Hypothesis testing

The null hypothesis (H_0) stating that 'changing climate has no significant effect on the livelihood options of farmers in the study area' was tested using the Chi-square (χ^2) test and pseudo- R^2 statistics derived from the multinomial logit model. Statistical significance was determined at the 5% level. A rejection of the null hypothesis indicated that changing climate significantly affects the livelihood options of farmers in the study area.

3. Results and Discussion

3.1 Effects of changing climate on livelihood options of farmers

The effects of changing climate on the livelihood options of farmers in Southeast Nigeria were analyzed using the multinomial logit regression model. The results, presented in Table 1, indicate that climatic variables such as rainfall, temperature, drought, flood frequency, and pest and disease outbreaks significantly influenced farmers' livelihood choices at various probability levels.

Table 1: Multinomial logit regression results showing the effects of changing climate on livelihood options of farmers in southeast Nigeria

Climate Change Indicators	Farming	Petty Trading	Agro-processing	Driving	Electronic Repairing
Increase in climate-induced pests and diseases	-0.429***	0.434***	0.322***	0.341***	0.299***
Increase in rainfall amount	0.056***	-0.323***	0.262***	0.208***	0.272***
Increase in temperature	0.065	-0.005	0.007***	0.159***	0.050***
Increased drought conditions	-0.032**	-0.153***	0.020	-0.028	0.101*
Increased flood frequency	-0.035	0.131**	0.156***	0.154***	0.140***
Constant	-3.752***	1.684	-2.350**	-1.936**	-2.885***

Model summary: Nagelkerke $R^2 = 0.602$; Cox & Snell $R^2 = 0.474$; McFadden $R^2 = 0.334$; $\chi^2 = 64.022^{***}$; Goodness-of-fit $\chi^2 = 45.38^{***}$; Overall classification = 90.3%. (Significance levels: *** = 1%, ** = 5%, * = 10%)

Source: Field Survey Data, 2022.

The model results show that the Nagelkerke R^2 value of 0.602 and the significant Chi-square statistic ($p < 0.01$) imply that approximately 60% of the variation in farmers' livelihood choices can be explained by changes in climatic variables. This demonstrates that climate variability significantly affects livelihood diversification among rural households in Southeast Nigeria. Specifically, an increase in climate-induced pests and diseases had a significant negative relationship with farming (-0.429) but positive effects on non-farm activities such as petty trading (0.434), driving (0.341), and electronic repairs (0.299). This suggests that climate-related pest outbreaks reduce farm productivity, compelling farmers to seek alternative income sources. Similar findings were reported by Antwi-Agyei *et al.* (2018), who observed that pest invasions linked to climate change led to livelihood shifts in northern Ghana. Increased rainfall variability showed a positive effect on farming (0.056) but negative on petty trading (-0.323), indicating that while moderate rainfall supports agricultural production, excessive or erratic rainfall disrupts market activities. Likewise, temperature increases significantly influenced farmers' engagement in agro-processing, petty trading, and driving, reflecting a gradual shift toward climate-resilient and income-stable activities. The coefficients for drought and flood frequencies also revealed

significant effects. Droughts were negatively associated with farming (-0.032) and petty trading (-0.153), while floods had positive coefficients for non-farm livelihoods such as agro-processing (0.156), driving (0.154), and electronics repair (0.140). This implies that extreme weather events compel farmers to adopt off-farm strategies to stabilize household income. These findings align with those of Dovie (2019)^[6] and Gitz and Meybeck (2018)^[6], who reported similar adaptive responses among smallholders facing hydrological imbalances and drought-induced production risks.

In summary, the multinomial regression results reveal that climate change significantly reshapes rural livelihood patterns, pushing smallholder farmers to diversify into non-agricultural income-generating activities to mitigate climate-induced shocks.

3.2 Constraints to livelihood diversification under changing climatic conditions

The constraints to livelihood diversification among farmers were analyzed using Principal Component Factor Analysis (PCA) to identify and categorize the major limiting factors. The Kaiser-Meyer-Olkin (KMO) value of 0.744 and the Bartlett's test of sphericity ($\chi^2 = 3768.74$; $p < 0.01$) confirmed that the data were suitable for factor analysis.

Table 2: Principal component factor analysis of constraints to livelihood diversification under changing climatic conditions

Constraint Variables	Environmental	Institutional	Economic
Increase in pests and diseases	0.882	0.098	0.041
Decrease in agricultural yield	0.812	0.129	-0.072
Depreciation of household assets	0.787	0.172	0.011
Poor dry season farming	0.800	0.170	0.086
Low expansion of banks to rural areas	0.120	0.760	-0.040
Long distance from financial institutions	0.117	0.869	-0.131
Lack of guarantor	0.256	0.828	0.030
Poor implementation of regulatory policies	-0.122	0.602	-0.085
Inadequate market information	0.173	0.140	0.860
Inadequate farm input	-0.238	0.190	0.908
High interest rate on credit	0.273	-0.253	0.742
Lack of collateral	0.114	-0.055	0.514

KMO = 0.744; Bartlett's Test of Sphericity $\chi^2 = 3768.74^{***}$ (Significance level: *** = 1%)

Source: Field Survey Data, 2022.

The results in Table 2 revealed three major categories of constraints affecting livelihood diversification among farm households: environmental, institutional, and economic factors.

The environmental constraints included increased pest and disease incidences (0.882), declining agricultural yields (0.812), depletion of household assets (0.787), and poor dry-season farming (0.800). These factors highlight the direct influence of changing climatic conditions on agricultural productivity and livelihood sustainability. The institutional constraints notably, long distances from financial institutions (0.869), lack of guarantors (0.828), low rural banking presence (0.760), and weak policy implementation (0.602) reflect systemic barriers that limit farmers' access to credit and institutional support. These findings are consistent with those of Beck *et al.* (2017) [4] and Raji and Adeoti (2017) [19], who reported that stringent credit policies and poor institutional frameworks often restrict smallholder farmers' financial inclusion.

The economic constraints, including inadequate market information (0.860), insufficient farm inputs (0.908), high interest rates on credit (0.742), and lack of collateral (0.514), underscore the financial and infrastructural challenges faced by rural farmers. Similar observations were made by Esiobu, Nwosu, and Onubuogu (2014) [7], who found that poor market access and input scarcity were major impediments to agricultural development in Nigeria.

Overall, the PCA results suggest that the ability of farm households to diversify their livelihoods is hindered by a complex interaction of environmental stressors, institutional weaknesses, and economic limitations. Addressing these challenges through integrated policy interventions could enhance adaptive capacity and promote sustainable livelihood diversification in the face of climate change.

4. Conclusion and Recommendations

4.1 Conclusion

This study examined the effects of changing climate on the livelihood options of farmers in Southeast Nigeria. Results from the multinomial logit regression model revealed that key climatic variables such as rising temperatures, rainfall variability, drought frequency, flood occurrence, and pest outbreaks significantly influence the livelihood choices of rural farmers. As climate variability intensifies, smallholder farmers increasingly diversify their income sources, shifting from traditional crop-based activities to non-farm enterprises such as petty trading, agro-processing, transportation, and electronic repairs.

The Nagelkerke R^2 value of 0.602 and a highly significant Chi-square statistic ($p < 0.01$) confirmed that climate variability strongly determines the livelihood strategies adopted by farmers in the study area. Furthermore, results from the Principal Component Factor Analysis (PCA) identified three major categories of constraints: environmental, institutional, and economic factors which collectively hinder farmers' ability to effectively diversify their livelihoods.

In conclusion, climate change serves as a key driver of livelihood transformation among smallholder farmers in Southeast Nigeria. Without deliberate and proactive adaptation measures, the increasing frequency and intensity of climate-induced shocks will continue to undermine agricultural productivity, food security, and the overall resilience of rural households. Strengthening policy frameworks, improving access to finance, and promoting sustainable livelihood diversification are therefore essential for safeguarding the livelihoods of vulnerable farming communities in the region.

4.2 Recommendations

Based on the findings of this study, the following recommendations are proposed to strengthen the adaptive capacity of farmers and promote sustainable livelihood diversification under changing climatic conditions:

- 1. Strengthen climate adaptation policies:** Federal and state governments should develop and implement comprehensive climate adaptation frameworks that promote sustainable agricultural practices, efficient land use, and disaster risk management. Policies should also emphasize climate-resilient technologies and early warning systems to minimize vulnerability to climatic shocks.
- 2. Enhance access to agricultural finance:** Financial institutions should expand their operations to rural areas and provide flexible, low-interest credit facilities tailored to the needs of smallholder farmers. Simplified loan procedures and financial literacy training would further enhance farmers' ability to access and effectively utilize credit for both farm and non-farm ventures.
- 3. Promote livelihood diversification and skill development:** Agricultural extension agencies, NGOs, and development partners should implement training programs focused on non-farm income-generating activities such as agro-processing, value addition, and rural entrepreneurship. Empowering farmers with

relevant skills will reduce their dependence on climate-sensitive agricultural activities.

4. **Strengthen agricultural extension and information services:** Effective and well-resourced extension systems should be established to ensure timely dissemination of climate information, adaptation technologies, and best farming practices. Integrating mobile technology and digital platforms can improve farmers' access to weather forecasts and market information.
5. **Invest in rural infrastructure and market access:** Investment in rural infrastructure such as roads, irrigation systems, storage facilities, and rural markets is essential to support livelihood diversification. Improved infrastructure enhances farmers' access to inputs, markets, and services, thereby increasing productivity and income stability.
6. **Encourage research and innovation:** Research institutions and universities should intensify studies on localized climate impacts, indigenous adaptation strategies, and innovative livelihood models. The outcomes of such research should guide evidence-based policy formulation and community-level interventions.

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