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# COST AND RETURN ANALYSIS OF YAM FARMERS RESILIENCE TO CLIMATE CHANGE IN BENUE STATE

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## ABSTRACT

This study conducted a cost and return analysis of yam farmers' resilience to climate change in Benue State, Nigeria. The analysis focused on understanding the socio-economic characteristics of the farmers and how these factors influence their resilience and economic returns. The socio-economic data revealed that the majority of yam farmers were male (65.18%), aged between 36 and 65 years, with a mean age of 46 years. The majority (41.30%) completed primary education and (74.09%) were primarily engaged in farming as their main occupation. A budgetary analysis of the farmers' production revealed that yam farming is profitable, with a benefit-cost ratio (BCR) of 1.13, indicating that for every ₦1 invested in yam production, farmers gained a return of ₦1.13. The study further explored resilience factors through factor analysis and structural equation modeling, identifying assets, adaptive capacity, and agricultural practices as key variables significantly impacting resilience to climate change. Assets had the strongest relationship with productivity (p=0.002), followed by agricultural practices and technology (p=0.025) and social networks (p=0.078). Among the analyzed variables, only farm size showed statistical significance at the 0.05 level (p=0.012). For farmers with high resilience, the t-value of 50.97 and p-value of 0.000 indicated a very strong and significant positive relationship with productivity outcomes. The findings highlight that increasing adaptive capacity, enhancing social networks, and improving access to technology are crucial to strengthening farmers' resilience. These results underscore the need for policy interventions aimed at improving access to affordable inputs, mechanization, and resilient yam varieties to enhance productivity and climate change adaptation among yam farmers in Benue State.

**Key words**: Cost and return analysis, Yam production, Resilience, Climate change, Benefit-cost ratio (BCR), Adaptive capacity, Profitability.

## INTRODUCTION

The production of yams is a major contributor to local food security, livelihoods, and national agricultural outputs in Benue State, Nigeria, which is referred to as the "Food Basket of the Nation." However, yam farming is seriously threatened by climate change, which could result in unreliable yields and higher production costs. Improving the region's food security and economic sustainability requires an understanding of the cost and return dynamics of yam producers' climate change resilience (Adepoju *et al*., 2017). This investigation sheds light on the economic feasibility of yam farmers' tactics and how they adjust to climate-related difficulties (Adebayo *et al*., 2022).

The production of yams is seriously threatened by climate change, which will affect yields, quality, and availability. In Benue State, the effects of climate change include more frequent extreme weather events, extended droughts, erratic rainfall patterns, and rising temperatures. The cycles of yam cultivation are disturbed by these environmental changes, which also lower soil fertility and raise the prevalence of pests and illnesses. Consequently, yam growers are exposed to increased production risks, and these climate-related disruptions require higher financial investments in cultivation inputs including fertilizers, irrigation systems, and insect control methods. As a result, assessing the profitability of yam growing under climate stress requires a cost and return analysis. (Etwire *et al*., 2022).

According to Ojewumi *et al.,* (2022), Benue State's yam growers are susceptible to climate-related stocks such as rising temperatures, altered rainfall patterns, and a rise in the frequency of extreme weather events. A thorough cost and return analysis take into account the money made from yam sales as well as the other costs that farmers incur, such as labor, seeds, fertilizer, and equipment. Climate-related issues have the potential to dramatically raise production costs in Benue State, where smallholder farmers primarily cultivate yams. In order to maintain yields in the face of changing climate conditions, farmers may need to invest in climate-resilient methods, such as better seed types and irrigation systems, which can increase their overall production costs (Soomiyol *et al.,*2020).

Policy and programmatic responses must be informed by an understanding of the economic costs and benefits of yam producers' climate change resistance (Mason *et al.,* 2021). In Nigeria, recent research has emphasized the necessity of climate-resilient agriculture and the significance of climate change adaptation (Aiyelari *et al.,* 2022). A major contributor to the nation's yam production, Benue State is a crucial yam-producing region (Adebayo *et al.,* 2022). As a result, this study evaluated the response of yam growers in Nigeria's Benue State to climate change.

The specific objectives were to:

1. Describe the socio-economic characteristics of the respondents in the study area.
2. Estimate the cost and return analysis of yam farmers resilience to climate change in Benue state.

## MATERIALS AND METHODS

*Study area*

The study was carried out in Nigeria's Benue State widely referred to as "the nation's food basket." This is ascribed to the abundance of land and agricultural resources that may be used to produce a wide range of crops, including rice, cowpeas, soy beans, cassava, and yam. The state experiences two distinct seasons: the dry season and the rainy season. Every year, the dry season begins in November and ends in March, whereas the rainy season begins in April and lasts until October. With 3 ADPs and 23 LGAs, Benue State is known as the nation's food basket. Benue is situated at an elevation of 97 meters above sea level in the Southern Guinea savannah agro ecological zone in the central belt of Nigeria, roughly between latitudes 6030°N and 8010°N of the equator and longitudes 6035°E and 8010°E of the Greenwich meridian. According to the 2006 population censors, Benue State has a total population of 4,253,641 (with 2,144,043 are male and 2,109,598 are female) out of which 2,169,357 are children (0-17years) (FMWA and SD, 2008). The state occupies a landmass of 32,518 square kilometers. The state comprised of several ethnic groups: Tiv, Idoma, Igede, Etulo, Abakpa, Jukun, Hausa, Akweya and Nyifon. The Tiv are the dominant ethnic group, occupying 14 local government areas, while the Idoma and Igede occupy the remaining nine local government areas. Benue state has a Guinea savannah kind of vegetation characterized with scattered trees and coarse grasses. The people of Benue state are mostly farmers, traders and artesian but majority are farmers. The farmers produce food crops such as yam, cassava, rice, soya beans, sweet potatoes, Irish potatoes, maize beans tomatoes and fruits. The cash crops produce include yam, orange tomatoes, and rice. (Morse, 2020).

**Population and Sampling Procedure**

The population for this study consisted of all registered yam farmers in selected local governments in Benue State. A three-stage sampling procedure was used to select the farmers. In the first stage, the study area was selected. The second stage was randomly selected of four local government under Agricultural Development Zones (ADPs) in the study area constituted farmer settlement and highly cultivation of yam tuber prominent. The second stages were randomly selected of the three Agricultural Development Zones (ADPs) in the state. In the third stage, two farming communities or villages were randomly selected from each Agricultural Development Zones (ADPs), totaling eight communities. This process led to a final sample size of 247 yam farmers. Approximately 24.7% of the total yam farmers in the selected local governments were chosen randomly for this study.

**Source of Data and Method of Data Collection**

Questionnaire was used to obtain the required information related to background information and socio-economic characteristics of farmer's combination of capabilities, adaptative responses, and transformation strategies in combating climate change; production cost and returns of yam farmers' productivity strategies were solicited through the questionnaire.

**Analytical techniques**

The analytical techniques that used for the study are include descriptive statistics as frequency count, percentage, mean and standard deviation were employed to analyze data collected and farm budgetary analytical technique was used to estimate the cost and returns of yam farmer production in the study area This includes use of the following variables: Gross margin (GM) is the difference between the total revenue earned and the total variable cost incurred GM = TR - TVC. Variable cost (VC) is the cost that varies with changes in output; it is a function of output level. Total cost is the total expenditure on the output that is, addition of both variable and fixed costs TC = TFC + TVC. Total revenue (TR) is the total income realized on output produced that is, quantity sold multiplied by price per unit. Net Revenue (also known as profit) is the difference between the total revenue and the total cost.

Mathematical representation of gross margin analysis is given as:

Where, GM = Gross Margin,

Π = profit

TR = Total Revenue

TVC = Total Variable Cost

TFC = Total Fixed Cost.

Also, Resilience index measurement and analysis (RIMA) Model were used to evaluate the resilience and coping strategies of yam farmers provides a detailed and multifaceted understanding of how yam farmers are managing the effects of climate.

The Resilience Index Measurement and Analysis (RIMA) Model was used to determine the level of resilience of yam farmers to climate change shocks and it will be represented as below:

$R_i = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7)$

Where R = Resilience; $X_1$ = Assets; $X_2$ = Social Networks; $X_3$ = Agricultural Practice and Technology; $X_4$ =Sensitivity; $X_5$ = Adaptive Capacity

## RESULTS AND DISCUSSION

### Socio-economic Characteristics of the Yam Farmers

The socio-economic characteristics are crucial factors in the choice of agricultural practices of farmers. Studies have shown that social and economic status of yam farmers played critical roles in the practices cost and return analysis of yam farmers resilience to climate change in Benue state **Eze, *et al.*, (2023)** characteristics of yam farmers. This study therefore described the socio-economic characteristics of yam farmers.

The study revealed that the average age of respondents was 46 years, with a notable portion (25.10%) between 36 and 45 years old, highlighting that the farming population is largely within the economically active age group.

Additionally, the findings showed that the majority of respondents were male (65.18%). This indicates a significant male dominance in yam farming, with men constituting nearly two-thirds of the farming population and in the surveyed area, men often have better access to farming resources such as land, inputs, and credit facilities but women, on the other hand, face limitations due to societal norms that restrict their ownership and control over these assets, reducing their involvement in yam farming.

In terms of education, most respondents (41.30%) had completed primary education, while a smaller percentage had secondary (25.91%) and tertiary (9.31%) education. This indicates that the respondents possess basic educational skills, which could aid in adopting improved farming practices and climate-resilient techniques while approximately 23.48% had no formal education, indicate the need for educational programs targeting farmers. Regarding marital status, the majority of respondents (53.45%) were married, suggesting that family-based farming operations are common, which contributed to stability and support within agricultural households.

The average household size was between 6–10 members for most respondents (39.68%), indicating that extended families are common, which help reduce labor costs and improve farm productivity. Farming was the dominant occupation, with (74.09%) of respondents engaged in it, indicated that, it measures the central role of agriculture in the study area. The study also revealed that farm size varied, with the largest group of farmers (27.13%) cultivating between 7–8 hectares. Larger farm sizes are associated with better productivity, which enhance economic viability and access to resources like loans and subsidies in the sturdy area. Experience-wise, the majority of respondents (27.13%) had over 20 years of farming experience, followed by 26.72% with 11–15 years. This indicates that farmers are seasoned and familiar with long-term climate patterns, which is essential for adapting to climate change and ensuring resilience in yam production.

**Distribution on cost and returns of yam farmers' productivity**

The budgetary analysis of benefit cost ration of cost and returns of yam farmers' productivity. AVC were observed as (₦132,331), AFC were (₦138447 per year) while TC (₦66,611,788) and TR (₦75,837,500), Therefore, the benefit cost ratio (BCR) indicates that:

$$\text{BCF} = \frac{total\ benefit(TR)}{total\ cost(TC)} = \frac{₦75837500}{₦66611788}$$

$$= ₦1.138499 \approx 1.13$$

This implies that in the study area, productivity was measured by the output per unit of input cost of production per unit of yam or yam seedlings, therefore on the average, for every ₦ 1 spent on yam production, the return is ₦1.13. This suggests that yam production is profitable since the BCR is greater than 1. The significant difference between the costs and returns favor to investment in yam production in the study area. Since the BCR > 1, it showed profitability, making yam production a viable investment. This report consonance with report by Anozie *et al.,* (2023) that yam production remains a viable investment due to favorable economic returns.

The cost of inputs, including labor, seeds, fertilizers, and transportation, represents a significant portion of the production costs. Recent studies have emphasized the need for improved access to affordable inputs and mechanization to reduce the high labor costs that yam farmers typically face. Furthermore, the adoption of improved yam varieties that are more resistant to pests and diseases can help increase yields while keeping production costs in check.

**Factor analysis**

The factor analysis conducted to identify the resilience structures among the strategic adoption variables for resilience to climate change to yam farmers based in Table 3 on five variables with eigenvalue of the indicators as: Assets (AST), Sensitivity (SST), Adaptive capacity (AC), Social safety network (SSN), and Agricultural practices and Technology (APT). It further revealed the observed number of 247 with retained factors of three numbers why the number of parameters is 18.

Furthermore, from the observed frequency 247, variable 1, variable 2 and variable 3 are significantly correlated with the eigenvalues of 0.30842, 0.18427 and 0.00691 with their proportion.

Also, variable 4, 5, and 6 with eigenvalue of -0.00691, -0.03697 and -0.08688 with their proportion are not significant. explaining a negligible amount of variance in the data. Therefore, having the independent vs saturated $chi^2$ of 21 = 24.35 and probability of $chi^2$ = 0.2766 approximately = 0.3. This implies that, assets (AST) correlate with the resilience index (RI). The LR test (Likelihood Ratio test) indicates that the model is a good fit, with a probability of 0.2766 (approximately 0.3).

**Structural equation model**

From structural equation model, in Table 4 shows that, there is log likelihood of 152.3345. The model vs saturated of $chi^2$ of 21 = 10620.80 with the probability of $chi^2$ = 0.0000. From the number of observed of 247, the table revealed that social safety network, adaptive capacity, assets and agricultural practices and technology were significantly influence resilience to climate change among yam farmers in the study area. The result showed social safety networks (SSN) increases the chance of yam farmers' resilience to climate change provided all other factors are held constant. SSN having the p-value = 0.078 indicated that the variable is significant at 10% level of confidence. Additionally, adaptive capacity (AC) having p-value = 0.025 was significant at 5% level. The result indicated that increasing adaptive capacity of yam farmers will increase the likelihood of being resilience to climate change in the study area. The coefficient of both assets and Agricultural practices and technology followed the same trend as AST has p-value of 0.002 and APT has 0.035. These variables are significant at 1% and 5% level respectively. However, this result implies that, adaptive capacity (AC) is highly significant under the resilience to climate change among yam farmers in the study area.

**Distribution of respondent by estimation of the yield / output of the yam due to climate change**

Table 4.8 presents the analysis of various variables that affect productivity (output) in yam farming.

The results indicate that gender, marital status, education, primary occupation, farm size, years of farm experience, association membership, and climate change awareness all have a significant impact on yam productivity. In contrast, age, with a t-value of (-2.23), does not show significance and negatively affects productivity, implying that as yam farmers age getting older, their output slightly decreases due to reduced physical capacity or adaptability. Similarly, household size, with a t-value of -0.26, was found to be non-significant, suggesting that the number of household members does not directly affect productivity. This could be due to the increased demand on available resources (such as food and income), which may limit the resources available for farming investments. Also, the result shows that, among the variables analyzed, only farm size in hectares showed statistical significance at the 0.05 level, with a p-value of 0.012. The positive coefficient indicates that larger farm sizes are associated with higher productivity.

Nevertheless, the results for resilience status are categorized into three levels: low, medium, and high resilience. The t-value of -1.70 for low resilience suggests that it is not statistically significant, meaning that as resilience decreases, yam productivity also declines, but the relationship is not strong enough to be conclusive. For medium resilience with a t-value of -0.98 and p-value of 0.330, the effect is not statistically significant, indicating that medium resilience does not have a reliable impact on yam productivity in this study. However, for high resilience, the t-value of 50.97 and p-value of 0.000 show a very strong and significant positive relationship with the outcome variable. This indicates that farmers with high resilience experience much higher productivity, as their ability to adapt to challenges significantly enhances their output. This work goes in-line with Batungwanayo *et al.,* (2023) and Norman, (2019) stated that, farmers with high resilience are more likely to experience better productivity outcomes, as their ability to adapt and cope with environmental and socio-economic stresses directly correlates with increased crop yields.

## CONCLUSION

The cost-return study of Benue State's yam farmers' climate change resilience shows that, in spite of the difficulties posed by climate change, yam growing is still a lucrative endeavor. The economic viability of yam production is suggested by the benefit-cost ratio (BCR) of 1.13, which shows that for every ₦1 invested, a return of ₦1.13 is generated. However, substantial financial outlays are necessary to increase climate change resistance, particularly in the areas of irrigation, pest management, and enhanced seed types. In order to deal with the increased production risks brought on by erratic rainfall, rising temperatures, and pest infestations, yam farmers in Benue State have resorted to techniques including social safety networks, enhanced farming techniques, and diversification. Although these tactics increase farmers' resilience, they also increase production costs overall, which affects profitability.

The structural equation model further confirms that assets, social safety networks, adaptive capacity, and agricultural practices significantly influence the resilience of yam farmers. Adaptive capacity and social safety networks, in particular, play critical roles in mitigating climate-related risks. Despite these adaptive strategies, the farmers' sensitivity to climate shocks remains high, emphasizing the need for more robust interventions.

The analysis identifies key factors influencing yam productivity. Significant contributors include gender, marital status, education, primary occupation, farm size, years of farm experience, association membership, and climate change awareness. Among these, farm size has the strongest positive impact, with statistical significance (p=0.012), indicating larger farms yield higher productivity. In contrast, age negatively affects productivity but lacks significance, suggesting older farmers face reduced output due to diminished physical capacity. Similarly, household size shows no significant effect, potentially due to resource constraints for farming.

Regarding resilience, high resilience demonstrates a strong, significant positive impact (p=0.000), showing adaptive farmers achieve significantly higher productivity.

However, low and medium resilience are non-significant, though low resilience slightly hints at reduced productivity. These findings align with prior studies, emphasizing that high resilience enhances farmers' ability to adapt to challenges, resulting in better crop yields.

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**Table 1: Table of Resilience Indicators and Sub-Components**

| Indicators | Sub-components |
|---|---|
| **Assets (AST)** | Agricultural assets<br>Non- Agricultural assets |
| **Agricultural practices and technology (APT)** | Fertilizers and chemical<br>Technological inputs adopted in farming and marketing<br>Agro forestry practices |
| **Social Networks (SSN)** | Agricultural associations<br>Insurance<br>Cooperative |
| **Adaptive capacity (AC)** | Diversification index<br>Numbers of income sources<br>Crop diversity<br>Education<br>Dependency ratio |
| **Sensitivity** | The degree to which the farmer is actually affected by climate-induce shock<br>The degree to which the farmer has been affected by the shock in recent past |

**Table 2: Socio-economic characteristics of respondents**

| Variables | Frequency | Percentage (%) | Mean |
|---|---|---|---|
| **Age** | | | |
| 36 – 45 | 62 | 25.10 | 46 |
| 46 – 65 | 61 | 24.70 | |
| 36 – 45 | 53 | 21.46 | |
| 18 – 25 | 39 | 15.79 | |
| 56 – 65 | 25 | 10.12 | |
| > 65 | 7 | 2.83 | |
| **Total** | **247** | **100.00** | |
| **Gender** | | | |
| Male | 161 | 65.18 | |
| Female | 36 | 34.82 | |
| **Total** | **247** | **100.00** | |
| **Education** | | | **Mean** |
| Primary Education | 102 | 41.30 | 41 |
| Secondary Education | 64 | 25.91 | |
| Non formal education | 58 | 23.48 | |
| Tertiary Education | 23 | 9.31 | |
| **Marital status** | | | |
| Married | 102 | 53.45 | |
| Divorced | 64 | 25.35 | |
| Widowed | 58 | 15.35 | |
| Single | 23 | 5.85 | |
| **Total** | **247** | **100.00** | |
| **Household size** | | | |
| 6 – 10 | 98 | 39.68 | |
| 11 – 15 | 84 | 34.01 | |
| 1 – 5 | 51 | 20.65 | |
| 16 – 20 | 13 | 5.26 | |
| Above | 1 | 0.40 | |
| **Total** | **247** | **100.00** | |
| **Major occupation** | | | |
| Farming | 183 | 74.09 | |
| Trading | 41 | 16.60 | |
| Artisans | 13 | 5.20 | |
| Civil service | 9 | 3.01 | |
| Others | 1 | 1.06 | |
| **Total** | **247** | **100.00** | |
| **Farm size** | | | **Mean** |
| 7 – 6 | 67 | 27.13 | 7.6 |
| 2 – 4 | 63 | 25.51 | |
| 9 – 10 | 46 | 18.62 | |
| 5 – 6 | 45 | 18.22 | |
| 1 – 2 | 26 | 10.53 | |
| **Total** | **247** | **100.00** | |
| **Farm experience (years)** | | | **Mean** |
| Above 20 | 67 | 27.13 | 23.8 |
| 11 - 15 | 66 | 26.72 | |
| 6 - 10 | 44 | 17.81 | |
| 16 - 20 | 38 | 15.38 | |
| 1- 5 | 32 | 12.96 | |
| **Total** | **247** | **100.00** | |

**Source: Field Survey, 2019**

**Table 3: Factor analysis distribution by diversification**

| Variables | Eigenvalue | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Asset (AST) | 0.30842 | 0.12415 | 1.5508 | 1.5508 |
| Sensitivity | 0.07693 | 0.08384 | 0.3868 | 2.8641 |
| Adaptive capacity (AC) | -0.00691 | 0.03006 | -0.0348 | 2.8293 |
| Social Networks (SSN) | -0.03697 | 0.04992 | -0.1859 | 2.6434 |
| Agricultural practices and technology (APT) | -0.08688 | 0.15308 | -0.4369 | 2.2066 |

LR test: independent vs. saturated: $chi^2(21) = 24.35$
Prob > $chi^2 = 0.2766$ Approximately = 0.3
**Source: Field survey, 2022**

**Table 4: Analysis of the Resilience index of the structural equation model**

| Variables | Coefficient | Std. Err. | z | P>\|z\| |
|---|---|---|---|---|
| Social Networks (SSN) | 1.100392 | 0.1124657 | 1.73 | 0.078 |
| Agricultural practices and technology (APT) | 0.2515043 | 0.1124657 | 2.24 | 0.025 |
| Asset | 0.0388681 | 0.0125441 | 3.10 | 0.002 |
| Agric. Practices & Technology | 0.2285589 | 0.1085247 | 2.11 | 0.035 |
| Sensitivity | 0.0467692 | 0.1609785 | 0.29 | 0.772 |
| Diagnostics | | | | |
| Number of observed values = 247. Log likelihood = 152.3345 | | | | |
| LR test of model vs saturated: chi $^2(21) = 106020.80$ | | | | |
| Prob > chi $^2 = 0.0000$ | | | | |

**Source: Field Survey, 2022**

**Table 5: Distribution of respondent by estimation of the yield / output of the yam due to climate change**

| Variable (output) | Coef. | Std. Err. | t | P>\|t\| |
|---|---|---|---|---|
| Age | -.0812143 | .0364202 | -2.23 | 0.027 |
| Gender | .0331302 | .0455202 | 0.73 | 0.468 |
| Marital status | .1093638 | .0482264 | 2.27 | 0.024 |
| Household size | -.0036529 | .014034 | -0.26 | 0.795 |
| Education | .0137606 | .0300248 | 0.46 | 0.647 |
| Pry Occupation | .0777696 | .0391479 | 1.99 | 0.048 |
| Farm Size hectare | .0193911 | .0076381 | 2.54 | 0.012 |
| Year of farm experience | .0015298 | .0042244 | 0.36 | 0.718 |
| Association Membership | 9990457 | .5314408 | 1.88 | 0.062 |
| Climate change awareness | .0202316 | .0091388 | 2.21 | 0.028 |
| | | | | |
| **Resilience status** | **Coef.** | **Std. Err.** | **t** | **P>\|t\|** |
| Low resilience | -.1466157 | .0862783 | -1.70 | 0.091 |
| Medium resilience | -.0572584 | .0586711 | -0.98 | 0.330 |
| High resilience | 12.83102 | .251751 | 50.97 | 0.000 |