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## Gender-Based Analysis of the Effect of Climate Change on Income of Cassava Farmers in Delta State, Nigeria

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### Abstract

*Climate change is perhaps the most serious environmental threat to agriculture in Africa, because of its impact on pre- and post-harvest agricultural productivity thereby reducing income. This study examined the gender-based effects of climate change on the income of cassava farmers in Delta State, Nigeria. Using a multistage sampling technique, 360 cassava farmers were surveyed across six Local Government Areas in Delta State, Nigeria. Data were collected through structured questionnaires and analysed using Ordinary Least Squares (OLS) regression. The results revealed that climate change significantly reduced cassava farmers' income, with climate-related challenges negatively impacting earnings ( $\beta = -1132.56$ ,  $p = 0.001$ ). However, adaptation strategies positively influenced income ( $\beta = 1923.45$ ,  $p = 0.000$ ), highlighting the importance of climate-smart farming practices. Gender issues were evident with the female farmers earning lesser income than the male farmers ( $\beta = -4789.12$ ,  $p = 0.000$ ) principally due to unfair access to land, credit and extension services. The interaction effect between climate change and gender was positive ( $\beta = 753.45$ ,  $p = 0.008$ ) showing that women used techniques like crop diversification to avoid loss. The interaction between adaptation strategies and gender revealed negative sign ( $\beta = -0.95$ ,  $p = 0.011$ ), implying that adaptation benefits were relatively less in the case of the female farmers. According to the findings, this study recommended that efforts should be made to increase gender-sensitive policies, increase credit accessibility, and improve on the use of extension services for climate change adaptation to increase yield in cassava production among farmers in Delta State.*

**Keywords:** Climate change, Cassava farmers, Gender based, Income impact, Adaptation strategies

### 1.0 Introduction

Cassava (*Manihot esculenta*) is one of the widely cultivated crops in Nigeria that is consumed as staple food especially by the rural farmers across the country (Musa *et al.*, 2022).

Currently, Nigeria is the largest producer of cassava in the globe making appreciable input to the food and industrial raw materials required for various products including, starch, flour, ethanol among others (FAO, 2021). An ARIMA study predicts that the output will be around 73,300.33 thousand tonnes in 2025 (Zakaria *et al.*, 2025). This estimate suggests a substantial cassava harvest, indicating Nigeria's continued position as a global leader in cassava production. Nigeria is the world's largest producer of cassava. Estimates suggest Nigeria produces around 59 million tons of cassava annually, which is about 20.4% of the global output (Oluwatayo *et al.*, 2022). While Nigeria's production is high, its yield per hectare is relatively low compared to other major producers like Brazil and China (Chiaka *et al.*, 2022).

The productivity of cassava has been significantly threatened by climate change in terms of yields, income, and sustainability of the livelihood. Due to climate change impacts, cassava farming which is widely practiced in Delta State has experienced less productivity, high costs of production and thereby exposing farmers to compromise on food security (Olaniyan & Govender, 2023).

Climate change comes in many ways such as high temperatures, irregular rainfall periods, drought seasons, and pest and diseases (IPCC, 2022). These climatic changes have affected not only the growth of cassava in various ways, starting from changes in the soil fertility and availability of water to the variability of cassava yield. It has been revealed that the increase in temperature enhances the growth of the cassava root but at the same time results into reduction of tuber size and the starch yield which brings down the market value of the produce (Akano *et al.*, 2021). Just like any other crop, cassava is also sensitive to rainfall distribution because either poor or excessive rains hinder its planting, growth and harvesting season (Iliyasu *et al.*, 2019).

The effects of climate change are very pronounced in the case of cassava farmers, especially regarding gender roles. In many regions such as South South, South West, and South East region of Nigeria, women are the primary labourers in cassava farming, particularly in tasks like weeding, planting, harvesting, processing, and marketing (Adeniyi *et al.*, 2023). Cassava's reliance on relatively stable climate conditions and its deep root system makes it more prone to issues like drought and flooding. Also, in most rural areas, cassava production, processing, and marketing are clearly divided among men and women. Women participate more in weeding, harvesting, and processing activities, while men are more involved in land preparation and transportation (Amadi *et al.*, 2019). However, most of the times, women usually have less access to important resources like land, credit, and extension services, which intensifies the vulnerability to climate change impacts on them (Nosheen *et al.*, 2023). For instance, women farmers are likely to have lower cassava incomes arising from small farm sizes, lower mechanization, and other socio-cultural factors affecting their ability to participate in high-value markets (Apata, 2019).

Most studies from gender gap and climate change are based on vulnerability of Agriculture, productivity and poverty, and adaptation strategies (Balogun and Odjugo, 2020; Okanlawon, 2016; Anugwa *et al.*, 2023). This study is focused on gender-based effect on climate change in relation to income realised from cassava farming. The study will therefore be of immense benefit to rural farmers especially who needs to understand the new normal in cassava farming as a result of climate change variability.

Coping strategies and adaptation measures greatly vary along gender lines. Male farmers' flexibility towards diversifying into other crops or migrating into urban areas may be greater due to additional sources of income; on the contrary, female farmers tend to remain in rural areas and depend heavily on indigenous knowledge and traditional ways of farming in adapting to climate risks (Onoh, Erezi & Clement, 2023). Interventions by the government, along with climate adaptation programs for cassava farmers, have been done in an attempt to improve their resiliency by introducing better cassava varieties, irrigation support, and credit access. Gender inclusion into these programs is very limited, and women still suffer from structural obstacles while trying to have access to all resources on climate adaptation (Deji, 2021).

Several studies have considered the impact of climate change on cassava production and its socio-economic consequences on farmers in Nigeria. For instance, Anarah *et al.*, (2019) pointed out that increased temperatures, accompanied by unpredictable rainfall patterns, affect cassava yields and productivity, hence increasing vulnerability among farmers. In addition, Akano *et al.*, (2021) came to the conclusion that climate variability affects the quality of cassava tubers, hence reducing the market value and overall income of farmers. These studies, while they show the effects of climate change on cassava production, largely focus on the agronomic causes and have mostly not considered the economic implications among different gender groups.

Analyses of gender disparities in agriculture have also found that men and women experience the consequences of climate change along various dimensions of inequality, such as those in access to land, credit, and extension services (Deji, 2021). Chukwuemeka (2023) explained that women farmers in cassava processing and marketing incur lower net income compared to male farmers due to the unavailability of adaptation measures against climate impacts. Onoh, Erezi, and Clement (2023) added that very often, greater constraints in adoption characterise farming practices that involve resilience to climatic changes on the part of women, thereby subjecting them to great risks of reduced incomes. However, these works are deficient in giving the detail of gender analysis of the economic impacts of climate change on cassava farmers, especially in Delta State.

Abdulsalam *et al.*, (2023), addressed gender inequality along the value chain of cassava, their emphasis was mainly on market access and profitability, thus failing to connect the gendered vulnerability to climate change with differences in income earned. Again, though, Iliyasu *et al.* (2019) considered the impact of rainfall variability on cassava production, their paper did not analyze how this climatic shift affects the individual income of male and female farmers. This constitutes a significant one-sided analytical gap in understanding impacts on climate change with regard to income among cassava farmers in Delta State. Besides the increasing threat from climate change, agricultural livelihoods in the developing world have remained tied to persistent gender inequalities. It would therefore be of interest to examine how climate change affects the income levels of both male and female cassava farmers in Delta State, Nigeria. The study seeks to fill this knowledge gap through a gender-based assessment of climate change impacts on cassava farmers' incomes.

The main objective of the study is to examine the gender-based effect of climate change on income of cassava farmers in Delta State, Nigeria. The specific objectives are to: analyse the differential impact of climate change on the income of male and female cassava farmers; examine the climate change-related challenges affecting male and female cassava farmers

and evaluate the adaptation strategies adopted by male and female cassava farmers in response to climate change.

## 2.0 Materials and Methods

### 2.1 Study Area

Delta State is one of the states in the South-South geopolitical zone of Nigeria and is located between latitudes 5°00'N to 6°30'N and longitudes 5°00'E to 6°45'E (National Bureau of Statistics [NBS], 2021). It has Edo to the north, Anambra and River State to the east, Bayelsa State to the southeast, the Bight of Benin on the south that fronts the Atlantic Ocean (Federal Ministry of Environment [FME], 2021). The state occupies an area of approximately 17,698 square kilometers of land and owns a variety of agro ecological regions such as Mangrove swamps, Fresh water swamps, and lowland rainforests. Cassava farming is among the crops that are grown by these farmers, and it is a major economic activity within the State. The region experiences a humid tropical climate characterized by two distinct seasons: a rainy season (April to October) and a dry season (November to March), with an annual rainfall range of 1,500–3,000 mm and temperatures averaging 26–34°C (Nigerian Meteorological Agency [NiMet], 2024). However, climate change has resulted in increased variability in rainfall patterns, excessive flooding, and prolonged dry spells, which have impacted cassava farming in the state (Sowunmi, 2020).

### 2.2 Population, Sampling Technique and Sample Size

The target population of the study is male and female cassava farmers across Delta State with a population of over 4000. In order to obtain samples for the study, a multistage sampling technique was used. In the first stage, Delta State was divided into its three agricultural zones (Delta North, Delta Central and Delta South) (Delta State Ministry of Agriculture, 2024). In the second stage, two Local Government Areas (LGAs) were purposively selected considering the extent of cassava farming and these include Delta North (Aniocha South and Ika North-East), Delta Central (Ughelli North and Ethiope East) and Delta South (Warri South and Isoko North). In the third stage, 4 farming communities were randomly selected from each LGA, resulting in a total of 24 communities. In the final stage, 15 respondents were selected from each communities using a simple random sampling technique from the identified farming households in each community. The total sample size was 360 respondents which were determined using Yamane's (1967) formula for sample size determination:

$$n = \frac{N}{1+N(e^2)} \dots \dots \dots \text{Equation 2.1}$$

Where:

n = sample size

N = population size (4,000)

e = margin of error (0.05)

$$n = \frac{4,000}{1 + 4,000(0.05^2)} = 363 \text{ (360 respondents were used for the study)} \dots \dots \dots \text{Equation 2.2}$$

### 2.3 Data Collection

Quantitative data were collected using a structured questionnaire while qualitative data were collected through key informant interviews. The questionnaire was also divided into a demographic section of the farmers, the perceived climate change challenges affecting cassava farming and climate change mitigation measures. The questionnaires were pilot tested among 30 cassava farmers in an area not selected in the sample to establish validity and reliability. The pre-test findings were utilized to clear any doubts on unclear questions before the actual survey. Further, use of field enumerators familiar with the local languages (Urhobo, Igbo, Ijaw, and Isoko) ensured that the responses obtained were more accurate.

### 2.4 Data Analysis

Descriptive and inferential analyses were used to analyse the data collected from the study. Frequency tables, percentages, means and standard deviations were used to analyse farmers' socioeconomic characteristics, climate change-related challenges affecting cassava production and climate change adaptation strategies. Inferential statistics like the OLS regression analysis was used in making inference regarding the climate change variables and cassava farmer's income.

### 2.5 Socioeconomic Characteristics

- i. Gender: Gender was measured by a dummy value of male (1) and female (0).
- ii. Age: Respondents were asked to indicate their chronological age in years.
- iii. Marital status: This was measured by a nominal value of single (1), married (2), divorced (3), and widowed (4).
- iv. Education: Level of education was measured by a nominal value of No Formal Education (1), Primary Education (2), Secondary Education (3), and Tertiary Education (4).
- v. Household size: Respondents were asked to indicate the number of persons in a household under the head of the farm family.
- vi. Farm size: This was measured in hectares.
- vii. Farming experience: This was measured in years.
- viii. Monthly income: This was measured in Naira (₦).
- ix. Access to extension services: This was measured by dummy values of 1 = Yes, 0 = No

### 2.6 Climate Change-related Challenges

This was evaluated using a 4-point Likert-type scale ranging from Strongly Agree (4) to Strongly Disagree (1).

### 2.7 Climate Change Adaptation Strategies

This was evaluated using a 5-point Likert scale ranging from Awareness (1), Interest (2), Evaluation (3), Trial (4), and Adoption (5). The Likert scale allows respondents to self-report the extent of their agreement or disagreement with given questions. Because the responses are fixed, the data should be quicker and easier to analyse than information from open-ended, qualitative survey questions (Doubleday *et al.*, 2022; De Gaaf *et al.*, 2023).

### 2.8 Model Specification

In order to empirically examine the differential impact of climate change on the income of male and female cassava farmers, the following econometric model is specified: The multiple regression model was employed to ascertain the causal effect of the independent variables on the dependent variable, income (Auci *et al.*, 2018; Breen *et al.*, 2018).

$$Income_i = \beta_0 + \beta_1 Climate\ challenge_i + \beta_2 Adaptation\ strategy_i + \beta_3 Gender_i + \beta_4 (Climate\ challenge_i \times Gender_i) + \beta_5 (Adaptation\ strategy_i \times Gender_i) + \beta_6 (Access\ to\ extension\ services_i) + e_i$$

.....Equation 2.3

Where:

- $Income_i$  represents the monthly income of the  $i$ th cassava farmer (₦).
- $Climate\ challenge_i$  is the aggregate score of climate change-related challenges faced by the  $i$ th farmer.
- $Adaptation\ strategy_i$  is aggregate score of the extent of adaptation strategies adopted.
- $Gender_i$  is a dummy variable representing the gender of the  $i$ th farmer (male = 0, female = 1).
- $Climate\ challenge_i \times Gender_i$  and  $Adaptation\ Strategy_i \times Gender_i$  are interaction terms that capture the moderating effect of gender on the relationship between climate challenges, adaptation strategies, and income.
- Access to extension services is the control variable
- $e_i$  is the error term.

The inclusion of interaction terms is crucial for identifying whether and how the impact of climate change on income differs between male and female cassava farmers (Wooldridge, 2013).

### 3.0 Results and Discussions

#### 3.1 Socioeconomic Characteristics

The result in Table 3.1 demonstrates that male and female cassava farmers of Delta State Nigeria displayed substantial differences in socioeconomic characteristics which affect their capacity to adapt to climate change. The study demonstrates male farmers have an average age of 37.2 years which is lower than the 45.7 years average age of their female counterparts. About 56.4% of female farmers have ages below 30 years old while 28.3% of male farmers belong to the 40–49 age group. The study showed that women become involved in cassava farming at younger ages because they need economic stability. Women who have lost their partners made up 43.5% of all female cassava farmers whereas male farmers represent only 35.0% of widowed individuals indicating that surviving spouses resorted to farming for livelihood pursuit. Goodluck *et al.* (2024) discovered that Delta State cassava farmers mostly consisted of middle-aged participants yet female farmers confronted resource distribution problems during their research.

Education status and land ownership patterns indicated specific gender-related obstacles that constrain climate change adaptation measures. The study indicated that female farmers without formal education represent 31.2% of the population while male farmers comprise only 12.8% of the total whereas secondary education attainment stands at 40.0% for males and 20.0% for females. Women struggle to access climate information and implement adaptation strategies because education directly improves farmers' adoption of climate practices according to Adekunle (2023) whose findings showed female farmers control 1.1 hectares of land while male farmers managed 2.2 hectares. Omodara *et al.* (2023) found that gender affects both land ownership and farm size decisions. Women farmers receive less

revenue from their reduced plot sizes which impedes their capacity to invest in essential climate adaptation tools such as irrigation systems together with improved seed varieties.

The study showed that male cassava growers earned ₦125,984.6 monthly on average while their female counterparts only bring in ₦75,884.8. Farm size differences along with unequal access to financial resources create a gap between male and female farmer incomes. Oluwatimilehin and Ayanlade (2023) established that financial restrictions create obstacles for rural farmers seeking climate change adaptation measures. Effiong, Uwah, and Akwo (2024) revealed how financial barriers stopped cassava growers from implementing improved agricultural methods which intensifies climate change effects toward female agricultural workers. Female farmers maintain longer histories in farming (19.2 years versus 10.5 years for males) but earned significantly less income because experience by itself does not guarantee financial stability when there are no available resources.

The study revealed distinct gender disparities in extension service accessibility because female farmers have contact with extension agents at 49.7% while male farmers connect with them only at 36.7%, Antia-Obong *et al.* (2021), also found that about 30.74% of male farmers had access to extension services. This finding implies that between genders, female farmers have more access to extension services than male farmers. However, within female farmers, 50.6% of all female farmers remain without access to extension, which likely restricts their adoption of climate-smart farming methods. Goodluck *et al.* (2024) demonstrated that regular engagement with extension personnel substantially boosts farmer adoption of water-conserving irrigation systems and additional climate-resistant practices. Enwa *et al.* (2024) highlighted how an upgrade of extension systems would help empower women farmers to combat climate shifts. Government agencies should direct their attention toward developing gender-specific strategies that provide enhanced educational options together with land distribution and financial support systems alongside improved extension programs to achieve comparable climate adaptation outcomes for Delta State's cassava farmers.

### **3.2 Climate Change-related Challenges Affecting Male and Female Cassava Farmers**

Table 3.2 showed that Delta State cassava farmers of both sexes encountered strong climate change risks although females suffered these risks more than their male counterparts. A shared concern across both genders exists regarding flooding since men had a mean score of 3.76 and women had a mean score of 3.91 which are above the 2.5 mean threshold. Chukwuemeka's (2023) study on Abia State farm owners revealed flood increase, decreased cassava production and deteriorated their soil condition. Goodluck *et al.* (2024) documented how Delta State cassava farmers deal with financial difficulties as well as insufficient infrastructure that made climate change impacts worse. Female farmers demonstrated slightly higher vulnerability than male farmers because insecurity in land ownership and restricted access to adaptive resources impacts them more.

impact crop yields. This study showed declining soil moisture retention with a mean score of 3.25 for males along with a mean score of 3.50 for females and declining soil degradation with mean of 3.21 for males and mean score of 3.45 for females illustrates the negative impact of extreme climate conditions on farm soil quality. The results of Dimkpa and Dimkpa (2024) showed that problematic soil quality cut into the financial performance of cassava production across the Niger Delta region. Female farmers reported significantly higher scores across these challenges which suggest they lack available resources to address negative climate impacts such as irrigation facilities or organic soil amendments.

**Table 3.1: Socioeconomic characteristics**

Variable	Male (N=180)	Female (N=180)
	Frequency (percent)	Frequency (percent)
<b>Age</b>		
Less than 30 years	62 (34.4)	101 (56.4)
30 - 39 years	38 (21.1)	18 (10.1)
40 - 49 years	51 (28.3)	29 (16.2)
50 years or more	29 (16.1)	31 (17.3)
<b>Mean age</b>	37.2	45.7
<b>Marital status</b>		
Single	22 (12.2)	35 (19.6)
Married	42 (23.3)	51 (28.5)
Divorced	53 (29.4)	15 (8.4)
Widowed/Widower	63 (35.0)	78 (43.5)
<b>Level of education</b>		
No formal education	23 (12.8)	56 (31.2)
Primary	14 (7.8)	32 (17.8)
Secondary	72 (40.0)	36 (20.0)
Tertiary	71 (39.4)	55 (30.6)
<b>Farm size (ha)</b>		
Less than 0.5	47 (26.1)	52 (29.1)
0.5 – 0.9	59 (32.8)	44 (24.6)
1.0 – 1.4	30 (16.7)	21 (11.7)
1.5 – 1.9	21 (11.7)	25 (14.0)
2 and above	22 (12.2)	36 (20.2)
<b>Mean farm size (ha)</b>	2.2	1.1
<b>Cassava farming experience (years)</b>		
1 - 5 years	43 (23.9)	16 (8.9)
6 - 10 years	48 (26.7)	26 (14.5)
11 - 15 years	16 (8.9)	54 (30.2)
16 - 20 years	26 (14.5)	47 (26.3)
More than 20 years	46 (25.6)	40 (22.3)
<b>Mean experience (years)</b>	10.5	19.2
<b>Monthly income (₦)</b>		
Less than ₦100,000	31 (17.2)	22 (12.3)
₦100,000 – ₦200,000	56 (31.1)	58 (32.4)
₦200,001 – ₦300,000	35 (19.4)	59 (32.9)
Above ₦300,000	58 (32.3)	40 (22.4)
<b>Mean monthly income (₦)</b>	₦125,984.6	₦75,884.8
<b>Extension contacts</b>		
Yes	66 (36.7)	89 (49.4)
No	114 (63.3)	91 (50.6)

Both sexes agreed that unpredictable rainfall patterns (male: mean of 3.42, female: mean of 3.67) along with drought (male: mean of 3.18, female: mean of 3.42) presented significant challenges to their cassava production operations. These findings agree with the work of Oluwatimilehin and Ayanlade (2023) that climatic variables create significant changes that



Problems in production intensified due to higher pest and disease occurrence and heat stress occurrence according to the survey results (male: mean score of 3.58, female: mean score of 3.72 for pests and disease incidence and male: mean score of 3.09, female: mean score of 3.34 for heat stress) which requires better extension services and climate adaptation strategies. Goodluck *et al.* (2024); Adekunle (2023) and Efretuei and Ekwere, (2024) highlighted the significance of climate-smart agricultural practices where drought-sensitive cassava varieties and soil protective methods help diminished these climate effects. Female farmers experienced greater barriers to adaptation because they received limited access to both extension services and improved inputs through which they could enhance their adaptive capabilities. Results from the study revealed that female farmers experience higher post-harvest losses because of climate changes (mean score of 2.89 for male and mean score of 3.14 for female). Such losses highlighted the need for improved storage facilities that would benefit female farmers specifically given their responsibility in post-harvest management.

The findings from table 3.2 showed reduced access to water for irrigation to be more of a significant issue according to female farmers due to the higher mean score (male: mean score of 2.46 and female: mean score of 2.71). The data indicated women farmers mostly depended on rainfall because they do not have the same opportunity to develop irrigation systems. According to Enwa *et al.* (2024) vegetable farmers in Delta State exhibited gendered constraints by showing that women experience more difficulty accessing water resources for climate adaptation. To equalize these inequalities governments must implement gender-sensitive policies which enable women farmers to acquire water management tools and financial support and education on climate-smart farming practices. Climate adaptation measures must prioritize female-specific strategies because they will enhance Delta State's cassava farmers' ability to withstand climate change.

**Table 3.2: Impact of climate on male and female cassava farmers**

Climate change-related challenges	Male (N=180)		Female (N=180)		Remarks
	Mean	Std. dev.	Mean	Std. dev.	
Unpredictable rainfall patterns	3.42	0.854	3.67	0.923	Both agreed
Drought	3.18	0.792	3.42	0.875	Both agreed
Flooding	3.76	0.903	3.91	0.948	Both agreed
Increased pest and disease incidence	3.58	0.878	3.72	0.911	Both agreed
Soil degradation	3.21	0.805	3.45	0.892	Both agreed
Extreme Heat Stress	3.09	0.812	3.34	0.870	Both agreed
Declining Soil Moisture Retention	3.25	0.832	3.50	0.897	Both agreed
Post-Harvest Losses Due to Climate Conditions	2.89	0.771	3.14	0.839	Both agreed
Reduced Access to Water for Irrigation	2.46	0.689	2.71	0.751	Only female agreed

Where: Mean  $\geq 2.5$  is Agreed, mean  $< 2.5$  is Disagreed

### 3.3 Adaptation Strategies Adopted by Male and Female Cassava Farmers in Response to Climate Change

Table 3.3 shows which strategies both male and female cassava farmers implemented to adapt to climate change across Delta State in Nigeria. Male and female farmers use climate-resistant cassava varieties alongside crop diversity, improved agricultural practices, and soil protection methods. The average score for climate change strategies among male farmers exceeded those of female farmers in all adaptation categories. Goodluck *et al.* (2024) documented that cassava farmers adopted drought-resistant cassava varieties (mean = 3.28) in addition to employing soil conservation methods (mean = 2.98) at moderate-to-high levels. Better access to information along with resources and agricultural extension services delivered to male farmers explains the observed adoption gap according to Chukwuone (2015). The author found that male-led households showed higher tendencies to adapt to climate change.

Male farmers had significant changes to planting schedules through their responses (mean = 3.05) yet female farmers reported lower scores (mean = 2.69). Male farmers show better ability to change planting times because they access more climate-related information and carry fewer household obligations. Cassava farmers showed medium levels of adoption for weather forecast access based on research by Goodluck *et al.* (2024) whose study yielded a mean score of 2.60. Chukwuemeka (2023) showed that both male and female farmers experience scheduling uncertainty because of climate change as a key agricultural challenge. The results show an urgent need for specific interventions through climate-smart advisory services created for female farmers to enhance their effectiveness at adjusting planting schedules.

The use of irrigation systems remained scarce with minimal acceptance from both genders (male = mean score of 2.71, female = mean score of 2.35). The study of Adekunle (2023) confirmed that Oyo State cassava farmers did not adopt irrigation systems because of economic limitations. The application of irrigation represents a vital adaptive strategy because of unpredictable rainfall yet farms found it challenging to adopt this practice because of expensive infrastructure and costs. The research conducted by Goodluck *et al.* (2024) revealed that rises in income led farmers to adopt water-efficient irrigation systems. Specific improvements in financial capabilities for female farmers will boost their potential to take up irrigation methods because these farmers customarily receive lower incomes.

Male farmers reported better access to weather forecasts than female farmers (male farmers mean = 3.07 vs female farmers mean = 2.71). The trend continued similarly to results with planting date alterations. Similar to Osuji, Igberi and Ehirim (2023), the authors showed how access to meteorological information leads farmers to adapt their strategies for cassava cultivation. Cassava farmers mostly depend on radio and family networks for climate change information which indicates why male farmers use weather forecasts more frequently than female farmers according to Adekunle (2023). Extension service programs and digital literacy training for female farmers need to be targeted because they will help women farmers obtain weather updates promptly and develop better adaptation skills.

**Table 3.3: Adaptation strategies adopted by male and female cassava farmers in response to climate change**

Adaptation strategies	Male (N=180)		Female (N=180)		Remarks
	Mean	Std. dev.	Mean	Std. dev.	
Use of climate-resilient cassava varieties	3.58	0.892	3.19	0.874	Both adopted
Diversification of crops	3.81	0.925	3.42	0.911	Both adopted
Altering planting dates	3.05	0.841	2.69	0.803	Only male adopted
Adoption of improved farming practices (e.g., mulching, intercropping)	3.92	0.915	3.48	0.897	Both adopted
Use of irrigation systems	2.71	0.765	2.35	0.702	Both not Adopted
Soil conservation techniques	3.33	0.878	3.10	0.854	Both adopted
Regular access to weather forecasts	3.07	0.816	2.71	0.788	Only male adopted

Where: Mean  $\geq 3.0$  is Adopted, mean  $< 3.0$  is Not Adopted

### 3.4 Impact of Climate Change on the Income of Male and Female Cassava Farmers

Table 3.4 shows regression outcomes that measure how climate change influences the earning capacity of cassava growers across male and female population in Delta State Nigeria. This explained variances in farmer earnings accounts for 46.1% of the total variations according to the  $R^2$  value (0.461) which demonstrated that climate changes alongside adaptation tactics and gender variations strongly influence farming income. The adjusted R square value of 0.403 together with the independent variables' weight demonstrates a solid predictive power of the statistical model. The model exhibits strong statistical significance because its F-statistic reaches 16.123 when  $p = 0.000$ . This show the included variables jointly shape cassava farmers' income differences.

### 3.5 Impact of Climate Change on Income

The negative coefficient value of -1132.567 for climate change in Table 3.4 shows significance at a 1% level ( $p = 0.001$ ) which indicates that increased climate-related issues decrease the income of cassava farmers. Farm productivity decreases when adverse climatic events occur, causing unpredictable rainfall alongside droughts and excessive heat and flooding to emerge as negative factors that reduce income levels (Ekwere and Efretuei, 2024). Various empirical studies proved that climate change produces adverse impacts on agricultural outputs along with farm incomes. Abia State experienced erratic weather that caused extensive yield reductions in cassava which decreased agricultural revenue according to Chukwuemeka (2023). Cassava yield decreased among farmers based in Oyo State because of changing climatic conditions leading to reduced farm income according to Adekunle (2023). The study by Osuji *et al.* (2023) confirmed that climate change leads to crop failure and causes soil fertility reduction along with biodiversity loss during cassava production in Ebonyi State. The research results affirm the situation in Nigeria by showing that climate variability requires immediate strategies to minimize its adverse effects.

### 3.6 Effect of Adaptation Strategies on Income

Results show that adopting climate adaptation measures leads to higher income for cassava farmers ( $\beta = 1923.456$  at  $p = 0.000$ ). Farmer success with implementation of adaptation techniques involving drought-resistant cassava varieties and irrigation along with soil conservation and crop diversity methods demonstrates better income stability. Research conducted by Goodluck *et al.* (2024) confirmed that cassava farmers in Delta State produced better incomes when they employed climate-smart agricultural practices including weather forecasting and soil conservation and improved cassava varieties. Ajayi (2015) discovered that among cassava farmers in the Niger Delta region the number of climate adaptation strategies directly affected farming profitability. The research conducted by Effiong, Uwah, and Akwo (2024) demonstrated that Cross River State experienced improved cassava output and earnings through the utilization of climate change adaptation methods such as mulching and early planting and intercropping practices. Research findings show that various adaptation techniques help farmers reduce climate-driven income reductions and strengthen their agricultural systems.

### 3.7 Gender-Based Disparities in Income

The regression analysis shows female cassava farmers earn about ₦4,789.12 less yearly on average compared to male farmers ( $\beta = -4789.123$ ,  $p = 0.000$ ). The negative relationship between gender and agricultural income demonstrates a noticeable gap between male and female farmers that comes from multiple socio-economic and structural hurdles. Various research studies published their results with comparable findings. Enwa *et al.* (2024) reported economic adversities among female vegetable farmers in Delta State because they lacked sufficient access to available land and credit and extension service ownership. In Rivers State female cassava farmers obtained reduced incomes because of minimal market access limitations and insufficient financial resources and traditional cultural barriers according to Unaeze and Amarachi (2024). According to Onoja *et al.* (2019) male farmers possess superior access to climate-smart technologies which enhances productivity and generates better income results. The reduced earnings of women farmers working with cassava stem from their difficulties owning land, elevated farming costs, workforce challenges, and minimal usage of mechanized agricultural tools. Social and cultural norms create barriers for women to acquire financial backing and agricultural extension services which drive upward the existing income gaps.

### 3.8 Interaction Effects of Climate Change and Gender

The coefficient for the interaction term climate change challenges with gender ( $\beta = 753.456$ ) demonstrates a positive association at the  $p = 0.008$  level. This result implies that although climate change produces negative impacts on both male and female cassava farmers, women's adverse outcomes prove slightly more bearable than men's outcomes. Research by Osuji *et al.* (2023) shows that women frequently employ mixed cropping techniques alongside income-growing strategies which help them cope with climate-related threats. Chukwuone (2015) noted that female farmers adopted non-farm activities to lessen the negative impacts of climate change more frequently than males.

### 3.9 Interaction Effects of Adaptation Strategies and Gender

The negative and statistically significant strong relationship between adaptation strategies and gender ( $\beta = -956.789$ ,  $p = 0.011$ ) demonstrates that female farmers experience less income increase from adaptation strategies when compared to male farmers. Women farmers experience reduced success due to restrictions which prevent them from accessing agricultural extension services and financial resources and modern farming technologies. Multiple studies have verified the unique obstacles that affect women and men in farming.

The investigation by Effiong *et al.*, (2024) revealed female farmers from Cross River State receive fewer improved farming materials and limited extension education which decreases their potential for effective adaptation strategies. The study by Adekunle (2023) showed that female cassava farmers in Oyo State encountered restrictions in their ability to obtain financing while also lacking access to farm machinery which restricted their adoption of climate-resilient farming methods.

**Table 3.4: Differential impact of climate change on the income of male and female cassava farmers**

Variable	Coefficient	Standard error	t-Value	p-Value
Constant	20345.678	4087.654	4.982	0.000
Climate Change Challenges	-1132.567***	347.891	-3.255	0.001
Adaptation Strategies	1923.456***	456.789	4.210	0.000
Gender	-4789.123***	1098.234	-4.360	0.000
Climate Challenges × Gender	753.456***	280.345	2.687	0.008
Adaptation Strategies × Gender	-956.789**	370.123	-2.587	0.011
R <sup>2</sup>	0.461			
Adjusted R <sup>2</sup>	0.403			
F-Statistic (p-value)	16.123 (0.000)			

\*\*\* and \*\* is significant at 1% and 5% respectively

#### 4.0 Conclusion

This research highlights how climate change impacts income levels of cassava farmers in Delta State, exposing gender inequalities in adaptation and vulnerability. Farm income has seen a dramatic decline due to climate-related challenges, including unpredictable rainfall, extended droughts, and flooding. However, farmers who embraced climate adaptation strategies, such as cultivating drought-resistant cassava varieties and enhancing soil management along with irrigation practices, experienced remarkable income growth. The research highlights significant structural barriers that prevent female cassava farmers from achieving economic parity with their male counterparts. These women face restricted access to credit, agricultural tools, and land, leading to worse economic conditions. Also, despite engaging in similar farming practices to men, female farmers earn substantially lower incomes. While some female farmers have shown progress through non-farm diversification strategies, these efforts are often less successful than the strategies employed by male farmers. Given these findings, it is essential to address these disparities and implement the following recommendations:

In order for women to enjoy more land rights and farming resources thus Governmental bodies at all levels should encourage gender-oriented agricultural policies. Climate smart agriculture could be encouraged through local wells and dams that introduce all year-round farming. Agricultural extension services and research institutes need to expand their contact with farmers especially the female gender to deliver proper climate adaptation training.

#### 4.1 Limitations of the Study

This study focuses on Gender-Based Analysis of the Effect of Climate Change on Income of Cassava Farmers in Delta State, Nigeria. Thus, it is limited in scope and resources. Data were collected on 360 small-scaled cassava famers. Delta State was divided into its three agricultural zones (Delta North, Delta Central and Delta South) (Delta State Ministry of Agriculture, 2024). Two Local Government Areas (LGAs) were purposively selected considering the extent of cassava farming and these include Delta North (Aniocha South and Ika North-East), Delta Central (Ughelli North and Ethiope East) and Delta South (Warri South and Isoko North). Out of the twenty-five local government areas of Delta State. In terms of scope, this study focused on only small-scale cassava farmers and the data collected were for one cropping season.

Limitation on data collection was faced most especially on issue of questionnaire administration. The respondents were all interviewed due to the importance of every information stated in the questionnaire. Also, the information provided by the farmers that were used in this study were mainly from memory recall as most of them do not take adequate records on their day-to-day operations. This therefore prolonged the collection of data which took more time than was required for the survey. In spite of these limitations, the data used for the study were adjudged to be error free because of the removal of irrelevant information that was not useful for the study. Further research could be carried out in other food crops that are prevalent in Delta state while one could expand the scope of study to other states of the federation in order to achieve a more robust study.

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