Bioscene

Bioscene
Volume- 22 Number- 02
ISSN: 1539-2422 (P) 2055-1583 (O)
www.explorebioscene.com

Gender Effect of Socioeconomic Characteristics on Choice of Climate Change Adaptation Strategies in Southeast Nigeria

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Abstract: Climate change threatens agriculture in Nigeria, with gender influencing exposure and adaptation strategies. This study investigates how gender and socioeconomic factors affect the choice of climate change adaptation strategies among 240 crop-based smallholder farmers in Southeast Nigeria. Data were collected using structured questionnaires and interviews. Descriptive statistics, multinomial logistic regression, and Principal Component Analysis (PCA) were employed. Results show that factors such as farm experience, income, farm size, credit access, household size, and cooperative membership significantly influence adaptation choices. Males were more likely to adopt construction of bunds, soil and water conservation, and crop diversification, while females preferred mulching and date adjustments, reflecting disparities in access to resources. PCA revealed key constraints to adaptation strategies like inadequate credit, high technology costs, weak governance and limited inputs, affecting men and women differently. The study recommends gender-sensitive adaptation interventions and policies that address these disparities and enhance inclusive resilient adaptation efforts among smallholder farmers in Southeast Nigeria.

Key words: Climate change, Climate change adaptation, gender, productivity, socioeconomic characteristics, smallholder farmers, food security, capacity, constraints, adoption

1. Introduction

The ongoing threat of climate change on agricultural productivity and livelihoods of smallholder farmers across globe, particularly in Africa where rain-fed farming dominates has necessitated the need for resilient adaptation practices (Buchner et al., 2020; FAO, 2016). Nigeria is the most populous African country and one of the top ten most vulnerable to climate change, which is exposing tens of millions of people to climate change crisis (Butu et al., 2022). The urgency of this threat is heighted by the gendered gap in smallholder farmers' ability to adapt to climate impacts such as erratic rainfall, flooding, heat, drought and increased pest infestation. Climate change affects men and women differently with the women being disproportionately affected (Gicheru et al., 2024; Resurreccion et al., 2019), due to socio-cultural reasons and decision-making power (Adzawala et. el., 2019; Amusa et al., 2015; Anugwa et al., 2023; Quisumbing et. al., 2018; Yiridomoh et al., 2022).

Climate change adaptation strategies are deliberate actions taken to reduce vulnerability and enhance resilience to the adverse effects of climate change (IPCC 2024). These adaptation strategies comprise of mulching, improved variety crops, irrigation, soil and water conservation, construction of bunds, crop diversification and planting and harvesting dates adjustment; help smallholder farmers in reducing their vulnerability by boosting their capacity to cope and recover from climate crisis. Access to resilient adaptation strategies empower smallholder farmers to build climate resilience, increase yields, improve food security and ensure sustainable agriculture (Adeagbo et al., 2021; Balogun et. al 2020; Karoline & Malgorzata 2020; Rojas-Downing etal 2017; Ume et al., 2021). Ojo etal., (2020), in their study found that a unit increase in adoption of climate change adaptation strategies will increase household food security by about 3 units while decreasing severity in food insecurity by about 3.2 units. Also, (Nnadi et al., 2023; Oyi Madu, 2023), observed that women's equal accessibility to productive resources as their men's counterpart increases their adoption of adaptation strategies, yields and household nutrition. Ackerl et al., (2023) in their studies found that most smallholder farmers do not adopt resilient adaptation strategies at the long run either due to inability to afford them or for institutional reasons; and emphasized of the reason to examine the factors behind this.

Smallholder farmers despite being key players in agricultural productivity, food security, and poverty reduction still face significant barriers in adopting resilient adaptation strategies (Ackerl. et al., 2023). There is a controversy on the reason behind low adoption of adaptation strategies by smallholder farmers. While some argue that it's caused by socioeconomic factors like land ownership, income, access to information, education, and access to extension services, particularly for women farmers (Ackerl. et al., 2023; Ifeanyi-Obi et al., 2017; Amusa et al., 2015). Others emphasize policy inconsistency, non-involvement of smallholder farmers at policy design and implementation, short-term intervention, non-integration of gender in national Adaptation Plan (NAP) and financial hindrances (Butu et al., 2022; Eneji et al., 2021; Ogunjinmi & Ogunjinmi, 2022; Wredström, (2024); Ylipaa et al., 2019). Addressing this policy issues is vital in designing comprehensive tailored adaptation interventions that works for both genders in achieving climate resilience among smallholder farmers.

Governmental and development agencies have responded to this by implementing a number of programs designed to increase farmers' ability to adapt. These include training in climate-smart agriculture, access to microcredit, agricultural extension reforms, and the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN). The systemic gender disparities and regional socioeconomic realities that restrict the adoption of adaptation measures, however, have not been adequately addressed by many of these programs (Fakoya et al., 2022; Anugwa et al., 2020). Their efficacy is further compromised by poor institutional follow-up, uneven funding, and inadequate targeting. Furthermore, a lot of programs use a one-size-fits-all approach, neglecting the various and situation-specific requirements of farmers, both male and female, in various agro-ecological zones (Nnadi et al., 2019; Otum et al., 2019).

This study, therefore, investigates the socioeconomic determinants of climate change adaptation strategies and their effectson the adoption of different adaptation strategies across gender groups in Southeast Nigeria. Using multinomial logistic regression, it aims to uncover how these socioeconomic characteristics influence the choice and adoption of adaptation strategies. By linking these insights to broader development and policy goals, the study contributes to gender-responsive climate policy design that is both inclusive and impactful. The findings are expected to inform targeted interventions that can raise the adoption of climate adaptation strategies among genders, improve farmer resilience, and advance progress toward increased productivity.

Sustainable Livelihoods Framework (SLF) introduced by DFID in 1999, is the theoretical underpinning for this study. The SLF explains how rural populations use various assets human, social, financial, natural, and physical to adapt to climate shocks like climate change. It highlights the role of socioeconomic factors, such as education and access to resources, which are central to this study. The framework accommodates a gender lens, allowing analysis of how men and women differ in their access to livelihood assets and in their capacity to adopt adaptation strategies. Existing literature on gender and climate change adaptation in Nigeria reveals that climate change impacts and adaptation are not gender-neutral, and women are often more vulnerable due to unequal access to productive resources (Amusa et al., 2015; Ume et al., 2021; Anugwa et al., 2023; Enwa et al., 2024; Nnadi et al., 2023; Ogunjinmi et al., 2022). While some studies rely on descriptive statistics and cross-tabulations (Ogunjinmi et al., 2022; Anugwa et al., 2020), others use econometric models like the Heckman selection model, binary and multinomial logit models, and principal component analysis for deeper analysis (Amusa et al., 2015; Adeagbo et al., 2021; Otum et al., 2019; Nnadi et al., 2023). However, many of these models lack gender disaggregation or focus only on female farmers, limiting insights into comparative gender dynamics (Otum et al., 2019; Oyi Madu, 2023).

There is also a regional imbalance, with most studies on gender and climate change adaptation focused in Southwest Nigeria especially Ekiti, Ogun, and Osun States while few are based in the Southeast (Nnadi et al., 2019; Ifeanyi-Obi et al., 2017; Ogunjinmi et al., 2022; Fakoya et al., 2022). Given Nigeria's regional diversity, this limits the generalizability of findings and underscores the need for context-specific research in the Southeast. Existing studies on climate change adaptation in Southeast Nigeria often focus on single states, limiting regional insights. For example, Otum et al., (2019) studied Enugu, Ifeanyi-Obi et al., (2017) focused on Anambra, and Anugwa et al., (2020) examined Abia. This study addresses these gaps by covering three agrarian, climate-vulnerable states; Anambra, Ebonyi, and Enugu. The study also provided a more comprehensive and gender-sensitive analysis of the effects of socioeconomic determinants on adoption of different adaptation strategies in the region, thus filling the methodological gap. The three questions addressed by this study are: what are adaptation strategies adopted by men and women smallholder farmers? What are the effects of socioeconomic characteristics on the adoption of climate change adaptation strategies? What are the major constraints to adoption of climate change adaptation strategies?

3.0 Materials and Methods

3.1 The Study Area

The study was conducted in Southeast Nigeria, one of the country's six geopolitical zones, comprising five states: Abia, Anambra, Ebonyi, Enugu, and Imo. Located in the tropical rainforest zone, the region experiences mean temperatures between 26°C and 28°C, annual rainfall of 1,400–2,000 mm, and over 70% relative humidity (NiMeT, 2025). With a population of over 22 million and a landmass of about 10.95 million hectares, the area is densely populated, averaging about 1,000 people per km^2 (NPC, 2019; 2020). Agriculture is the mainstay, employing 60–70% of the population (Okoye et al., 2010), with crops like yam, cassava, cocoyam, and maize grown on predominantly loamy soils through mixed cropping systems. The region has two main seasons and has faced increasing climate variability, including floods and droughts (NiMeT, 2025; Feyissa et al., 2018), prompting smallholder farmers to adopt various climate adaptation strategies.

3.2 Sampling Procedure

A multi-stage sampling technique was employed. In the first stage, three states—Anambra, Ebonyi, and Enuguwere randomly selected from the five states in Southeast Nigeria. The second stage involved randomly selecting two agricultural zones from each of the three states, resulting in six zones. In the third stage, two Local Government Areas (LGAs) were purposively selected from each zone based on the high concentration of crop-based agribusinesses and effects of climate change, totalling twelve LGAs. In the fourth stage, male and female smallholder farmers were purposively identified within these LGAs with assistance from extension officers. Finally, in the fifth stage, 20 male and female crop-based smallholder farmers were randomly selected from each LGA, yielding a total sample size of 240 respondents.

3.3 Data Collection

Data for this study were collected using mixed method. Quantitative data were collected using semi-structured questionnaires while qualitative data were collected using in-depth interview. Information was obtained on; socio economic characteristics of smallholder farmers, climate change adaptation strategies available to smallholder farmers. Enumerators were trained by the researcher to assist in administering and retrieving questionnaires. Data were collected from September to December, 2023. Statistical software packages such as Stata 15, and Excel were employed for data analysis.

3.4 Model Specification

Descriptive statistics like frequency, percentages and mean were used to achieve objective i and multinomial logit model was used to realize objective ii. The study employed multinomial logistic regression (MNL) to analyze the factors influencing the adoption of climate change adaptation strategies. MNL is a statistical technique used to predict the likelihood of outcomes with more than two categories by estimating multiple equations concurrently. For the analysis, the respondents were asked to tick one major adaptation strategies they use from the different adaptation strategies available to them. Each equation compares one category to a designated base outcome or reference category. The dependent variables are the choice of adaptation strategies such as, mulching, improved variety crops, crop diversification, planting date and harvesting date adjustment, soil and water conversation, irrigation, and construction of bunds. Improved variety crops are selected as the base outcome or reference category by both genders. It is also one of the adaptation strategies mostly promoted by extension agents and international agencies. The explanatory variables are described below;

X_1-X_{12} are explanatory variables that influence Choice of adaptation strategies such as;

X_1 = age of the crop-based enterprises (years)
X_2 = farm income (naira)
X_3 = educational level (years)
X_4 = marital status (married=1, single=0)
X_5 = farm size (hectares)
X_6 = farming experience (years)
X_7 = extension contact (no of times)
X_8 = membership of farmers association (1= member, 0= otherwise)
X_9 = household size (number)
μ = error term

the multinomial logistic regression is given below as:

$$\text{Prob}(Ai = j) = \frac{e^{\beta j Xi}}{\sum_{k=0}^{j} e\beta kxi} \quad j = 0, 1,,,J \qquad 2.1$$

Where Ai represents a random variable representing adaptation strategy chosen by smallholder farmers. We will assume that each crop-based entrepreneur faces a set of discrete, mutually exclusive choices of adaptation strategies. These strategies are assumed to depend on a number of climate attributes, socioeconomic characteristics and other factors X. The MNL model for adaptation choice will specify the following relationship between the probabilities of choosing option Ai and the set of explanatory variables X as (Greene, 2003).
To identify the major constraints which is objective iii, a two-step approach was used. First descriptive statistics (sum of means) was used to rank individual constraints across genders. Second, inferential statistics (Principal Component Analysis (PCA)) was conducted across genders to extract underlying components. Correlation matrices and rotated components loadings were used to determine the dominant constraints variables after the scree plot.

4.0: Results and Discussion

4.1 Adaptation Strategies Adopted by Men and Women Smallholder Farmers

Table 1 presents the adaptation strategies adopted by men and women smallholder farmers.
For crop diversification, 55% of male and 45% of female respondents adopted the strategy, totalling 150 adopters, making it one of the most commonly used adaptation methods. The higher male adoption rate may be linked to better land access. Interview findings revealed that many women prefer mixed farming over crop diversification due to limited availability of land, this is in line with the findings of Jost et al. (2016), who found that women often opt for low-resource strategies due to land insecurity.

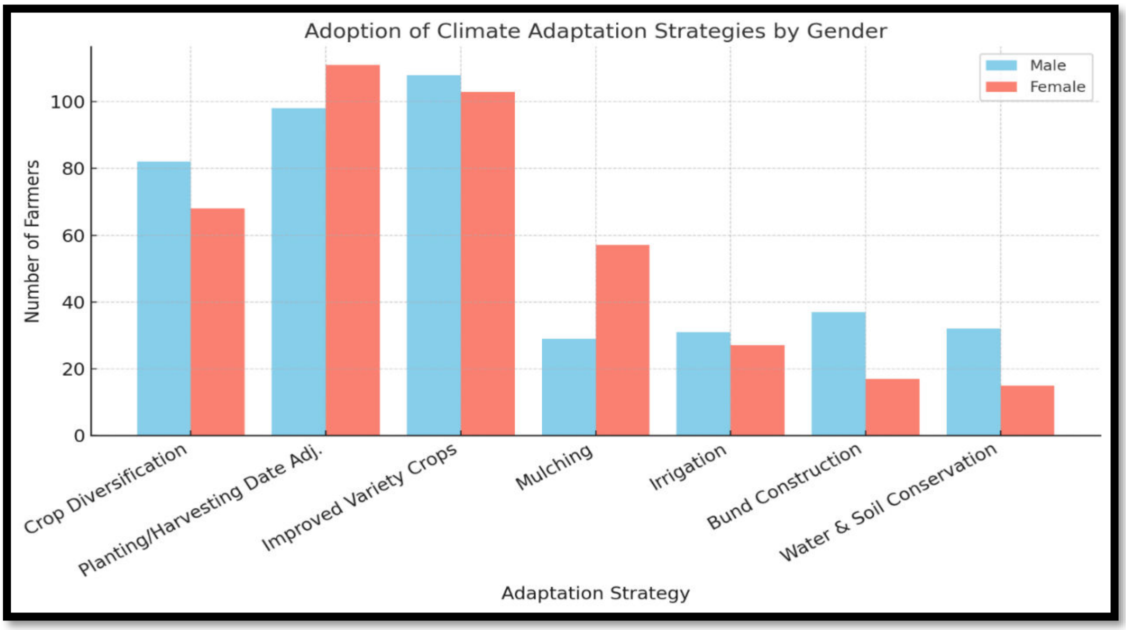
Table 4.1: Gendered Distribution of Adaptation Strategies By Smallholder Farmers

	Male	Female	Total
Crop diversification	82(55%)	68(45%)	150(100%)
Planting /Harvesting date adjustment	98 (47%)	111 (53%)	209 (100%)
Improved Variety crops	108 (51%)	103 (49%)	211 (100%)
Mulching	29 (34%)	57 (66%)	86 (100%)
Irrigation	31 (53%)	27 (47%)	58 (100%)
Construction of bunds	37 (69%)	17 (31%)	54 (100%)
Water and soil conservation	32 (68%)	15(32%)	47(100%)

The table shows that most smallholder farmers (209 respondents) adopted this strategy. There is a slight gender differences in adoption of planting and harvesting adjustment (53%) for women and (47%) for men. This is likely due to their sensitivity to seasonal changes and the affordability of this strategy. Use of improved variety crops was nearly equal between genders (51% male, 49%

female), reflecting high overall adoption, possibly due to availability and support from extension services, consistent with the findings of Asfaw & Maggio (2017).
In contrast, strategies like soil and water conservation were more male-dominated, with 68% of adopters being men and only 32% women. This trend is similar for capital-intensive methods such as bund construction (men 69%, women 54%) and irrigation (men 53%, women 47%), where men also predominate. These differences suggest that men have greater access to training and productive resources than their counterparts. On the other hand, women adopted labour-intensive, timing-sensitive practices like mulching (66% female adoption) and date adjustments, reflecting their traditional roles and limited resource access, as noted by Enwa et al., (2024).Interview data also revealed that both genders face inadequate access to credit, which hampers the adoption of capital-intensive adaptation strategies, especially irrigation and bund construction.

Figure 1: Gender Distribution of Climate Adaptation Strategies



4.2: Socioeconomic Determinants of Choice of Climate Change Adaptation Strategies

Table 2 presents the results of a multinomial regression analysis on the socioeconomic determinants of climate change adaptation strategies among smallholder farmers. The adoption of mulching is significantly influenced by household size (coefficient = 0.9178, p = 0.000), indicating that larger households are more likely to adopt this strategy due to increased labour availability. Also, farm size (coefficient = -1.2971, p = 0.001) and access to credit (coefficient = -1.1259, p = 0.000) negatively affect mulching adoption, suggesting that farmers with more land or better credit access may prefer more resource-intensive alternatives. Gender also plays a significant role, with female farmers more likely to adopt mulching (coefficient = 2.9323, p = 0.008), likely due to their limited access to land and credit. These findings align with those of Ochieng et al. (2017), Aryal et al. (2021), and Enwa et al. (2024), emphasizing that resource-constrained groups particularly women and larger households adopt mulching as a practical and accessible adaptation strategy. The study underscores the need for gender-responsive policies to support equitable and resilient climate adaptation.

The adoption of irrigation is significantly influenced by farm income (β = 2.1744, p = 0.013) and access to credit (β = 2.2040, p = 0.039), indicating that higher-income and credit-accessible smallholder farmers are more likely to use irrigation due to their greater financial capacity. Age (β = -2.4592, p = 0.066) and access to extension services (β = 1.3013, p = 0.076) are also important at the 10% significance level. Older farmers are less likely to adopt irrigation, likely due to concerns about investment returns, while those with better extension access are more likely to adopt it. Although gender (β = -0.7184, p = 0.294) is not statistically significant, the negative coefficient suggests that male farmers are more inclined to adopt irrigation than females. These results underscore the influence of demographic, financial, and technical factors, as well as existing gender disparities in access to productive resources. They align with findings by Ayanlade et al. (2023); Aryal et al., (2021); Ochieng et al., (2017); Elais et al. (2017), which observed that male farmers had greater access to irrigation and other productive assets.

Farm income (β = 1.8519, p = 0.04) and farm size (β = 1.6065, p = 0.02) significantly increase the likelihood of adopting crop diversification, as higher income and larger landholdings offer flexibility and resources to diversify. Conversely, farm experience (β = -1.6760, p = 0.000) and access to credit (β = -2.4870, p = 0.014) significantly reduce the odds of diversification; suggesting experienced farmers may stick to familiar crops with known markets, while credit schemes tied to specific crops (e.g., IFAD-funded rice or cassava programs) may discourage variety. Gender (β = -1.6080, p = 0.021) also significantly influences adoption, with male farmers more likely to diversify due to greater access to land and resources, while female farmers tend toward mixed farming on smaller plots. These findings are consistent with the findings of Aryal et al., (2021); Amare &Simane (2018), who found that large farm size increases the likelihood of adopting climate strategies. These results indicate that effective promotion of crop diversification should go beyond improving credit access, by addressing institutional constraints and supporting flexible, gender-sensitive, and experience-tailored policies, echoing findings from Ayanlade et al., (2023) and Elias et al. (2017).

The results show that farm experience ($\beta = 0.5597$, $p = 0.000$) and access to credit ($\beta = 0.8636$, $p = 0.021$) significantly influence the adoption of planting and harvesting date adjustments. Experienced farmers are better at recognizing climate changes and responding effectively, while credit access enables timely investments in inputs and technologies. Although gender ($\beta = 0.9177$, $p = 0.532$) is not statistically significant, the positive coefficient suggests that women have higher likelihood toward this strategy, possibly due to their agribusiness involvement. These findings are consistent with Aryal et al. (2021) and Marie et al. (2020), who emphasize the roles of experience and financial support in enhancing adaptive capacity.

Table 4.4: Determinants of the Choice of Climate Change Adaptation Strategies

Variable	Mulching	Irrigation	Crop diversification	Planting & harvesting dates adjustment	Construction of bunds	Soil & water conservation
Household size	0.000***(0.9178)	0.717(0.3239)	0.28(0.7741)	0.381(0.3661)	0.013***(0.0638)	0.575(0.3213)
Age	0.231(1.388)	0.066*(-2.4592)	0.93(0.0708)	0.823(0.0906)	0.87(-0.0485)	0.618(-0.2595)
Farm income	0.991(-0.0093)	0.013***(2.1744)	0.04**(1.8519)	0.55(0.2472)	0.938(0.7786)	0.279(0.6038)
Education	0.703(-0.3546)	0.599(0.4883)	0.67(0.3466)	0.173(0.5969)	0.312(1.0207)	0.955(0.0301)
Farm experience	0.548(-0.469)	0.796(0.2092)	0.000***(-1.676)	0.000***(0.5597)	0.000***(0.7856)	0.014***(1.251)
Access to credit	0.000***(-1.1259)	0.039**(2.204)	0.014***(-2.487)	0.021**(0.8636)	0.000***(0.1976)	0.045**(1.7985)
Farm size	0.011***(-1.1846)	0.521(-0.6086)	0.02**(1.6065)	0.79(-0.1183)	0.76(0.0638)	0.932(0.0469)
Access to extension service	0.365(-0.6335)	0.076*(1.3013)	0.109(-1.1152)	0.219(0.4451)	0.78(0.1672)	0.374(0.4299)
Marital status	0.535(0.5055)	0.433(0.6398)	0.274(0.7644)	0.678(0.1792)	0.468(0.4579)	0.4(0.5297)
Membership of cooperative	0.48(-0.6559)	0.242(1.4105)	0.49(0.552)	0.399(0.3672)	0.948(0.0436)	0.044**(0.042)
Gender	0.008***(2.9323)	0.294(-0.7184)	0.021**(-1.608)	0.532(0.9177)	0.000***(-0.0788)	0.018***(-0.1946)
-Constant	0.037(-6.0093)	0.309(-2.1997)	0.139(-3.0162)	0.929(-0.1036)	0.295(-1.9413)	0.86(0.2414)
Number of observations = 239						
LR = 106.33						
Chi 2 (66) prob> = 0.0012						
Pseudo R square = 0.6347						

Source: Field Survey, 2023. *, ** and * indicate significant levels at 1%, 5% and 10% respectively.**

For bund construction, household size (β = 0.0638, p = 0.013), farm experience (β = 0.7856, p = 0.000), and access to credit (β = 0.1976, p = 0.000) are significant predictors. Larger households contribute labor, while experienced and credit-supported farmers are more likely to adopt this water management strategy. Gender (β = -0.0788, p = 0.000) also significantly influences adoption, with men more likely to construct bunds reflecting disparities in access to credit and training. These results align with Enwa et al., (2024) who found that men adopt more capital-intensive strategies and reinforce the importance of inclusive policies that enhance women's access to resources and training to promote equitable and widespread adoption of effective climate adaptation strategies.
Farm experience (β = 1.2510, p = 0.014), access to credit (β = 1.7985, p = 0.045), and cooperative membership (β = 0.0420, p = 0.044) significantly increase the likelihood of adopting soil and water conservation practices. These findings suggest that experienced farmers are more knowledgeable about sustainable practices, credit access enables necessary investments, and cooperatives provide support and training. These findings align with Aryal et al., (2021); Ochieng et al., (2017), on farm experience and access to credit, aiding adoption of capital-intensive strategies. Gender (β = -0.1946, p = 0.018) is also significant, with male farmers more likely to adopt these practices; indicating disparities in access to resources and technical know-how. Addressing these gender-based constraints and strengthening financial and institutional support systems can promote inclusive and effective adoption of soil and water conservation strategies for enhanced climate resilience.
Credit is a significant factor influencing all climate change adaptation strategies, highlighting its critical role in farmers' adoption of adaptation strategies. The model's Pseudo R-squared value of 0.6347 indicates that 63% of the variation in adaptation strategy choices is explained by the independent variables. The likelihood ratio chi-square (LR chi2) value of 106.33, with a p-value of 0.012, confirms that the model is statistically significant. This signifies a meaningful difference in adaptation strategy choices between genders, leading to the rejection of the null hypothesis that no such difference exists. The findings further show that male smallholder farmers have greater access to innovative, productive, and financial resources than their female counterparts. their female counterparts which made it possible for them to easily adapt to resilient adaptation strategies. This is in agreement with Ayanlade et al., (2023), and Marie et al., (2020).

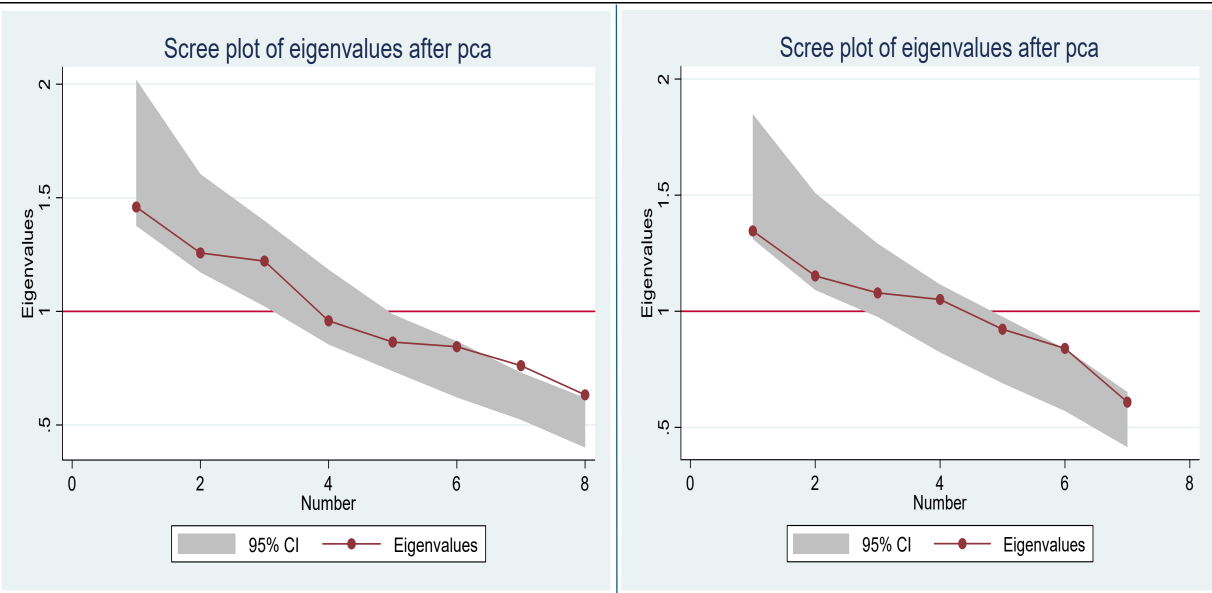
4.3 Constraints to Climate Change Adaptation

Table 3 shows the result of constraints to adoption of climate change adaptation strategies across gender, using sum of the means. From the table, all estimated mean values exceed the threshold of 2.50, except for the variable lack of knowledge on climate-resilient practices, leading to the rejection of the null hypothesis for the other variables. The main constraints to climate change adaptation identified include inadequate access to credit and inputs, insufficient training, limited climate information, high costs of adaptation technologies, delayed government input provision, poor governance, weak institutional capacity, and inadequate climate technologies. These results align with Ogunjinmi et al. (2022), who also highlighted lack of climate information and costly technologies as major barriers. While lack of knowledge on climate-resilient practices is a concern, it is not a primary constraint for either gender. Gender differences exist in most perceived barriers, except for access to credit, which is the top constraint for both male and female farmers. To further identify the most significant constraints, Principal Component Analysis (PCA) was employed.

Table 3: Mean Scores of Constraints to Climate Change Adaptation Strategies Across Genders

Variables	**Male & Female smallholder farmers**			
	Mean Critical Value (Males	Decision	Mean Critical Value (Females)	Decision
Lack of Knowledge on climate resilient practices	1.642	Disagree	1.672	Disagree
Inadequate access to credit	3.800	Agree	3.765	Agree
Inadequate access to input resources	3.692	Agree	3.597	Agree
Inadequate access to training on agronomic practices that enhance adaptation	2.517	Agree	2.454	Disagree
Inadequate climate change information	2.933	Agree	2.866	Agree
High cost of adaptation technologies	3.508	Agree	3.647	Agree
Untimely provisions of inputs from the government	3.475	Agree	3.504	Agree
Poor governance and institutional capacity	3.575	Agree	3.529	Agree
Inadequate technologies for climate change	3.642	Agree	3.655	Agree

Figure 2: Scree plot of the Eigenvalues of the constraints to climate change adaptation for Male and Female smallholder farmers.



Males Females

The scree plot in Figure 2 shows the distribution of eigenvalues for the extracted components. For male smallholder farmers, an elbow appears after the third component, suggesting three components should be retained based on the Kaiser criterion and visual inspection. These three components capture the major constraint dimensions. For female farmers, the elbow occurs after the fourth component, leading to the retention of four components. This gender-based difference highlights variations in the underlying constraints to adaptation strategies.

Table 4: Rotated Component Matrix for Loadings of Constraints to Adaptation Strategies for Female Smallholder Farmers

Variables	Comp 1	Comp 2	Comp3	Comp 4
Inadequate access to credit	0.4351	-0.5909	0.8547	-0.604
Inadequate access to input resources	0.7708	-0.3329	0.2343	0.5397
Inadequate climate change information	0.4936	0.4166	-0.6146	0.7584
High cost of adaptation technologies	0.4059	0.2686	-0.2595	0.8084
Untimely provisions of inputs from the government	0.5943	-0.4554	-0.3975	-0.4196
Poor governance and institutional capacity	0.4598	-0.0293	0.5608	-0.074
Inadequate technologies for climate change	-0.1753	0.4045	-0.5016	0.5273
Note: The most constraining climate change adaptation constraints are highlighted (bolded). The cut off point for which a variable is selected as one of the most constraining business management constraints is 0.7 – 0.9. This range in correlation analysis is defined as a very strong or high correlation. Therefore, it is appropriate to be the basis for which the decision for a most constraining factor is reached.				

Table 5: Rotated Component Matrix for Loadings of Constraints to Adaptation Strategies for Male Smallholder Farmers

Variables	Comp 1	Comp 2	Comp3
Inadequate access to credit	0.5359	**-0.8472**	0.3132
Inadequate access to input resources	0.5627	-0.2581	0.0234
Inadequate access to training on agronomic practices that enhance adaptation	0.1470	0.6092	0.5615
Inadequate climate change information	-0.5289	-0.4828	0.5772
High cost of adaptation technologies	**0.7714**	0.5282	-0.3010
Untimely provisions of inputs from the government	0.4578	-0.3141	-0.3859
Poor governance and institutional capacity	0.5763	-0.4249	**0.7623**
Inadequate technologies for climate change	-0.2256	0.2978	-0.6315
Note: The most constraining climate change adaptation constraints are highlighted (bolded).			

The analysis of the rotated component matrix (Tables 4 and 5) reveals key barriers to climate change adaptation among male and female smallholder farmers. Both groups face major challenges such as inadequate access to credit and the high cost of adaptation technologies. However, gender-specific differences exist. For male farmers, institutional and technical issues like poor governance, limited climate information, and lack of agronomic training are prominent. In contrast, female farmers struggle more with limited access to input resources and climate information, reflecting systemic gender inequalities. Interestingly, the absence of training as a key constraint for women may indicate limited exposure rather than adequate provision.

These findings highlight the need for gender-responsive strategies that address both structural and informational barriers. Enhancing access to credit, cooperative membership, and training especially for women can improve the adoption of sustainable practices and boost adaptive capacity. Such targeted interventions are essential to achieving equitable and effective climate resilience among smallholder farmers.

Conclusion and Recommendations

The study highlights clear gender differences in climate change adaptation among smallholder farmers, with women adopting low-cost, labour-intensive practices and men adopting more capital-intensive infrastructure strategies, reflecting disparities in access to resources, credit, and knowledge. Socioeconomic factors such as farm experience, credit access, farm size, and cooperative membership significantly influence adaptation choices across genders, while key constraints; including inadequate credit, high technology costs, poor governance, and limited inputs; vary in prominence between men and women. These findings emphasize the critical need for gender-responsive policies that improve resource access, provide inclusive training, and address both structural and informational barriers to empower all farmers in building resilient and effective adaptation strategies.

Based on the findings, it is recommended that policymakers and development agencies design gender-responsive climate adaptation programs that prioritize improving women's access to productive resources such as credit, inputs, and technical training. Financial institutions should develop flexible and inclusive credit schemes tailored to the diverse needs of smallholder farmers, especially targeting women and resource-limited groups.

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