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Effects of Climate Variability on Technical Efficiency of Maize Production among Farmers in Remo North Local Government Area, Ogun State, Nigeria

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Abstract

Agriculture being a cornerstone of the Nigerian economy, climate change poses significant challenges due to erratic weather patterns, rising temperatures, and increased pest infestations. Using primary data collected from 140 maize farmers, this study employed the use of primary data through the use of well-structured questionnaire while multistage sampling technical was used. Data was analysed using descriptive statistics and Stochastic Frontier Analysis. The research revealed that socio-economic factors such as education, household size, and farming experience influence efficiency. farmers of 62.9% showed awareness of climate change impacts and employed various adaptation practices, such as crop diversification (27.9%), intercropping (58.6%), and irrigation (32.9%). However, technical inefficiencies persist, driven by limited resources and high variability in climate conditions. The findings underscore the need for targeted support, including improved access to credit, training on sustainable practices, and enhanced extension services, to foster resilience and productivity in maize farming.

Introduction

Agriculture is vital to Nigeria's economy, engaging over 70.0 % of the population and serving as a major income source through exports (Oluwole *et al*., 2021). The sector, however, is increasingly threatened by climate change, which results in extreme weather, shifting seasons, and rising temperatures due to greenhouse gas emissions from activities like transportation, manufacturing, and energy production (Azare *et al*., 2020). Africa, contributing minimally to global emissions, bears a disproportionate share of adverse effects, making food insecurity a pressing issue, especially for staple crops like maize (Horgan, 2020). Nigeria's agricultural productivity, heavily reliant on rain-fed farming, faces a projected Gross Domestic Product (GDP) loss between 2-11% by 2050 due to climate variability (Towolawi *et al*., 2023), evident in reduced crop yields, increased pest and disease outbreaks, and more frequent droughts and flooding.

Maize, which was introduced to Africa in the 1500s, is one of the continent's most important crops, and its demand has outstripped domestic production in recent years (Wright, 2023). This imbalance has led to a growing deficit, driven by its increasing use in food processing industries and livestock feed mills. Although Nigeria has made various efforts to boost agricultural output, including policies targeting smallholder farmers who produce over 90.0% of the country total agricultural output. The sector has been unable to meet rising demand due to challenges such as limited access to credit, lack of improved seed varieties, poor soil quality, and the destabilizing effects of climate change (Adewuyi, 2020).

Belief in climate change, closely linked to perceived risks and effectiveness of responses, varies

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with socioeconomic, environmental, and psychological factors, influencing farmers' adaptation strategies (Simpson *et al*., 2021). Despite the increase in studies on climate change perception and response among farmers, more research is needed (Aragón *et al.,* 2021). Technical efficiency analysis is critical in establishing associations between climate change perception and agricultural productivity, with important implications across various sectors (Long *et al.,* 2020, Hornsey *et al.,* 2021).

Research on farmers' perceptions of climate change and their technical efficiency is limited particularly in Remo North Local Government Area of Ogun State, crucial for developing effective coping strategies (Adebajo and Iseoluwa, 2020, Singh, 2020, Nyang'au *et al*. 2021, Ojo and Baiyegunhi, 2021) (). This study aimed to assess farmers' views on climate variability, their coping strategies, and efficiency in maize production, vital for improving agricultural productivity and resilience. This research underscores the urgency due to Nigeria's high vulnerability to climate change, which could lead to significant GDP loss by 2050 (Raimi *et al*., 2021). The study's findings aided policymakers in mitigating climate impacts and enhancing agricultural practices, essential for ensuring national food security and supporting smallholder farmers pivotal to the nation's food system.

Materials and Methods

The Study area

This study was conducted in Remo Local Government Areas of Ogun State. Ogun state was created in 1976 with Abeokuta being the State capital. The state is predominantly agrarian and comprises of four divisions with twenty Local Government Areas (LGAs). The four divisions in Ogun state include Ijebu, Egba, Yewa and Remo divided on the basis of their socio-cultural and historical peculiarities. The Remo division however consists of LGAs namely Ikenne, Sagamu and Remo North local government areas. The land size of Remo division is approximately 97,298 hectares (NPC, 2006) which is effectively used for farming. The climatic pattern is humid tropical region characterized by the relatively high annual temperature, high precipitation, high evaporation, low pressure and high relative humidity. The inhabitants are mainly Yoruba, speaking various dialect of Remo. Remo is noted for production of kola nut, large scale production of rubber, about 25% of the total area is of forest reserve suitable for livestock. The study area is good for maize, plantain, beans, cassava, sugarcane, and other food crops, and is also endowed with human and mineral resources (Smith, 2020).

Sampling procedure and sampling size

The populations of this study are the maize farmers in Remo North Local Government Areas, Ogun State. The study employed the use of primary data through well-structured questionnaire. Multistage sampling technique was used in this study. The first stage involved the purposive selection of 5 wards out of 12 principal wards in Remo North Local Government Area based on the population of maize farmers in the area. The selected five wards were: Ipara, Ilara, Akaka, Ayegbami and Ode-remo. In the second stage, 3 villages/communities each were randomly selected from the five (5) wards to give a total of fifteen (15) villages. In the third stage, 10 respondents were randomly selected from each village/community to give sample size of 150 respondents in the study area while only 140 questionnaires were adequately filled and returned.

Method of Data Analysis

Descriptive technique which includes percentage and proportion/frequency, mean, standard deviation, among others to profile the socio-economic characteristics of individual maize farmers, while four likert scale was employed to identify their perception to climate change and their adaptation strategies. Stochastic Frontier Analysis was used to estimate the farm level of technical efficiency and identify factors that drove efficiency. The relationship between dependent and independent variables is explained in equation 1 (Battesse and Coelli, 1995). Five-point Likert scale was used to identify the perception of farmers towards climate change. For a given constraint the mean score was calculated as, mean score = Total score of each variable⁄Total number of respondents. Thus, any constraint with mean score greater than 2.5 were considered as perceived, while those less than 2.5 were considered as not perceived (Muthuprasad *et al*. 2021).

$Y = B_O + B_1 X_I + B_2 X_2 + B_3 X_3 + B_4 X_4 + B_5 X_5 + \mu$....1

Y = Output, value of total maize produced (kg),

X_1 = Farm size (hectares),

X_2 = Labour (man day),

X_3 = Agro chemicals (litres),

X_4 = Maize seeds (kg)

X_5 = Fertilizer (kg).

μ= Error term which can be decompose into (vi - μi)

The variables for the inefficiency model are represented by μ_i which is defined as follows:

$\mu_i=\partial_0+\partial_1Z_1+\partial_2Z_2+\partial_3Z_3+\partial_4Z_4+\partial_5Z_5+\partial_6Z_6+\partial_7Z_7$ ……2

μi = Technical inefficiency of the Maize farmers

Z_1 = Age of respondent (years)

Z_2 = Gender (Male=1, Female=0)

Z_3 = Access to extension (No=0, Yes=1)

Z_4 = Access to credit (No=0, Yes=1)

Z_5=Number of Household size

Z_6= Farming experience (years)

Z_7 = Perception to climate change (Negative 1, positive 0)

∂0, ∂1………∂7 are parameters estimated

Results and Discussion

The socio-economic characteristics of maize farmers in the study area reveal a relatively high level of education, with (50.7 %) having tertiary education, which suggests better access to information and potential for adopting improved farming practices (Table 1). The gender distribution is nearly equal, with (52.1 %) males and (47.9 %) females, indicating balanced participation. Majority of the respondents are Christians (46.4 %) and Muslims (40.0 %), and 48.6% are married. A significant portion (67.1 %) are members of associations, which enhances access to resources and market linkages. Most farmers also have access to extension (67.1%), credit (63.6%), and health services (68.6%), which supports their capacity and well-being. Farmers source maize stocks mainly from research institutes (34.3%) and local markets (18.6%), with 42.9% owning inherited land and 35.7% selling produce to private traders. The predominant age groups are 15-30 years (45.0 %) and 31-46 years (38.6 %), indicating a young farming population, while the majority have a household size of 1-5 members (59.3 %). Farming experience ranges from 1-10 years (61.4%) to over 30 years (3.6%). These attributes suggest high technical efficiency potential but highlight opportunities to enhance productivity through improved market access, credit, and extension services

Perception of respondents to climate variability

The study showed a high level of climate change awareness among farmers in Remo North, with 62.9% understanding its implications (Table 2). Some of the respondents (46.4%) observed hotter weather, unpredictable rainfall, and noted increased crop losses and poor quality due to climate impacts like pest infestations and soil erosion. Farmers believe climate change reduces food availability, raises food crop prices, and decreases motivation to farm, indicating significant socio-economic impacts. Many view irrigation demand and crop diversification as necessary adaptations. This implies that respondents have an unfavourable perception of climate change in the study area. Farmers would also have a positive attitude to climate change adaptation to increase their level of maize production.

Coping strategies adopted by the maize farmers

The result in Table 3 reveals that maize farmers in Remo North employ various coping strategies to adapt to climate variability, with the most common being cereals/legumes intercropping (58.6%), which enhances soil fertility and reduces crop failure risks. Ridges across the slope (47.1%) and bush fallowing (39.3%) are also widely used to control soil erosion and restore soil fertility. Farmers frequently use mixed cropping (42.9%), changing planting dates (45.7%), and irrigation (41.4%) to manage unpredictable rainfall. Organic fertilizers, crop rotation, zero tillage, and mulching are employed by over 40.0% of respondents to improve soil health and conserve moisture. The adoption of improved crop varieties and water management techniques (47.1%) reflects efforts to enhance productivity and resilience.

Table1: Socio-economic characteristics (n =140)

Variables		Frequency	Percentage	Mean ± SD
Education Status	No Formal	14	10.00	
	Primary	27	19.30	
	Secondary	28	20.00	
	Tertiary	71	50.70	
Age(years)	15-30	63	45.00	
	31-46	54	38.60	
	47-62	18	12.90	
	63-78	5	3.60	35.36 ±12.40
Household size	1-5	83	59.30	
	6-10	39	27.90	
	11-15	18	12.90	6.00 ±4.00
Farming Experience(years)	1-10	86	61.40	
	11-20	35	25.00	
	21-30	14	10.00	
	31-40	5	3.60	10.69 ± 8.80
Sex	Female	67	47.90	
	Male	73	52.10	
Religion	Christian	65	46.40	
	Muslim	56	40.00	
	Traditional	19	13.60	
Marital Status	Single	58	41.40	
	Married	68	48.60	
	Divorced	12	8.60	
	Widowed	2	1.40	
Membership of Association	Non-Member	46	32.90	
	Member	94	67.10	
Extension service	No	46	32.90	
	Yes	94	67.10	
Credit Access	No	51	36.40	
	Yes	89	63.60	
Health Service	No	44	31.40	
	Yes	96	68.60	
Source Of Maize Stocks	Friend	42	30.00	
	Association	24	17.10	
	Research Institute	48	34.30	
	Local Markets	26	18.60	
Mode of Land Ownership	Purchased	41	29.30	
	Rented	33	23.60	
	Inherited	60	42.90	
	Leased	6	4.30	
Maize Produce Market	Private Trade	50	35.70	
	Cooperative Society	39	27.90	
	Consumers	41	29.30	
	Industries	10	7.10	
	Total	140	100.00	

Source: Field Survey, 2024; SD- Standard deviation

Table 2: Perception of respondents to climate variability

Variables	Strongly Disagree	Disagree	Agree	Strongly Agree
I know what climate change means	0	7(5)	45(32.1)	88(62.9)
The weather gets hotter, and rain become less and more unexpected over the years	2(1.4)	8(5.7)	65(46.4)	65(46.4)
The weather is steady over the last five years	4(2.9)	21(15)	45(32.1)	70(50)
The weather becomes unpredicted from year to year	8(5.7)	22(15.7)	63(45)	47(33.6)
I have lost more crops during the last years because of bad weather	7(5)	31(22.1)	55(39.3)	47(33.6)
The quality of my product has been excellent over the years	7(5)	21(15)	65(46.4)	47(33.6)
Infestation is common due to climate change	14(10)	17(12.1)	43(30.7)	66(47.1)
There is a loss of nutrients due to erosion due to climate change	13(9.3)	19(13.6)	55(39.3)	53(37.9)
There is poor germination of food due to climate change	15(10.7)	25(17.9)	47(33.6)	53(37.9)
Climate change will make food available more	9(6.4)	17(12.1)	67(47.9)	47(33.6)
High cost of food Crops can be linked to climate change	7(5)	16(11.4)	64(45.7)	53(37.9)
Farmers are losing interest in farming due to climate change	10(7.1)	20(14.3)	62(44.3)	48(34.3)
Climate change has led to an increase in demand for irrigated farming	11(7.9)	19(13.6)	48(34.3)	62(44.3)
With this rainfall pattern, we may be forced to change the type of crops that grow	9(6.4)	16(11.4)	63(45)	52(37.1)
The occurrence of the flood is not traceable to climate change	6(4.3)	18(12.9)	67(47.9)	49(35)
Climate change cannot increase the cost of production	3(2.1)	29(20.7)	71(50.7)	37(26.4)
Farming operations are becoming more tedious due to climate change	7(5)	25(17.9)	65(46.4)	42(30)
Drought during the rainy season cannot be due to climate change	1(0.7)	121(86.4)	14(10)	4(2.9)

Source: Field Survey, 2024; - Figures in parentheses are in percentages

Table 3: Coping strategies adopted by the maize farmers

Coping Strategies	Always	Often	Rarely	Never
Cereals/ legumes intercropping	82(58.6)	36(25.7)	14(10.0)	8(5.7)
Ridges across the slope	48(34.3)	66(47.1)	21(15.0)	5(3.6)
Bush fallowing	58(41.4)	55(39.3)	22(15.7)	5(3.6)
Mixed cropping	51(36.4)	60(42.9)	23(16.4)	6(4.3)
Changing planting date	51(36.4)	64(45.7)	18(12.9)	7(5.0)
Fadama/ irrigation	46(32.9)	58(41.4)	28(20.0)	8(5.7)
Use of organic fertilizers	44(31.4)	67(47.9)	23(16.4)	6(4.3)
Crop rotation	39(27.9)	68(48.6)	29(20.7)	4(2.9)
Zero tillage	42(30.0)	61(43.6)	27(19.3)	10(7.1)
Mulching	43(30.7)	59(42.1)	28(20.0)	10(7.1)
Use of manure	39(27.9)	62(44.3)	26(18.6)	13(9.3)
Use of improved varieties	44(31.4)	66(47.1)	22(15.7)	8(27.9)
Improved water management	46(32.9)	66(47.1)	18(12.9)	10(7.1)

Source: Field Survey, 2024 * - Figures in parentheses are in percentages

Estimation of technical efficiency level of maize farmers

The frequency distribution of the efficiency indices of the farmers in Table 4 showed that technical efficiency ranges between 0 and 0.4 which indicated that the farmers were operating below frontier. This result is in line with Bempomaa (2014). The average technical efficiency level of 48.0% showed that with available resources farmers could increase yield by 74.0 % without employing any additional resources

Factors affecting maize production in Remo North Area of Ogun State

As shown in Table 5, the sigma – squared estimate (δ^2) is 0.0867 which is significant at 5% attests to the goodness of fit and correctness of the distributional assumption of the composite error term of the model. The gamma (γ) estimates of 0.4545 showed that 45% of the variation in the output of maize is as a result of technical inefficiency. Farm size was positive and statistically significant at 10% showing that 1% increase in farm size leads to 0.186% increase in maize output per hectare. Fertilizer was positive and significant at 10% indicating that 1% increase in fertilizer leads to 0.2013% increase in maize output per hectare. The coefficient of maize seed was positive and statistically significant at 5% with output. An explanation of this result is that the quantity of maize seed used by the farmers is within the recommended seed rate. Similar result was reported in Ghana (Bempomaa, 2014).

Factors driving technical inefficiency of maize production among the farmers

Table 6 shows the factors driving the technical inefficiency of maize production among the farmers. The gamma value of 0.354 showed that 35.4% of the farmers are inefficient in their maize production as explained by the variables in the model. In the model, four out of seven variables were significant (gender, household size, farmers' experience and perception to climate change). Gender was positive and significant at 5% which is contrary to apriori expectation. It showed that female farmers were more technically efficient than the male farmers. This is in line with result reported in Ghana by Bempomaa (2014).

Table 4: Frequency Distribution of Technical Efficiency Score

Technical Efficiency Range	Frequency	Percentage
0.21-0.30	35	25.10
0.31-0.40	105	74.99
Total	140	100.00
Mean Technical Efficiency		48.00
Minimum T.E		9.00
Maximum T.E		90.00

Source: Field Survey, 2024;

Table 5: Maximum Likelihood Estimates of the Stochastic Production Frontier Function

Variable	Parameters	Co-efficient	Standard Error	P>/Z/
Constant	β0	2.5546	0.0845	0.003
Farm size	β1	0.1867*	0.0534	0.012
Labor	β2	0.3045	0.0733	0.601
Agro chemical	β3	0.2234	0.0656	0.756
Maize seed	β4	0.2834**	0.0901	0.008
Fertilizer	β5	0.2013*	0.0434	0.015
Maize variety	β6	0.3521***	0.1066	0.002
Variance Parameter				
Sigma squared (δ2)		0.0867	0.0367	0.0478
Gamma (γ)		0.4545		
Log-likelihood function		69.677		
LR Test		u=0 chibar2 (01)= 0.00		Prob>=chibar2 =1.000

Source: Field Survey, 2024, *** indicates that the variable is statistically significant at 1% ** & * indicates that the variable is statistically significant at 5% and 10% respectively.

Table 6: Factors driving technical inefficiency of maize farmers.

Variable	Parameters	Co-efficient	Standard Error	P>/Z/
Constant	C0	3.0807	0.3501	0.003
Age	C1	-0.1068	0.0521	0.612
Gender	C2	0.3670**	0.0734	0.035
Access to extension	C3	0.2254	0.0616	0.734
Access to credit	C4	0.2843	0.0923	0.845
Number of Household size	C5	0.2560***	0.0457	0.005
Farming experience	C6	0.3513*	0.1043	0.062
Perception to CC	C7	0.0546**	0.0265	0.047
Variance Parameters				
Sigma squared (δ2)		0.0824	0.0344	0.0451
Gamma (γ)		0.3541		
Log likelihood		1.8973		
LR Test		u=0 chibar2 (01) =0.02		Prob. ≥ chibar2 = 0.436

Source: Field Survey, 2024 *** indicates that the variable is statistically significant at 1%, ** and * indicates that the variable is statistically significant at 5% and 10% respectively

Household size was positively significant at 1% which indicated that as household size increases there is decrease in technical efficiency. This could be attributed to a reduction of farm investment due to an increase in family consumption expenditure. This is in tandem with the result of Oyewo (2011) who reported that large household size increases expenditure and reduce farming investment. Farming experience was positive and significant which showed that farmers with high experience are less technically efficient in maize production. The reason for this may be attributed to the fact that farmers who have spent longer years in farming may be less willing to adopt modern technology of agricultural production. This is in line with research work of Bempomaa (2014) which implies that such farmers are conservative with respect to their usual traditional methods of farming. The perception of farmers to climate change coefficient was positive and significant at 5% and decreased technical efficiency. The reason for this can be due to high negative level of farmers’ perception to climate change which results in low investment in maize production, inputs used and maize output. This is similar to result of Olajide (2014) who reported that high negative level of farmers’ perception to climate change may results in low investment in maize production, inputs used and maize output.

Conclusion

The findings of this study highlight that while maize farmers in Remo North are moderately aware of climate change and adopt some adaptive practices, significant challenges remain. Climate change impacts, such as erratic weather, crop failures, and increased production costs, continue to hinder technical efficiency and productivity. Socio-economic factors, including household size, access to credit, and years of experience, play a crucial role in influencing farmers' capacity to respond effectively to climate challenges. Technical efficiency levels are below optimal, indicating that there is room for increased productivity without additional resource input. The study concludes that fostering resilience in maize production requires targeted interventions in education, financial support, and infrastructure development.

Recommendations

Policymakers and financial institutions should create affordable credit schemes to support investments in climate-resilient technologies, while expanded extension programs provide hands-on training in adaptive practices such as crop diversification, water management, and soil conservation, alongside infrastructure investments in water reservoirs, irrigation systems, and storage facilities to mitigate erratic rainfall impacts and reduce post-harvest losses; efforts should also enhance access to quality inputs like improved seeds and organic fertilizers through partnerships with research institutions and cooperatives, incentivize sustainable practices such as crop rotation and intercropping to improve soil health and yields, promote gender-inclusive policies to empower efficient female farmers through training and leadership roles, address inefficiencies linked to household size and farming experience by encouraging technology adoption and providing targeted support, and conduct continuous climate education campaigns to enhance awareness and motivate adoption of climate-smart strategies, ultimately improving technical efficiency, resilience, food security, and sustainable agricultural development. There is also a need to further support farmers through training, access to improved seeds, investment in irrigation infrastructure, and incentives for sustainable practices, ensuring the long-term productivity and climate resilience of maize farming in the region.

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