Analysis of climate variation adaptation measures and land-use intensification among maize-based farmers in Oyo State, Nigeria

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Abstract: More often than not, the climate change is accompanied by natural disasters which affect agricultural activities, most especially in the poorest countries. However, as a precaution to its extreme impact on crop cultivation, integrated weather adaptation measure has been conveniently in use as a sustainable climate action. Therefore, this study examined the effect of climate change adaptation measures on land-use intensification of maize farming in rural districts of Oyo state, Nigeria. Primary data were collected from population size of 240 maize-based farmers during the 2022 production season by both structured questionnaire and interview schedule. Descriptive statistics, Ruthenberg index, and Tobit regression were employed to analyse the data. The results revealed that most farmers were males, and their average age was 51.52 years, they have huge years of farming experience (26.56years) and farm size was around 5.73ha on the average. The common climate variation adaptation measures adopted include adjustment of planting date, crop diversification, and relocation to new site and irrigation facilities. The average land-use intensity index was estimated to be 0.653 which indicates the extent of land-use intensification. Also, the analysis of Tobit regression signified that farm size, practice of crop diversification, climate adaptation measure index and drought incidence are the significant drivers of land-use intensification. The study, therefore, concludes that the adoption of climate adaptation measures is crucial to reduce the excessiveness of climate variation impact on intensification strategy. The analysis of climate variation adaptation measures and land-use intensification will strengthen land policy intervention and necessary climate action.

Keywords: climate change, adaptation measures, maize farming, land-use intensification, Ruthenberg index, Nigeria

INTRODUCTION

Foremost, Sub-Saharan Africa (SSA) inclusive Nigeria is among the most vulnerable regions to climate change shocks, for instance climate vagaries had undermined Nigerians agriculture to a large extent. Agriculture, which provides a livelihood for about three-quarters of Africa's population, is mainly rain fed. Indeed, the farmers in most cases based their crop propagations on weather dictate which is quite unpredictable and consequently render majority of farm households vulnerable to extreme effect of climate change. Climate change could cause variations in rainfall timing, droughts with severe temperature, fluctuation in regional temperature, heavy storms and floods. Its dreadful side effects could lead to agricultural productivity failure and threats to the livelihood of farmers and consequently aggravate the national food security and poverty challenges overtime especially in underdeveloped countries (Aryal *et al.*, 2018; Aryal *et al.,* 2020 and Ani *et al.,* 2021).

According to Hlophe-Ginindza and Mpandeli (2020) the sub-Saharan Africa is well known for relying heavy on rain fed agriculture, however, due to threats posed by extreme climatic events, high climate variation, the majority of the climate sensitive sectors are struggling to cope and adapt to challenges posed this natural vagary. Climate change is a persistent departure of most climatic elements from the mean or/and variability properties of the climate. The climate change experiencing globally in the present time, has been compounded by the human emission of greenhouse gases effect (Intergovernmental Panel on Climate Change IPCC, 2014).

In essence, climate change plays a significant role in the performance of agricultural production by predetermined the condition of farm operations. It impacts the time to plant crop, what plant to cultivate, and how to cultivate them particularly for the food crop under consideration which is maize. Throughout Nigeria, maize crop formed the major cereal crop followed by guinea corn and sorghum. It responds quickly to climate variations sensation. Maize is a major cereal and one of the most important food crops in Nigeria. Being photoperiod insensitive, it can be grown any time of the year, giving greater flexibility to fitting into different cropping patterns. Over the years, maize has become an important crop, taking over acreages from traditional crops such as millet and sorghum. In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa (FAO, 2018). Research efforts by breeders and agronomists have led to the production of many technologies including the breeding of high yielding varieties that are tolerant to drought, diseases, low nitrogen, and Striga infestation (Kamara *et al.,* 2014).

According to Silva *et al.,* (2020) maize is cultivated in almost all countries, occupying an area of approximately 160 million hectares.

By and large, the impact of climate change on agricultural productivity especially in developing countries is well noticed (Mark, 2023). But the gravity of influence of climate change on agricultural intensification strategy is going to be a serious one, since agricultural intensification is more sensitive to change in volume of agricultural inputs particularly water conservation system, fertile land, labour and capital. Consistently, the extreme case of climate change is suspected to create more challenges in the sustainability of these farm resources, hence disrupt the potential of agricultural intensification strategy. Testing the effectiveness of climate change adaptation measures on agricultural land-use intensification (ALUI) empirically should be a topic of growing debate in the context of sustainable agricultural development and land-use policy.

Agricultural land-use intensification is an improved system of farming planned towards continuous cultivation of available farmland to increase output. Looking at this, the expectation is that the farmers use adaptation and climate smart measures to mitigate climate variability impact on agricultural practices. Therefore, a better understanding of adaptation strategies is imperative to support the agricultural sector, especially in developing countries because of their vulnerability to climate change (IPCC 2007; Tibesigwa *et al.,* 2014). As argued by Vol (2018) adaptation is being considered by economists more widely as part of important measures to complement climate mitigation. The different climate smart practices, including planting of new crop varieties, changing planting dates, growing drought-resistant crops, use of crop insurance mechanisms, irrigation approach, and adoption of soil and water conservation measures, have been used by farmers in developing countries to cope with the negative consequence of climate change and to ensure high yields.

Adaptation to climate change also involves any activity designed to reduce vulnerability and enhance the resilience of the system (Adger 2006; Vogel and Meyer 2018), and therefore, the actual impacts of climate change largely depend on the adaptive capacity. Vermeulen *et al.,* (2012); Ojha *et al.,* (2014) thus, households with better access to multiple resources and diverse livelihood portfolios are more likely to better cope with climate risks. Adaptation is defined as a process of reducing damages or harm that are associated with extreme weather events such as floods, droughts, landslides, storms and the likes. Adaptation includes all actions intended to respond to the existing or anticipated climatic stimuli and their impacts. Adaptation depends significantly on the adaptive capacity or adaptability of an affected system, region, or community to cope with the impacts and risks of climate change. The adaptive capacity of communities is determined by their socioeconomic characteristics. The use of adaptation strategies to climate change is particularly fundamental to Oyo state as agriculture is the primary source of livelihood; farmers here are largely dependent on rain-fed which make it vulnerable to extreme climate. Farmers, hence, tend to use a wide range of resources to adapt to climate change. Given these research viewpoints and observations about climate change impacts on agricultural land use intensification practice, climate change-smart adaptation strategies must acknowledge environmental and cultural contexts at the regional and local levels.

In essence, sustainable agricultural intensification strategy remains the paradigm to promote agriculture in a period of burgeoning food demand and deteriorating resources. Overall, agricultural land-use intensification permits forestland and ecosystem conservation by lessening the area of land that exposed to deforestation and desertification each year through agriculture (Ganiyu *et al.,* 2023). However, climate-smart measures or adaptation strategies are targeted mechanisms to mitigate negative influence of climate change on crop yields. As a result, this study investigated the effect of climate change adaptation measures on agricultural land-use intensification (ALUI) among maize-based farmers in rural districts of Oyo State, Nigeria.

METHODOLOGY

The study was carried out in Oyo state among maize-based farmers from January 2022 to April 2023. Oyo state is situated in the south-western part of the country and is known as the "Pace Setter State." The study was carried out in Oyo state. Oyo state was created in February 1976 from the former Western state which originally included Osun state and covers approximately an area of 28,454 square kilometres of land mass. It is located in the southwestern part of the country, consisting of 33 local government areas grouped under four (4) agricultural zones of Oyo state Agricultural Development Programme (OSADEP), which are Ogbomoso, Oyo, Saki and Ibadan – Ibarapa zones.

Oyo state is an inland state in south-western Nigeria, with its capital located at Ibadan. It is bounded in the south by Ogun state and in the north by Kwara state, in the west partly by Ogun state and partly by the Republic of Benin while in the east it is bounded by Osun state. Oyo state has 33 Local Government Area Councils and with a projected population of 7,976,100 in 2022*,* Oyo state is the sixth most populous in Nigeria.

The people of the state are predominantly farmers while some others are elite people that are teachers, doctors, nurse managers and accountants and traders. The climate is equatorial, notably with dry and wet seasons with relatively high humidity. The dry season lasts from November to March while the wet season starts from April and ends in October. Average daily temperature ranges between 25°C (77°F) and 35°C (95°F), almost throughout the year; this favours the cultivation of crops like maize, yam, cassava, millet, rice, plantains, cocoa, palm produce, cashew et cetera. The state is not homogenous in term of tribes, but mainly inhabited by the Yoruba ethnic group who are primarily agrarian but have a predilection for living in high density urban centres; also, there are few other minority ethnic groups. Ibadan had been the centre of administration of the old Western Region, Nigeria since the days of the British colonial rule. The primary occupation of the people is farming, and the farms are subsistence and semi-commercial units which depend mostly on rainfall as the chief source of water supply. The prevailing vegetation type of Oyo state is that of Guinea Savanna woodland which is characterized by species of Derived Savanna especially the Ogbomoso, Oyo and Saki zones while Ibadan-Ibarapa zone is a Tropical rain forest.

Multistage sampling technique was adopted for this study. Oyo state has four Agricultural Development Programme (ADP) zones, namely, Ibadan/Ibarapa zone, Oyo zone, Saki zone and Ogbomoso zone. The first stage involved the selection of Oyo and Saki ADP zones in Oyo state. At the second stage three LGA from Saki and two LGA from Oyo zones, making five LGAs were selected respectively. Lastly, the approximated list of registered maize- based crop farmers was obtained from individual local governments sampled. According to the record 850 farmers were registered across the five LGAs altogether and this formed the population frame for this study. Based on (Krejcie and Morgan, 1970) sampling approach to determine sample size, the sample size is

$$S = \frac{X^2 NP (1-P)}{d^2 (N-1) + X^2 P (1-P)}$$

where, S = required sample size, N = the population size, X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (95%), normally (1.96 x 1.96 =3.841).
P = the population proportion (assumed to be 0.50) and d = the degree of accuracy expressed as a proportion (0.05).

$$S = \frac{3.841 \times 850 \times 0.5\,(1-0.5)}{(0.05)^2\,(850-1) + 3.841 \times 0.5\,(1-0.5)}$$

= 256 farmers

However, the study was satisfactorily conducted with two-hundred and forty (240) farmers. All other respondents (farmers) do not give complete information required for the research.

Structured questionnaire and interview schedule were used to collect data. The data collected were analysed and discussed using descriptive statistics (frequency, mean, and standard deviation), Ruthenberg index and Tobit regression model.

Ruthenberg index

Several farms have been classified into high, moderate and low fallow rotation patterns (intensity of land use) based on R-value developed by Ruthenberg (1980) where R<33% = shifting cultivation (low) 33≤R≤66% farm fallow systems (medium) and R>66% is permanent/continuous cultivation (high). The Ruthenberg-value invariably shows the land use intensity for an area. It is specified that higher values imply higher land-use intensification. Hypothetical value of 1 means complete land-use intensification while 0 means no intensification. The closer the R is to 1, the higher the land-use intensity of farmers (Udoh, 2000; Saka *et al.,* 2011; Lawal, *et al.,* 2013).

Therefore, Land-use intensity, (Li) of each farmer falls within 0<R≤1 and specified as:

Land-use intensity, (Li) = T_i/C_i x 100 1

Where, (T_i) = number of years for which cropland is consecutively cultivated C_i, = addition of years of consecutive cultivation and period of fallow.

Tobit regression model

Tobit regression analysis is best fitted to some variables which are discrete continuous in nature, mostly when the dependent variable assumed values consisting of fractions between 0 and 1. It allows the existence of truncated data and so it also known as truncated regression model. According to Tobin, (1958) Tobit regression model is given by the equation below:

$Yi = \beta_0 + \beta_i iX + \mu_i$ 2

Yi = agric. land-use intensification index (0≤R≤1).
β_0 = constant term
β_i = coefficient estimates
X_i = vectors of explanatory variables including land ownership, farm size, practice of crop diversification, adjustment of growing period, drought occurrence, application of irrigation facilities, use of adaptation measures and farming experience.
μ_i = error term

RESULTS AND DISCUSSION

Discussion of descriptive analysis of the socio-economic characteristics among the selected crop farmers

The descriptive analysis of the socio-economic characteristics among the selected respondents were tabulated and discussed below. Table 1 showed that 52.92% of the farmers were males and 47.08% are females. This result indicated a high participation of men in farming; this is because the agricultural practices involve tedious works which women could not easily handled. It also showed that majority of the respondents comprising 37.5% fell within the age of 41 to 50 years, while 27.5% of them were within the age of 51 to 60 years and their mean age was 51.53years. It implied that most of the farmers were middle aged people and productive stages; this might have positive impact on the adoption of climate change adaptation mechanisms over their land-use intensification strategies and other agricultural practices. The finding of this study is agreed with that of (Osuji *et al.,* 2013).

In addition, 84.58% of the sampled farmers were married which is a strong indication of high family labour availability for farm production. The rest of them comprising 15.42% were single in the study area. The result further revealed that majority of the farmers comprising 87.5% had household size of 5 members or fewer, while the remaining (12.5%) of them have between 6 to 10 members with the mean household size around 4 persons. Considering the level of education, exactly 60.83% had secondary education, 20.84 % had primary education, and 8.75% had tertiary education, while 9.58% had no formal education. This finding indicated that most of respondents had formal education, the result is in consonance with the findings of Tsue *et al.,* (2014) where it was reported that 82% of the farmers had formal education at varying levels but contrasts the findings of Bamire, (2010) who reported a high level of illiteracy among farming households with (79.4%) having no formal education. in term of major occupation of the respondents the majority (70.17%) of them primarily engaged in farming while the fewer (25.83%) among them were having alternative source of livelihood. Also, the finding showed that the most (70.83%) of the farmers had spent more than 15 years in farming and averagely they have 26.56years of experience. This result means that most of them were highly experienced in farming which might considerably improve the practice of climate smart measures of mitigating climate change impact on agricultural intensification. It was found that 52.08% of the farmers had 5ha or fewer farm size, 42.5% and 5.42% of them had farm size of 6 to 10 ha and greater than 10ha of farm size respectively.

On the average farm size was 5.73ha and it indicated that the most farmers are smallholders. Only 87.92% of the farmers were members of association while the remaining (12.08%) did not belong to any association. However, access to extension agents by the farmers contributes tremendously to the level of farm operations, so also this study revealed that 86.67% of them had access extension agents while 13.33% of them do not. Extension trainings received by the farmers are valuable information to bring positive changes in the techniques of farming for agricultural improvement. Farm distance also tends to influence to performance of farming households at present, the cost of travelling has increased and it is either directly or indirectly impacting farmers' level of operating their agricultural system. That is the reason for most farmers who settled on farmland closed to their residences and continuously cultivate on the fixed land for several years. This finding exhibited that 85.0% of the farmers cultivate on farmland not farther than 5km or less from their residences while 15.0% farmed on a distant location that is ranging between 6 to 10 km and the mean farm distance is 4.39km, this suggests the reason for concentration of farming households in the area very closely to residence and evidence for land-use intensity.

Table 1: Distribution of socio-economic characteristics of the sampled food crop farmers

Socioeconomic variables	Frequency	Percentage	Means
Sex			
Male	127	52.92	
Female	113	47.08	
Farmers' age			
31-40	29	12.08	51.53 years
41-50	90	37.50	
51-60	66	27.50	
≥60	55	22.92	
Marital status			
Married	203	84.58	
Not married	37	15.42	
Households size			
≤5	210	87.50	4 people
6-10	30	12.50	
Educational status			
Primary	50	20.84	
	146	60.83	
Secondary			
Tertiary	21	8.75	
No formal education	23	9.58	
Farming			
Full time	178	74.17	

Socioeconomic variables	Frequency	Percentage	Means
Not full time	62	25.83	
Farming experience			
6-10	25	10.42	26.56 years
11-15	45	18.75	
≥15	170	70.83	
Farm size			
≤5	125	52.08	5.73ha
6-10	102	42.50	
≥10	13	5.42	
Farmers association			
Not Member of association	29	12.08	
Member of association	211	87.92	
Extension contacts			
No	32	13.33	
Yes	208	86.67	
Farm distance			
≤5	204	85.00	4.39km
6-10	36	15.00	
Total observation	240		

Source: Field survey, 2022

Agricultural land-use intensification practices among food crop farmers

The result presented in Table 2 shows the indices of agricultural land-use intensification among farmers according to Ruthenberg computation. It was found that most farmers comprising 50.83% are substantially participating in agricultural land-use intensification. This an implication and evidence to prove that food crop farming system is gradually shifting to that of land intensification practice due to the high demand for food among others. Also, 41.67% of the farmers' population were completely engaged in high/continuous land-use and intensification of farming and the rest (7.5%) are cultivated farmland at a low intensity rate, perhaps the farmers adopt a fallow rotation system. The Ruthenberg index for land-use intensification was estimated to be 0.653 on the average. Overall, the finding suggests that the crop farmers are already cropping permanently on their farmlands in the study area, thus the empirical analysis of effect of climate variation adaptation measures on land-use intensification for maize farming, is going to serve as a proactive measure to climate action.

Table 2: Distribution of farmers according to agricultural land-use intensification

Land use intensity	Frequency	Percentage
Low land use intensity	18	7.51
Moderate land use intensity	122	50.83
High land use intensity	100	41.67
Total	240	100

Source: Field survey, 2022 Mean value = 0.653

Ruthenberg index **: R<33%=low land-use intensity, 33≤R≤66% = moderate land-use intensity, and R>66% =high land-use intensity.

Adaptation measures for mitigating climate variation impact on land intensification

The adoption of climate change adaptation strategies is a critical climate action in agriculture and from the result given in Table 3, it was observed that some common adaptation strategies like crop diversification, change chemicals/fertilizers as well as planting at different dates comprising 65.0%, 50.83% and 44.58% of farmers respectively are highly adopted to cope with extreme impact of climate change on cropland use intensification. While planting improved varieties, relocation to different land site, use irrigation facilities, shortening length of growing periods and shading and shelter mechanisms are also put into practice by some farmers in the study area. This finding indicates that practicing crop diversification, change chemicals/fertilizers, planting at different dates, use irrigation method are commonly put into practice among farmers to check the effect of climate change on crop yields.

Table 3: Distribution of farmers according to adaptation measures

Adaptation measures (n = 240)	Frequency	Percentage
Planting at different dates	107	44.58
Crop diversification	156	65.00
Change chemicals / fertilizers	122	50.83
Planting improved varieties	76	31.67
Relocation to different land site	67	27.92
Shortening length of growing periods	64	27.92
Shading and shelter	61	25.42
Use irrigation	67	26.67

*Multiple choices Source: Field survey, 2022

Influence of climate variation adaptation measures on land-use intensification practice using Tobit regression

Tobit regression was estimated for the purpose of establishing the nexus between climate adaptation measures and agricultural land-use intensification practice. The result shown in Table 4 revealed that farm size under cultivation, practice of crop diversification and adaptation measures index are positively and significantly influenced agricultural land-use intensification practice, also land ownership, adjustment of growing period and irrigation measures associated positively with agricultural land-use intensification although their effects might not be significant at the present, but the reviewed literatures emphasised their significant effects on agricultural intensification practice. However, drought incidence has negative effect and significant relationship with land-use intensification and implied that the occurrence of drought in agrarian societies would be a setback to land-use intensification strategy.

Table 4: Tobit regression result showing the effect of climate adaptation measures on agricultural land-use intensification.

Explanatory variables	Coefficients	Std. Errors	t-values
Land ownership	0.0069196	0.021124	0.33
Farm size	0.0900153***	0.0267228	3.37
Farming experience	-0.0125319	0.0125319 0.0303431	-1.17
Crop diversification	0.0534657*		1.76
Adaptation measure index	0.0203282***	0.0064705	3.14
Drought occurrence	-0.0762437***	0.0269899	-2.82
Adjust growing period	0.0142423	0.0311892	0.46
Irrigation method	0.00226	0.005678	0.40
Constant	0.5030341	0.06850	7.34
Number of obs = 240			
Prob > chi2 = 0.0000			

* Denotes 10% level of significance; *** denotes 1% level of significance
Source: Field Survey, 2022

CONCLUSION AND RECOMMENDATIONS

This study typically conceptualized the effect of climate variation adaptation measures on land-use intensification for maize farming in rural districts of Oyo state, Nigeria. The agricultural land-use intensification index according to Ruthenberg computation indicated that the farmers are substantively involved in permanent/continuous cropland use. Crop diversification practices, change chemicals/fertilizers, planting at different dates, use of irrigation facilities is widely adopted to check the effect of climate change on crop yields. The finding further showed that the farm size, growing diverse crops, and drought occurrence have significant influences on agricultural land- use intensification strategy.

It was found that climate change adaptation mechanisms usage has a positive impact on the intensification of agriculture, also farm size and labour-use intensity have significant positive nexus with the intensification strategy except drought symptom that tends to show a negative effect on intensive maize farming. The study therefore suggests that the adoption of climate adaptation measures is crucial to reduce the excessiveness of climate variation impact on intensification strategy. The analysis of climate variation adaptation measures and land-use intensification has potential to strengthen land policy intervention and necessary climate action.

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