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Factors Affecting Use of Indigenous Climate Change Adaptation Strategies by Farmers in Wurno and Tambuwal Local Government Areas of Sokoto State, Nigeria https://dx.doi.org/10.4314/jae.v27i1.2S

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Abstract
Factors affecting the use of indigenous climate adaptation strategies by farmers in Sokoto State were assesse A multistageage sampling procedure was employed to select 160 respondents. Data were collected with the aid a of structured questionnaire. Objectives of the study were achieved using, percentages, means and multiple linear regression analysis. The majority (97.6%) of the respondents are aware of climate change, experienced both changes in temperature (92.5%) and rainfall patterns over the years. In using adaptation strategies, the majority (78.8%) of the respondents diversified their crop production, 75.6% practised intercropping and 70.6% cultivate drought-resistant crop varieties. Change in rainfall pattern was ranked first ($\bar{x} = 3.5$) in the order of perception rating of the respondents on the effect of climate change on crop production. This was closely followed by effect of poor crop yield ($\bar{\bar{x}} = 3.1$) and poor germination ($\bar{\bar{x}} = 3.0$) ranked second and third respectively. Factors affecting the use of indigenous climate change adaptation strategies revealed that age is significant and non-farm income jointly influenced the use of indigenous climate change adaptation strategies among others. It was concluded that the use of indigenous adaptation strategies to curb the effect of climate change was largely determined by age, farm annual income, farming experience, farm size and non-farm income among the farmers' socio-economic characteristics. It is recommended among others that farmers' capacity should be built around the effective use of farmers' indigenous adaptation strategies, such as diversification in crop production, use of mulching operation, crop rotation as well as adjustment in the planting calendar.

Keywords: Farmers, climate change, indigenous, adaptation strategies, awareness, factors.

Introduction

The Agricultural practices in African nations especially Nigeria largely rely on the natural weather conditions of the tropic. Over 70 percent of Nigeria's population is

engaged in agriculture as their primary occupation and means of livelihood (Onwutuebe, 2019; Shiru, 2018). However, the impact of climate change is more pronounced on smallholder farmers who are highly dependent on agriculture (Marie *et al.,* 2020). Nigeria's changing climate is evident in rises in temperature, variation in rainfall patterns, flooding, drought, desertification and land degradation among others (Haider, 2019). Economic development will be constrained by increase in droughts, floods and storms, caused by changes in climate. This will ultimately lead to decrease agricultural productivity, especially in developing countries like Nigeria with multiple stresses and low adaptive capacity (Ahaotu and Akagha, 2020).

Climate change refers to any change that occurs in the climate during a period of time which can range from decades to centuries (Osei, 2017). Other scholars such as Hope (2019) defined the term climate change as the variability in temperature due to emission of greenhouse gases produced by human activities. Thus, climate change is caused by both natural and human activities (Osei, 2017). The effects of climate change on agricultural production vary from one region to another depending on the prevailing climate of the region hence affect agricultural productivity differently. The Northeast and the Northwest are the most vulnerable due to the combination of rising heat and less rain which hastened desert encroachment, with loss of the wetlands, and fast reduction in the amount of surface water, flora and fauna resources on land (Haider, 2019; Abdulkadir *et al*., 2017; Akande *et al*., 2017).

Adaptation strategy is eminently an adjustment in natural and human systems in response to actual or expected climatic conditions or risks and can be regarded as a policy option to contain the negative effect of climate change (Ojo and Baiyegunhi, 2018). Autonomous adaptation involves coping strategies by farmers and others affected in rural settings. These include changing in planting date, diversification, irrigation and using tolerant varieties (Jallason, 2019). Farmers have inherent creativity, indigenous knowledge, and sometimes, develop ideas and technologies in response to alterations in elements of climate change. This can be established from their indigenous climate adaptation measures of synchronized cropping practice, choice of resilient crop variety, crop rotation system and other similar climate change adaptation practices in some parts of Northern Nigeria (Eze *et al*., 2020).They have done this using long-standing traditions, practices or traditional knowledge relating to adaptive ecosystem management and sustainable use of natural resources (Krystyna *et al*., 2018).

Climate change is exacerbating drought and aridity, affecting the entire savanna landscape of northern Nigeria and resulting in a decline of socio-economic activities, and with strong evidence of northeast and northwest being the worst hit (Akande, 2017). It has been projected that crop yields are to decline by 50 percent in some no distant years to come. However, indigenous innovative technologies have to be fully integrated into solutions to climate change adversity, and need to be evolved in the process of technology generation through a bottom-up approach.

As important as the knowledge about climate change is, scientific information has to be adequately available on specific adaptation strategies to use by farmers under a specific climate change element. However, farmers' knowledge on climate change effects in agriculture is utterly inadequate (Saiful *et al.*, 2019)

Furthermore, empirical studies assessing farmers' awareness about the reality of the climate change as it relates to devastating effect on agricultural productivity is yet to receive sufficient and proactive research attention for policy intervention (Damian *et al.*, 2020). Farmers' decision to use a climate change adaptation strategy to reduce its impacts relies largely on some socio-economic factors which are significant in formulating policies to support effective and efficient adoption in the agricultural sector. The use of the adaptation strategies may vary from farmer to farmer depending on land and farm management practices, farmer socio-demographic features, livelihood strategies and farm characteristics. It is therefore critical for farmers to undertake adaptation strategies to help cushion them against the hostile impacts of climate change. Adaptation strategies need to be supported by empirical data from farmers to enhance the clear difference between the realities and perceptions of climate change. Thus, the wellbeing of farmers could be enhanced if the adaptation experiences of farmers form a significant part of climate change policy (Mwinkom *et al*., 2021).

Objectives of the study

The study assessed the factors affecting use of indigenous climate adaptation strategies by farmers in Wurno and Tambuwal Local Government Areas (LGAs) of Sokoto State, Nigeria. However, the specific objectives are to:

i. determine the climate change awareness of the farmers,
ii. describe the farmers' perception of the effect of the climate change on crop production, and
iii. identify the indigenous climate change adaptation strategies used by the farmers.

Hypothesis of the study

There is no significant relationship between farmer's socio-economic characteristics and use of indigenous strategies to climate change adaptation.

Methodology

This study was conducted in Wurno and Tambuwal LGAs of Sokoto State. Tambuwal LGA occupies a total area of 1,717 km^2. Its coordinates are $12^0 19^1$N $4^0 48^1$E and 12.317^0N 4.800^0E. It has a projected population of 389,900 (NPC, 2022) with five districts (5) namely; Dogon Daji, Gindi, Jabo, Sanyinna and Tambuwal. Wurno LGA is located 50km north east of Sokoto town.The LGA has a projected population of 280,300 (NPC, 2022). It has a tropical climate with Sudan savannah occupying 92% of the area. Raining season in the LGA starts by April/May and ends by October. It's usually followed by dry season of cold and dusty wind which is experience between November and February. The weather in the area changes between March and April when heats become a little severe. The main occupation of majority of the inhabitants is farming. Mostly they cultivate rice, millet, onion, maize, guinea corn, garlic, cassava, livestock and other important food and cash crops. The LGA comprises of three (3) districts namely; Wurno, Achida, and Kwargaba district. Generally, the inhabitants of the three (3) districts are Fulani, Hausa, Gobirawa, Kabawa, Zamfarawa and Adarawa (Sokoto State Government, 2020).

Tambuwal and Wurno LGAs were targeted for this study. The sampling frame was established with the assistance of IFAD desk officers in each of the LGAs. Two staged sampling technique was used to arrive at the sample size for the study. The first stage

was the purposive selection of five out of 60 villages in the two (2) LGAs. The second stage was a random selection of 160 farmers out of 4000 farmers from the selected villages. The sample size for the study, therefore, constitutes 160 farmers.

Primary data were obtained by administering structured questionnaire to the farmers while the secondary information were sourced from published documents such as textbooks, journals, seminar papers and internet sources. Data collected were subjected to descriptive and inferential statistics. Frequencies, percentages and means were used to achieve objectives one (i), two (ii), four (iv) and five (v), while linear regression was used to achieve objective three (iii).

The study's dependent variable was the use of indigenous climate change adaptation strategies. It was measured by taking the number of indigenous adaptation strategies used by the farmers. The following indigenous practices were observed with the farmers in their crop production: diversification in crop production, growing drought-resistant varieties, producing an entirely new crop, using pest/disease resistant varieties, use of the cover crop, adopting crop rotation practice, intercropping, use of irrigation, and lastly, mulching.

The independent variables are those variables thought to influence the number of adaptations used by the farmers; it includes farmers' socioeconomic and institutional variables. The variables' definition and a priori expectations are summarized in Table 1.

Table 1: Measurement and definition of the study variables and apriori expectations

Variables	Variable definition	Apriori expectation
Age	Years of farmers	(-/+)
Educational attainment	Number .of schools attended	(+)
Household size	Household members engaged in farming, measured in number	(+)
Farm annual income	Cash receipt from selling farm produce in a year, measured in (₦).	(+)
Experience in farming	Years engaged in farming, in years	(+)
Land size	Hectares of land devoted to farming, in ha.	(+)
Extension contact	Number of visit by agent in the last I year	(+)
Non-farm income	Cash receipt from non-farm activities in a year, in (₦)	(+)

Model Specification

The econometric model used to test the relationship between the dependent and independent variables was the linear regression model It is generally expressed as:

$Y = a + b^{*}X + e$

It is implicitly specified as follows:

$Y = bo + biX_1 + b_2X_2 + b_3X_3 + \ldots + b_8X_8 + ei$

Where

Y = Number of indigenous climate adaptation practices used by i^{th}farmer

Xs = subscripts for explanatory variables

X_1 = farmer's age (years). X_2 = educational attainment. X_3 = Household size. X_4= Farm annual income. X_5 = Farming experience. X_6 = land size. X_7 = Extension contact. X_8 = Non-farm income.

a = constant

b_1 b_2 = coefficients of independent variables,

e =error term.

Results and Discussion

Climate Change Awareness of the Respondents

Table 2 shows the result on awareness of climate change by the respondents. About 97.8% and 95.8% of farmers in Tambuwal and Wurno LGAs, respectively had some level of awareness of climate change. To that effect, some elements of climate change which involve changes in temperature and rainfall distribution were noticed by the farmers. In Tambuwal LGA, a high proportion (91.2%) of the respondents were aware of the devastating effect caused by unusual temperature changes in the area being relatively closer to Northern Guinea Savannah vegetation while in Wurno LGA, an area of close proximity to Sudan Sahel vegetation recorded 91.7% of the respondents who were aware of the effect of changes in temperature as an element of climate change in the area. In addition, the effect of climate change was noticed by the changing pattern of rainfall distribution and observable effects on crop production by 91.2% of respondents in Tanbuwal LGA while in Wurno LGA, as high as 91.7% of the respondents were aware of the effect.

The findings suggest that the farmers are at the height of awareness of climate change, which could assist them to take proactive measures using their own indigenous knowledge to adjust their cropping calendar, and synchronization of cropping thereby reducing the risk of uncertainties associated with farming. This result is in agreement with Akano *et al.* (2023) who reported that farmers were aware of and perceived changes in temperature, rainfall, increasing incidence of pests and the occurrence of diseases, drought, and a prolonged dry season as indicators of climate change. On the contrary, the level of awareness on issues related to climate change in Nigeria is considered to be low, especially among the smallholder farmers in northern Nigeria (Akande, 2017).

Table 2: Climate change awareness

Variables	Tambuwal LGA	Wurno LGA	Pooled Data
	%	%	%
Climate change awareness			
Aware	97.8	95.8	97.6
Not aware	2.2	4.2	2.5
Kind of Change Noticed			
Temperature change	91.2	91.7	92.5
Rainfall change	91.2	91.7	92.5
Duration of Experience (years)			
1-7	96.3	87.5	95.0
8-15	3.8	12.5	5.0

Source: field survey, 2019.

Use of Indigenous Climate Change Adaptation Strategies

Table 3 shows descriptive information about indigenous climate change adaptation strategies used by the respondents. A cursory look at the results indicates that diversification in crop production was used by 83.8% of respondents in Tambuwal LGA while 50.0% in Wurno LGA used it as an adaptation strategy in mitigating the effect of climate change. This implies that diversification is adopted as an adaptive practice among the respondents in the study area to cope with the reality of ever-changing climate scenario.

The majority (74.3%) of the respondents prefer growing of drought resistance varieties alongside the use of cover crops in Tambuwal LGA to other practices. About 45.8% of the respondents in Wurno LGA, however, embarked on an intercropping strategy to cope with the effect of climate change. As adaptation strategies to unpredictable rainfall, some farmers identified the other strategies in both LGAs including mulching (58.1%) and (29.2%) the use of irrigation (61.8%) and 45.8%). This implies that multiple adaptation strategies have been used by different farmers in different locations as a measure to cope with the climatic change effects on crop production. Impacts of climate change have stimulated the need for crop diversification to ensure food insecurity. Households have concentrated on the production of fast-growing crops rather than slow-growing ones to reduce risks related to climate change (Lakhran *et al*., 2017).

Furthermore, the results conform to Osei (2017) who itemized the adaptation strategies used by smallholder farmers in the Central Region of Ghana to include crop diversification mechanisms and improved variety and breeds (63.2%), soil and water conservation (11.7%), changing planting dates and period (1.4%) among others. Findings reveal ample evidence of positive outcomes, including increased yields and household incomes, improved nutrition and food security, new marketing opportunities, reduced poverty, and strengthened adaptive and innovative capacity. Crop diversity is most often associated with risk-coping strategies. Bellon *et al*. (2019) sustain that it also offers other potential benefits, particularly in regions where markets function poorly. These benefits could include optimal crop production under difficult growing conditions; a larger portfolio of goods for different uses; new marketing avenues; increased consumption of self-produced crops with higher nutritional content, quality, and cultural significance; and poverty reduction. Crop diversification

could also improve the management of other natural resources, such as (irrigation) water (Watson, 2019), through the smart use of crop combinations that, together, are less water demanding.

Costa *et al.* (2020) reported that cereal-legume intercropping provided more stable yields in tropical and sub-tropical climatic zones, compared with pure cultures (Raseduzzaman & Jensen, 2017), and it could produce yields with high land use efficiency (Xu et al., 2020). Intercropping is efficient under water stress conditions and is thus a valuable measure against droughts. More in general, because of portfolio effects, crop failure in intercropped systems might be limited to one or few crop species. This suggests that intercropping can foster adaptation to a broad variety of extreme conditions, depending on the chosen crops (Costa et al., 2020).

Table 3: Use of indigenous climate change adaptation strategies

Variables	Tambuwal LGA %	Wurno LGA %	Pooled Data %
Producing new crops	25.0	0	21.3
Diversification in crop production	83.8	50.0	78.8
Growing drought resistant crop varieties	74.3	50.0	70.6
Use of pest/disease resistant crop varieties	64.7	50.0	62.5
Use of cover crops	74.3	45.8	70.0
Crop rotation	73.5	37.5	68.1
Intercropping	80.9	45.8	75.6
Use of irrigation	61.8	45.8	59.4
Mulching operation	58.1	29.2	53.8

Source: field survey, 2019

Farmers' Perceptions on the Effect of Climate Change on Crop Production

Table 4 presents the results of farmers' perceptions of the effect of climate change on crop production. Changes in rainfall patterns were ranked first with a mean $\bar{x}$ value of 3.5, perhaps due to the fact that the farmers experienced the effect of changes in rainfall patterns as a serious threat to their farming activities. The poor yield of crops due to climate change is second with a mean value of 3.1. The yield performance of crops has been poor as a result of pests and disease infestation and radiation intensity. More so, the effect was perceived as poor germination of crops due to climate change with a mean value of 3.0. As a result of this effect, seed dormancy and sterility of cultivars become a serious identified problem among the farmers in Sokoto State. Another perceived effect was changes in temperature ranked as fourth with a mean $(\overline{X})$ value of 2.9. excessive temperature above the threshold level poses the danger of burning of the floral (vegetative parts) thereby hampering the proper photosynthetic process. In addition, the farmers' perception that climate change posed more risks than benefits and that climate change increased the cost of crop production was ranked fifth with a mean value of 2.5. The benefits are relatively less than the plethora of risks associated with climate change, hence the farmers who plant different crops due to climate change were ranked sixth in order of magnitude having a mean value of 2.3. The devastating trend of climate change effect on crop production was perceived to have reached the extent of posing threats to crops in storage and was ranked as seventh having recorded a mean value of 2.1. Other perceived effects of climate change on crop production include infestation of crops by pests with a mean

of 2.0, and prevalence of crop disease due to climate change as ninth with a mean value of 1.7.

Shrestha et al. (2022) reported that over 65% of farmers mentioned a decrease in rice and wheat production due to the change and uncertainty in the onset and withdrawal of monsoon and winter rainfall. About 80% of the farmers shared an increased incidence and severity of floods, flash floods, and landslides that led to reduced availability of food and caused damage to several hectares of agricultural land, making large areas of the farmland barren. Shrestha *et al.* (2022) added that farmers perceive that the rising temperatures have reduced the soil moisture and consequent decline in agricultural yield. The rising temperatures have also negatively affected livestock rearing and the production of quality livestock derivative products. In addition, farmers opined that pests, crop diseases, and weed infestation have increased due to the rise in temperature and irregular rainfall patterns. Such perception of an increase in pests, insects, and crop diseases is consistent with the study of Dawadi et al. (2022) in Central Nepal. In Northeastern Nigeria, drought caused the death of many animals and about a 60% drop in crop yield (Akande, 2017).

Table 4: Farmers' perceptions of the effect of climate change on crop production

Farmers' perceptions	Tambuwal LGA Mean	Wurno LGA Mean	Pooled Data Mean	Rank
Temperature change possess risk to crop production	1.8	1.1	2.9	4th
Rainfall change poses risk to crop production	2.4	1.1	3.5	1st
Climate change possess more risks than benefit	1.7	0.8	2.5	5th
Infestation of crops by pests is due to climate change	1.3	0.7	2.0	8th
Poor germination rate of crops is due to climate change	2.2	0.8	3.0	3rd
Poor yield of crops is due to climate change	2.2	0.9	3.1	2nd
Prevalence of crop diseases is due to climate change	1.1	0.6	1.7	9th
Farmers plant different crops due to climate change	1.5	0.8	2.3	6th
Climate change increases the cost of crop production	1.6	0.9	2.5	5th
Climate change affects crops in storage	1.3	0.8	2.1	7th

Source: field survey, 2019

Relationship between Socioeconomic Characteristics and Use of Indigenous Climate Adaptation Strategies by the Farmers

Table 5 presents result of regression analysis on the relationship between socioeconomic and institutional variables and the use of indigenous climate adaptation strategies by the farmers. Thus, of all the eight variables included in the model, four indicated a significant influence on the farmers' decision to use indigenous climate change adaptation strategies. Since the R^2 value was 0.46 and ANOVA F-value (7.325) was significant at the 1% level, the model was taken as a good fit. This implies that variables included in the model were able to explain about 46% of the variation in Y, that is, the dependent variable which is the use of indigenous climate change adaptation strategies.

The results show that the age of the farmers significantly (P≤ 0.01) relates to the use of indigenous strategies. Age has a negative coefficient, hence, as the farmers grow older there would be a corresponding decrease in the use of adaptation strategies. This result agrees with the position of Ogunpaino et al. (2021) who reported age as a significant factor that influences the decision on the use of climate adaptation measures among farmers in Nigeria. Also, the decision by farmers to aptly use innovative mechanisms to curb the devastating impact of climate elements is, sometimes, determined by income generated from non-farming activities. This was proved by the result obtained from this study which shows that non-farm annual income has positively and significantly (p ≤0.01) related to the use of adaptation strategies. This implies that a unit increase in non-farm income would lead to a corresponding increase in the use of indigenous climate change adaptation strategies by the farmers. The result confirms the submission by Damian *et al.* (2020) who revealed that non-farm income greatly demonstrated effects on the farmers' decision to adopt climate adaptive practices.

Revenue generated from non-farm activities is capable of adding more strength to the financial status of farmers for a more investment adoption of innovative measures. In contrast, farm annual income was found positive and significant (p ≤ 0.1). The result affirms the relationship between farm income and the use of indigenous climate change adaptation strategies by the respondents. It goes to show that an additional unit in farm income will contribute to a corresponding increase in the use of the strategies. There is no contrasting view about the fact that income plays important role in farmers' decision to use new knowledge or practice. The result is in consistent with Ojo and Baiyegunhi (2018) who found farm income to an important determinant of the adoption of climate adaptation measures by farmers in Southwestern Nigeria.

Most importantly, farming experience represents the number of years a farmer engages in active farming, which translates into a form of knowledge, ideas, skills and proactive instinct. Experience is capable of driving farmers' decisions to appropriately use innovative solutions to farm problems. The result reveals that years of farming experience was found statistically significant (p ≤0.01). It implies that the use of indigenous climate change adaptation strategies can be influenced by years of experience in farming, especially crop production. That is, the farmer can change planting time, use tolerant varieties, mulching and irrigations instantly from experience to cope with climatic variability effect on farming.

Land size is positive and statistically significant. This implies that the use of indigenous climate change adaptation strategies among the farmers was influenced by the expanse of land available to them and the fraction devoted to crop production. Impliedly, the more the land size the more tendency to use adaptation strategies. The finding is in conformity with the report by Damian et al. (2020) who indicated the size of land as one of the determinants affecting the use of adaptation practices by farmers in coping with the reality of climate variability in the farmers' communities.

Table 6: Relationship between farmers' socioeconomic characteristics and use of indigenous climate adaptation strategies

Variables	Coefficient	Standard error	T-statistic
Constant	0.293	0.429	0.683
Age	-0.038	0.012	-3.167*
Educational qualification	0.021	0.058	0.361
Household size	-0.034	0.023	-1.502
Farm annual income	9.205E-7	0.000	1.793
Land size	1.202E-6	0.000	2.583*
Extension contact	0.199	0.220	0.905
Non-farm annual income	0.367	0.152	2.41*
R^2- value	0.49		
Adjusted R^2	0.46		
F- value	7.325		

*P≤0.05.

Conclusion and Recommendations

The use of indigenous adaptation strategies to curb the effect of climate change was largely determined by age, farm annual income, farming experience, land size (farm size) and non-farm income among the farmers' socioeconomic characteristics. The farmers have varied perceptions of the effect of climate change on crop production enterprises. Their perception stemmed from point of view that changes in rainfall patterns pose risks to crop production which was ranked first in the order of magnitude. This was clearly followed by the poor yield of crops, poor germination; pest infestation and degree of vulnerability to various diseases as a result of climate change were perceived by the farmers as the obvious effect of climate change in the both Shelia and Guinea savannah zones.

Farmers used their own indigenous knowledge of climate change adaptation strategy as a coping mechanism. These include the use of diversification in crop production, adoption of mulching operations, crop rotation strategy, and growing drought tolerant cultivars among others. These strategies are seen as the best by the farmers in the study areas, due to increment in crop yield of productivity. The strategies can be modified through research and development to bring about more effective mitigating mechanisms. More so, it can be concluded that the farmers had awareness of the effect of climate change effect which they largely experienced from high-temperature changes over the years and unusual rainfall patterns as well as excessive floods. To preempt the situation, they, therefore, developed different adaptation strategies based on their indigenous knowledge.

Relevant adaptation measures are diverse and must be considered in the context of the local agro-ecological, production and socio-cultural conditions present for particular areas of Nigeria. Farmers' awareness level of issue relating climate change generally should be used as a build-up to policy and programs development for packaging mitigating strategies against climate change.

Farmers' capacity should be built around effective use of farmers' indigenous adaptation strategies, such as diversification in crop production, use of mulching operation, crop rotation as well as adjustment in planting calendar. More drought tolerant and pest/disease resistance varieties developed from research and development should be timely made available to farmers through effective outreach system of extension organizations as well as research institutes. Timely metrological information on climate change should reach the farmers through different radio stations, news-papers, public lectures, seminars as well as other mass media stations.

The farmers should be formed into organizations so as to be able to access financial facilities and incentives. More importantly, to be able to benefit from various empowerment programs that would aids their skills and knowledge of economic diversification, since non-farm income shows significant relationship with the use of adaptation strategies by the farmers.

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