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Analysis of Awareness and Adaptation to Climate Change among Farmers in the Sahel Savannah Agro-ecological Zone of Borno State, Nigeria

Y. L. Idrisa[1*], B. O. Ogunbameru[1], A. A. Ibrahim[1] and D. B. Bawa[1]

[1]Department of Agricultural Economics and Extension Services, University of Maiduguri, Maiduguri, Nigeria.

Authors' contributions

This work was carried out as a collaborative effort among all the authors. YLI conceptualized the idea of the work, constructed the data collection instrument, analyzed the data and did the first reporting. AAI collected the data. DBB handled the data entry and assisted in the review. BOO provided the technical know-how, vetted the article and certified it for publication. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

This study examined the awareness and adaptation to climate change among farmers in the Sahel Savannah agro-ecological zone of Borno State, Nigeria. Data for the study were collected from 225 respondents selected through the Multi-stage sampling technique. A socio-economic profile of the respondents indicated that 48.89% were above 45 years of age and majority (78.23%) had educational qualifications below the secondary school level. The study also revealed that a majority (79.12%) of the respondents were small-scale farm holders and more than half (67.56%) had fewer than 7 extension contacts during the 2010 farming season. An analysis of the source of climate change awareness revealed that majority (82.22%) of the respondents was aware of the phenomenon of climate change. Of that number, extension service and friends/neighbors were ranked high as source of awareness about climate change, accounting for 47.57% and 232.43% respectively. Analysis of adaptation practices used by the respondents showed that planting ahead of rains (97.78%) and planting of cover

**Corresponding author: Email: idrisaysf@yahoo.com;*

crops 80.00% were used most. Analysis of the relationships between some selected socio-economic variables and the use of climate change adaptation measures revealed that educational qualification and the number of extension contacts were the most important factors influencing the use of adaptation measures among the respondents. The main constraints on climate change adaptation measures by farmers in the study area were poor financial resources (86.67%) and unavailability of weather information (77.78%). The study concluded that the majority of farmers were aware of climate change and its consequences. The study also concluded that although the majority of farmers were engaged in husbandry practices aimed at climate change adaptation, they were constrained by some factors; therefore we recommended that extension education should be strengthened to boost farmers' awareness of climate change and prepare them for adaptation measures and that appropriate/indigenous technologies be promoted for adaptation by farmers.

Keywords: Awareness; adaptation; climate change; farmers; Borno State.

1. INTRODUCTION

The growing problems of climate change are becoming more threatening to sustainable economic development and the totality of human existence (Adejuwon, 2004). Over time, farmers have adjusted agricultural systems and practices to meet changing economic and physical conditions by adopting new technologies, changing crop mixtures and institutional arrangements. Such flexibility suggests a human potential to adapt to climate change (CAST, 1992; Rosenberg, 1992). Changes in temperatures and rainfall patterns as well as an increase in carbon dioxide (CO_2) levels are expected to affect agriculture, especially in tropical regions. Such changes may manifest in the reduction in land quality and low agricultural yields.

Oyekale (2009) asserted that the entire human condition is likely to be affected by climate change due to a decrease in water availability, especially in arid regions. Blaikie et al. (1994) suggested that some social factors influence both the vulnerability and adaptation to climate change. In the same vein, previous studies (Nhemachena, 2007; Adger and Kelly, 2001) highlighted the role of access to credit and extension services in the recovery from stress and disruption of livelihood. Oyekale (2009) postulated that through conditions of hazard exposure and vulnerability, poor countries disproportionately suffer climate change disasters.

The small-scale farmer still suffers most because of his dependence on rain-fed agriculture and lack of capacity to diversify. Carter (1997) pointed out that farmers react to climate change through adaptation. In an analysis of adaptation to climate change in the drought-prone areas of Bangladesh, Selvaraju et al. (2006) found that the main adaptation strategies practiced by small-scale farmers were in the form of modification of agronomic practices and in the choice of crop varieties that tolerate the new regime.

Desertification covers up 35% of Nigeria's land mass and more than 60% of Borno State, where the study was conducted (Badi, 2010). This situation, coupled with an ever decreasing rainfall regime, is threatening the livelihood of the population, which depends largely on rain-fed agriculture. The arable land mass is seriously being threatened due to desertification, and most of the local crop varieties are no longer appropriate due to

changing climatic conditions. Evidence abounds (Katz and Brown, 1992) that farmers can adapt to climate change by changing their agricultural practices, which may include planting tolerant crop varieties or changing husbandry practices. Adaptation may also involve blending scientific practices with local/traditional knowledge. It is expected that crop productivity will be altered due to weather events and changes in the pattern of pests and diseases (Aydinal and Cresser, 2008). The United Nations Environmental Programme UNEP (1996) report found that global warming, a result of climate change, will add to worsening food insecurity. The report added that reduced water availability will pose one of the greatest problems to agriculture, especially in developing countries.

Adaptation to climate change refers to the adjustments in ecological, social, and economic systems as well as response to climatic conditions and their effects (Tol, 1998). The capacity of farmers to adapt to climate change can be significantly influenced by the level of awareness about climate change in their communities. In this regard, Tol (1998) suggested that awareness about climate change has great capacity to drive farmers to improvise local technologies to aid adaptation. Kartz and Brown (1992) and Selvaraju et al. (2006) found some adaptation practices commonly used by farmer in response to climate change to include water harvesting, early planting, deep planting, planting of cover crops, application of mulch to conserve moisture, planting of draught tolerant, planting of early maturing crops, alley farming, and enterprise diversification. Although several studies have been carried out on adaptation to climate change in developing countries (Badi, 2010; Nhemachena, 2007; Selvaraju et al., 2006), these studies do not look at the effect of awareness and its linkage to adaptation to climate change by farmers.

In view of that, this study was designed to analyze the awareness and adaptation to climate change among small-scale farmers in the Sahel Savannah agro-ecological zone of Borno State, Nigeria. It is hypothesized that the level of awareness does not influence adaptation to climate change by farmers.

The specific objectives of this study were to:

(1) identify the socio-economic characteristics of the respondents;
(2) examine the level of awareness about climate change among respondents in the study area;
(3) analyze the adaptation mechanisms to climate change being used by the respondents in the study area;
(4) determine the factors that influence adaptation to climate change by the respondents; and
(5) identify the constraints to adaptation to climate change by small-scale farmers in the study area.

2. METHODOLOGY

The study was conducted in the Sahel Savannah agro-ecological zone of Borno State, Nigeria. The study area lies between longitude 13º30'–14º0'E and latitude 12º0'–13º30'N (Agboola, 1987) and consists of six Local Government Areas, (LGAs): Abadam, Gubio, Kukawa, Magumeri, Monguno and Nganzai. The mean annual rainfall of the study area is 500 mm and the vegetation is mainly shrubs and seasonal grasses with few stunted trees. The main crops grown in the study area are millet, cowpea, and maize. The soil type in the study area, located in a semi-arid region, is sandy.

Respondents for the study were selected through a multi-stage sampling procedure. In the first stage, three LGAs were randomly selected from the six LGAs in the study area. From each of the selected three LGAs, three communities were randomly selected, giving nine total communities used for the study. In the third stage, 25 farming households were selected. The heads of the selected households were taken as the respondents, yielding 225 total respondents for the study. All respondents were administered interview schedules. Information sought from the respondents related to their socio-economic characteristics, knowledge of climate change, adaptation practices undertaken, as well as the constraints faced in adapting to climate change.

Both descriptive and inferential statistics were used to analyze the data. Descriptive statistical tools (frequency counts and percentages) were used to categorize the respondents based on socioeconomic characteristics, awareness to climate change, adaptation measures used by farmers and constraints to the use of climate change adaptation technologies. The inferential statistical tool, mainly the Tobit regression model (Tobin, 1958), was used to establish the effects of some socio-economic characteristics on the use of climate change adaptation measures among farmers. The Tobit model was used in the study because it measures both the probability of use of adaptation practices and the intensity of use of such practices. The Tobit model assumes that use of adaptation practices is a continuous decision. It expresses farmer's use of adaptation practices as a function of linear combination of observable explanatory variables, some unknown parameters, and an error term (e). The major strength of Tobit model over other econometric models, such as the Ordinary Least Square (OLS) for estimation of adoption, is its inclusion of observations with non-use of adaptation practices. In its simplest form, the Tobit model is presented as:

$$\mu^{*}_{i} = B_{xi} + \mu$$

Algebraically expressed for the i_{th} farmer, the Tobit model is explicitly expressed as:

$$\mu_i = B_0 + B_1X_1 + \text{----------} B_NX_N \qquad i = 1\ldots\ldots\ldots N\ldots$$

where:

μ_i is the observed dependent variable *i.e.* adaptation to climate change, measured in the number of adaptation practices used by a farmer;

B_0 is the intercept or the level of adaptation that will occur regardless of the level of independent variable.

$B_1 \ldots\ldots B_N$ are coefficient of the independent variables.
$X_1 \ldots\ldots X_N$ are the independent variables (i.e. age, household size, educational level and extension contact).

Unlike OLS, the Tobit model coefficient does not directly correspond to the expected changes in explanatory variables; rather, it estimates a vector of normalized coefficients, which can be transformed into a vector of the first derivative. (Tobin, 1958) The Tobit model was also used in several studies of adoption of improved agricultural technologies (Adesina and Zinnah, 1993; Bamire et al., 2002; Ojiako, et al., 2007; Sall et al., 2002).

3. RESULTS AND DISCUSSION

3.1 Socio-economic Profile of the Respondents

A socio-economic profile of the respondents (Table 1) shows that 51.11% of the respondents were 45 years of age or younger, with close to half (48.89%) of the respondents above 45 years of age, indicating that a large proportion of the respondents have declining productivity. Aging populations are less able to engage in modern agricultural practices; they are also less able to source and synthesize information. Younger farmers are more able to adopt improved ideas and innovations. The socio-economic profile also revealed that the majority (78.23%) of the respondents had not gone beyond primary school level of education. This has serious implications for the level of awareness about climate change and also for the development of indigenous farm practices for adaptation. Education plays an important role in creating awareness in farming communities because educated people are better equipped to source information. A minimum threshold in terms of educational qualification is necessary for understanding the scientific and technical nature of modern agriculture. Education also helps farmers understand where to access farm inputs as well as how to use them. Earlier studies (Asfaw and Admassie, 2004; Bamire et al., 2002) reported that education affects agricultural productivity by increasing the ability of farmers to produce more output from given resources and by enhancing the capacity of farmers to obtain and analyze information. Education could also influence the ability of farmers to adjust quickly to disequilibria. The socio-economic profile (Table 1) further reveals that 79.12% of the respondents operated 1.5 ha of land or less, indicating that the majority of respondents are small-scale farmers. Small-scale farmers operate at subsistent level, making them vulnerable and less able to cope with the consequences of climate change, as indicated by Oyekale (2009). More than half (67.56%) of the respondents received not more than six extension visits during the 2010 farming season, implying that more than half of the respondents had very low extension contact. According to the Food and Agriculture Organization (FAO) recommendation, farmers are expected to receive at least one extension visit every week during a farming season, which translates to a minimum of 15 extension contacts in a farming season.

Extension contact determines the information that farmers obtain on production activities and the application of innovations through counseling and demonstrations by extension agents. The effect of exposure to extension programmes is enormous. For instance, Onu (2006) found that farmers who had access to extension contact adopted alley farming technologies 72% more often than farmers who had no access to extension contact. Nhemachena (2007) also noted that exposure to extension services influences the capacity of farmers to adapt to climate change.

3.2 Awareness about Climate Change

This study sought the level of awareness about climate change among the respondents. Results of the level of awareness of climate change among the respondents (Table 2) revealed that the majority (82.22%) of respondents were aware of the changing climate. Of that figure, 39.11% got their information about climate change from extension agents, 26.67% from friends and neighbours, and 11.11% through media (mainly radio), while a mere (5.33%) got the information from Non Governmental Organizations (NGOs). This underscores the importance of interpersonal communication in creating awareness.

Table 1. Distribution of respondents based on their socio-economic characteristics

Variable	Frequency	Percentage
Age(years):		
≤25	23	10.22
26-35	30	13.33
36-45	62	27.56
46-55	78	34.67
56 and above	32	14.22
Educational qualification:		
No formal education	26	11.56
Qur'anic Education	108	48.00
Primary education	42	18.67
Junior Sec. education	29	12.89
Senior Sec. education	20	08.89
Farm size (ha.):		
≤0.5	08	03.56
0.6-1.0	35	15.56
1.1-1.5	60	26.67
1.6-2.0	75	33.33
2.1-2.5	32	14.22
2.6-3.0	27	12.00
3.1 and above	06	02.67
Number of extension visit received:		
≤3	65	28.89
4-6	87	38.67
7-9	45	20.00
>9	28	12.44

Source: Field Survey, 2010

Table 2. Source of awareness about climate change

Source	Frequency	Percentage
Extension	88	39.11 (47.57)
Media (radio/television)	25	11.11 (13.51)
Friend/neighbours	60	26.67 (32.43)
NGOs and input sales agencies	12	05.33 (06.49)

Source: Field Survey, 2010

3.3 Figures in Parentheses are Percentage of Respondents that had Awareness of Climate Change

The extension agents are the main source of technical information among farmers. If the extension agents are empowered with knowledge/information about climate change, there is high likelihood that such information may reach the local farmers. As stated by Rogers and Shoemaker (1983), extension agents are not able to work closely with all farmers in a farming community; rather, they work with few farmers (the contact farmers or the opinion leaders) who become the agents to spread the information in their own communities.

3.4 Perceived Causes of Climate Change

The perception of the respondents as to the causes of climate change (Table 3) shows that nearly all (91.11%) of the respondents perceived climate change as being caused by deforestation, bush burning, and overgrazing by livestock. This was followed by natural process destined by God, as claimed by 75.56% of the respondents, while more than half (60.00%) of the respondents claimed that industrial activities are responsible for climate change. Other causes of climate change are emission by vehicles, domestic activities, and emission of green house gasses as reported by 36.44, 26.67 and 02.67% of the respondents, respectively.

Table 3. Perceived causes of climate change by respondents

Perceived cause	Frequency	Percentage*
Industrial activities (e.g. gas flaring CO_2 emission)	135	60.00
Domestic activities (e.g. burning of fire wood for cooking)	60	26.67
Deforestation, bush burning and overgrazing by livestock	205	91.11
Emission by vehicles	82	36.44
Emission of greenhouse gasses (e.g. CO_2, CH_4 and NO_2)	06	02.67
Natural process destined by God	170	75.56

Source: Field Survey, 2010

**Multiple responses resulted in a total percentage >100%.*

3.5 Adaptation to Climate Change

The result of adaptation measures responded by the respondents against climate change (Table 4) shows that majority (97.76%) of the respondents plant their crops ahead of rains to give the crop the advantage of benefiting from the first flush of rains. Mulching and cover cropping were also practiced by 80% of the respondents to reduce evaporation and add organic matter to the soil. About three-quarters (73.33%) of the respondents reported that they planted drought tolerant and early maturing crop varieties to cope with short rainfall regimes. Other adaptation measures used by the respondents include intensive manure application, planting deeper than usual and applying irrigation water to augment short fall in rains as reported by 66.67, 37.78, and 05.33% of the respondents, respectively. Earlier studies (Katz and Brown, 1992) found that farmers adapt to climate change by modifying their husbandry practices by changing crop mixes to cope with the new regime.

Table 4. Climate change adaptation measure responded by respondents

Adaptation measure	Frequency	Percentage*
Irrigation to augment shortfall in rain	12	05.33
Mulching/cover cropping	180	80.00
Planting deeper than usual	85	37.78
Planting ahead of rains	220	97.78
Intensive manure application	150	66.67
Planting crops tolerant to climate change induced conditions	165	73.33

Source: Field Survey, 2010

**Multiple responses resulted in a total percentage >100%*

3.6 Factors Influencing the Use of Adaptation Measures to Climate Change

Factors that influenced the use of adaptation measures among the respondents were determined (Table 5). Adaptation was measured in terms of the number of strategies used by a respondent (Table 4); the higher the number of such strategies used by a respondent, the higher he ranked in adaptation status. The results revealed that level of education of the respondents and extension visits were highly significant in influencing the use of adaptation measures among the respondents. Both variables were positive and significant at 0.01. This implies that as the level of education of the respondent increases, the capacity to use the adaptation strategies correspondingly increases; the same applies to extension visits. These two variables (educational level and the frequency of extension visits) also affect awareness. This therefore implies that level of awareness among the respondents also influence the level of adaptation to climate change by the respondents.

Table 5. Tobit estimate of factors influencing adaptation to climate change

Adaptation to Climate Change	Coefficient	Std. Error	Z	P> |z|	(95% Conf. Interval)	
Age	-0.5401261	0.2298583	-2.35	0.019**	0.9922079	0.0880444
Level of education	15.17621	2.017178	7.52	0.000***	11.20885	19.14356
Household size	1.65632	0.5433203	3.05	0.002**	2.724914	0.5877256
Extension visit	6.944238	1.86999	3.71	0.000***	3.279124	10.60935
Constant	2.833213	1.028992	2.75	0.006	4.85	0.816427

***= Significant at 5%*
****= Significant at 1%*

In a study of factors influencing the adoption of improved soybean seed among farmers in Borno State, Idrisa et al. (2010) found that extension visits were significant in influencing both the likelihood of adoption and the intensity of use of improved soybean seeds. Age was also significant in influencing the use of adaptation measures among the respondents. The variable was significant at 0.05 and the sign of the coefficient of age was negative, implying that the younger respondents used more adaptation measures compared to their older counterparts. This is in line with Adesina and Zinnah (1993) who postulated that younger farmers have greater tendencies to improvise and adopt new technologies because they are relatively more knowledgeable, more open to risk taking, and have longer planning horizons than their older counterparts. Household size was also significant in influencing the use of adaptation measure among the respondents. Household size could be a measure of available labour for farming activities. Some of the adaptation measures to climate change such as mulching and manure application are labour-intensive, which may explain why the capacity of farmers to use these technologies depends on availability of labour, and the main source of labour in subsistent agriculture is the family.

3.7 Constraints to Adaptation

The constraints to adaptation to climate change among the respondents (Table 6) show that the main hindrance to adaptation to climate change among the respondents was a poor financial resource base of the respondents, as reported by 86.67%. Unavailability of weather information was the second most important constraint, as reported by 77.78% of the respondents. Poor access to technology necessary for adaptation and poor access to

extension services were among the constraints that militated against adaptation to climate change as reported by 57.78% and 32.00% of the respondents, respectively.

Table 6. Constraints to adoption of climate change adaptation measures by respondents

Constraints	Frequency	Percentage*
Inadequate financial resource	195	86.67
Inadequate access to extension service	72	32.00
Poor access to the technologies necessary for adaptation	130	57.78
No availability of weather information	175	77.78

Source: Field Survey, 2010

**Multiple responses resulted in a total percentage >100%.*

As stated by Oyekale (2009), the small-scale farmers, having low resource base, are more vulnerable and less able to cope with the consequences of climate change. Such farmers also have less likelihood of accessing weather information or capacity to develop technologies on their own.

4. CONCLUSIONS

In this study, awareness and adaptation to climate change among small-scale farmers in the Sahel Savannah agro-ecological zone of Borno State were analyzed. Results of the study indicated that a large proportion of the respondents were above 45 years of age, with the majority (78.23%) having no or a low level of formal education. Access to extension service was also low in the study area, even though extension service played the leading role in providing information about climate change to the respondents. The study showed that planting ahead of rains (97.78%) was the leading adaptation measure responded by the respondents, followed by application of mulch/planting of cover crops. Important factors that influenced the use of adaptation practices among the respondents included level of education (P> |z| 0.01) and extension visits (P> |z| 0.01). Major constraints that militated against the use of adaptation measures include inadequate financial resource and unavailability of weather information. Based on the findings of this study, we suggest the following recommendations: (1) extension service should be strengthened through organizing adult education programmes for farmers to expose them to climate change coping strategies, and (2) programmes should be put in place to attract young people into farming, especially young school leavers and young graduates. These recommendations can be accomplished through strengthening programmes such as the National Directorate of Employment (NDE) and the National Poverty Alleviation Programme (NAPEP). In addition, (3) affordable climate change adaptation technologies should be appropriated and developed for resource-poor farmers to adopt.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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