AGRICULTURAL ADAPTATION STRATEGIES TO CLIMATE CHANGE IN SOKOTO STATE, SEMI-ARID REGION OF NIGERIA

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Abstract
Unfolding environmental strains, especially due to climate change have continued to prompt local farmers to search for coping strategies within the constraints of limited resources. This paper investigated the agricultural adaptation strategies to climate change in some selected rural settlements in Sokoto State. A sample size of 234 respondents was used in this study. Structured questionnaire was used to collect data on the local farmers' agricultural adaptation strategies. The variations of the strategies among the selected settlements were examined using chi-squared and z-score while the prevalence of each of the strategies was ranked using simple percentages. The results, among others, revealed that with the exception of the combination of farming with non-farm livelihoods, the strategies vary significantly among the selected settlements. This implies that the variation of agricultural adaptation to climate change is a function of the uneven distribution of natural and socio-economic resources. It is recommended that efforts toward complementing local farmers' strategies should be place-specific taking into consideration the spatial variations of environmental and socio-economic resources.
Key words: Agriculture, Adaptation strategies, climate change, Sokoto and Nigeria

Introduction

The United Nations (1992) in Article 1 of the Framework Convention on Climate Change defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". It remains the most devastating threat to mankind with imprints which vary spatially and from sector to sector. The evidences of climate change in Nigeria are already manifesting in the form of changes in the intensity and seasonality of rainfall, increase in average annual temperatures and rising frequency of extreme weather events (Odjugo, 2010a, Atedhor and Odjugo, 2012).

Despite the significance of the semi-arid region as major source of grains and animal protein in Nigeria, its fragile ecological nature makes it highly vulnerable to climate change. For example, studies have shown that the semi-arid belt of Nigeria is besieged by frequent drought (Ati et al., 2010; Atedhor and Odjugo, 2012; Atedhor, 2013) and desertification (Odjugo and Ikhuoria, 2003). As a result of environmental change and the proximal location of the semi-arid region of Nigeria to the Sahara desert which is more fragile ecologically, studies (Omiunu, 1985; Evans and Mohieldeen, 2003) have reported growing incidence of migratory pests with grave consequences on crops.

Agriculture has been identified as the most climate-sensitive sector owing to the susceptibility of its different stages to the vagaries of the elements of weather and climate (Ayoade, 2002). Of particular importance to the growth and yield of crops, is moisture which is mainly derived from rainfall in sub-Saharan African due to the dominance of rainfed agriculture. Consequently, the length of the growing season and the type of crops cultivated in the semi-arid belt of Nigeria as in other parts of the country is determined by the onset and cessation of rainfall. However, apart from the incidence of drought, rainfall in the semi-arid belt of Nigeria is characterized by late onset and early cessation coupled with increasing temperature and its associated rising evapo-transpiration.

The erratic nature of rainfall, increasing temperature and evapo-transpiration have contributed to the shrinking of surface water bodies (Evans and Mohieldeen, 2003; Ayuba *et al*., 2007 cited in Mustapha *et al*., 2012) which makes irrigation difficult and unattractive. Apart from the scarcity of environmental resources owing to climate change, the semi-arid belt is also bedeviled by inadequate socio-economic resources which make the region highly vulnerable. The inadequacies of environmental and socio-economic resources coupled with the impoverished condition of the local farmers have continued to weaken their adaptive capacities.

The consequences of climate change are therefore at a degree that requires exigency not only to the efforts to avert further change, but similarly significant efforts to adapt to the impacts already taking place (Oladipo, 2010). Thus, as climate change continues to stir environmental changes with weighty implications on livelihoods, the local farmers have relentlessly searched for alternatives that can alleviate his vulnerability over the years. "Climate change adaptation is the process of preparing for, and adjusting proactively to, climate change - both negative impacts as well as potential opportunities" (World Bank, 2011). Through the enhancement of the adaptive capacities of local farmers, their resilience to climate change shocks can be strengthened. While planned adaptation could offer better strategy against climate change, there is the need to identify local strategies for mainstreaming. As Adesina and Odekunle (2011) noted, suggested adaptation strategies may be entirely novel to an area or they may just be an improvement on what is previously well-known to a community. This paper therefore, examines agricultural adaptation to climate change in some selected rural settlements in Sokoto State of Nigeria.

Study area

Sokoto State (Fig. 1) is located in the Sudano-sahelian Savanna ecological belt of Nigeria with Longitude 11° 3′ to 13° 50′ E and Latitude 4° to 6° 40′′ N (Tsoho and Salau, 2012). It encompasses wide-ranging tracts of almost flat to slightly rolling landscape (Ologe, 2002; Ekpoh and Nsa, 2011). It experiences wet season from June to September (Odekunle, 2004). Rainfall in Sokoto State as in other parts of Nigeria is dominantly controlled by the movement and pulsation of the ITD (Inter-Tropical Discontinuity) (Ilesanmi, 1971). Similar to other extreme northern parts of the country, rainfall in Sokoto State is very erratic and unpredictable with irregular onsets and cessations which adversely affect the duration of the cropping seasons (Ojo, 1991). Annual rainfall ranges between 300 mm and 800 mm while mean annual temperature is 34.5 ^{o}C with dry seasons temperatures often exceeding 40 ^{o}C. The grasses with scattered trees which characterized the State have undergone severe modification due to human activities. Agriculture is the mainstay of the people.

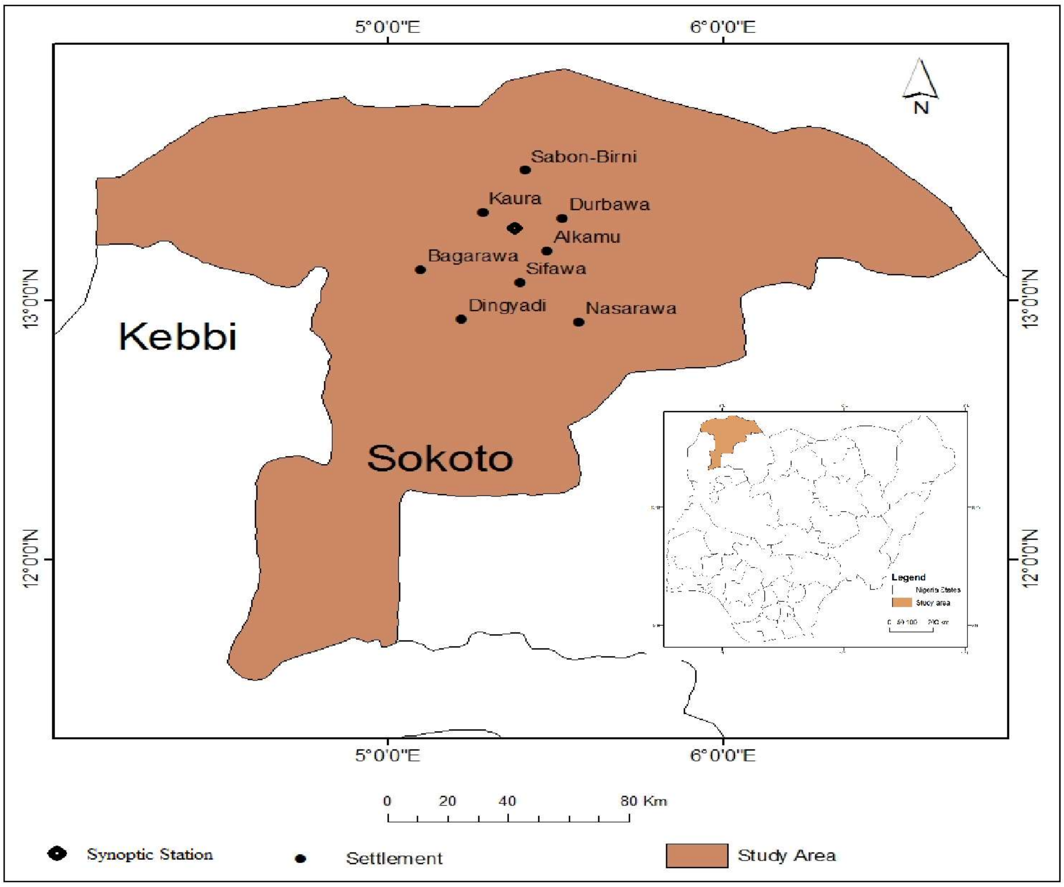

Figure 1: Selected Settlements for the Study

Materials and methods

Structured questionnaires were used to collect data on the local farmers' agricultural vulnerability to climate change in eight randomly selected rural settlements in Sokoto State (Fig. 1) within 45 km radii of the synoptic weather station since the climatic data from the station were used to establish climate change as reported in Atedhor (2013) of which this work is facet. Furthermore, agricultural activities are predominantly carried out in the rural areas in Nigeria. The projected 2010 population of the selected settlements were calculated from the 1991 census figures using 3.0 annual growth rates due to the non-availability of disaggregated 2006 census data. The number of households per settlement was obtained by dividing its projected population figures by the 2007 average rural household size of Sokoto State as specified by the National Bureau of Statistics (NBS, 2009). A sample size of 234 representing approximately 5.0 per cent of the total households in the selected settlements was computed and used for the survey based on Berenson and Levine (1998). The 234 copies of questionnaire were administered proportionally among the selected settlements based on household sizes (Table 1).

Table 1: Projected 2010 population, number of households and distribution of questionnaires among the selected settlements

S/N	Settlement	Projected 2010 population	Number of households	Distribution of the questionnaire by settlements
1	Alkamu	5006	1065	54
2	Nasarawa	3662	779	39
3	Kaura	666	142	7
4	Durbawa	2077	442	22
5	Bagarawa	552	117	6
6	Sifawa	5720	1217	61
7	Dingyadi	2514	535	27
8	Sabon-Birni	1617	344	18
		21814	4641	234

Chi-Squared (χ^2) was used to examine the significance of the difference of agricultural adaptation strategies to climate change amongst the selected settlements in Sokoto State of Nigeria. Z-score indicates how far an item deviates from its distribution mean, expressed in units of its distribution's standard deviation. Z-score was therefore employed in this study to facilitate the comparisons of the agricultural adaptation strategies to climate change in the selected settlements in Sokoto States. Z-score is given as:

Standard score (Z) = $\frac{x - \bar{x}}{s}$

Where Z = standard score, x = raw score for the original observation, $\bar{x}$ = the mean of the distribution and s = the sample standard deviation.
The prevalence of the adaptation strategies were classified and ranked as follows:

Percentage	Classification
0-30	Slight
31-60	Moderate
≥60	High

Results and Discussion

Socio-Demographic Characteristics of the Respondents

Out of the 234 respondents selected for this study, 205 were males while only 29 were females. This asymmetry is due to the limited access to female Muslims in the States. Besides, women in *pudah* do not engage in farming, particularly within their years of childbearing (Yahaya, 2002; Audu, 2009). Out of the 234 respondents, age group 40-49 representing 68 (29%) of the respondents form the largest while 5 (2%), 37 (16%), 48 (20%), 30 (13%), 46 (20%) represented age groups less than 20, 20-29, 30-39, 50-59 and 60 and above respectively. It can therefore be deduced that the agricultural workforce in the selected settlements is characterized mainly by people of less than 50 years of age which implies a young and vibrant workforce.

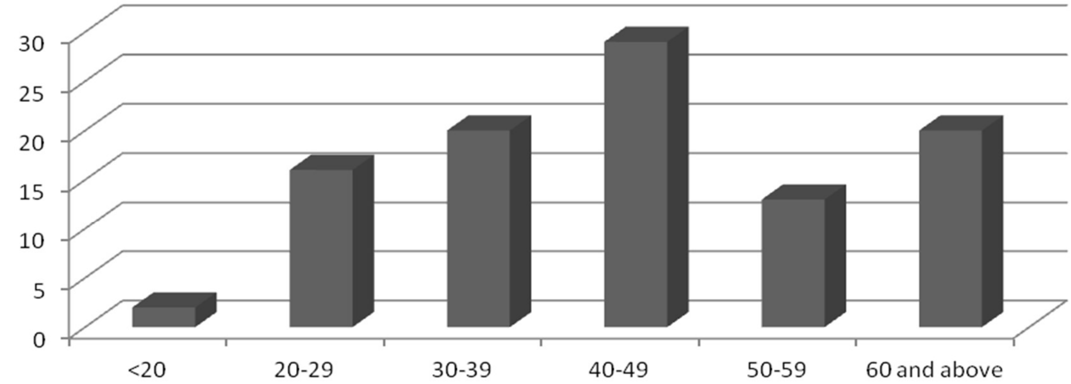

Figure 2: Age distribution of the respondents
Source: Fieldwork, 2011/2012

The educational distribution of the respondents revealed that 114 (48.7%) representing the largest proportion have no formal education while those with primary and secondary education were 51 (21.8%) each (Figure 3) and only 18 (7.7%) of the respondents have tertiary education. The high proportion of respondents with no formal education in the State is an indicator of low agricultural adaptive capacity to climate change since the higher the educational attainment of a farmer, the more knowledgeable and amenable to accepting alternating strategies (IIASA, 2010; Adebayo et al., 2012; Asante et al., 2012).

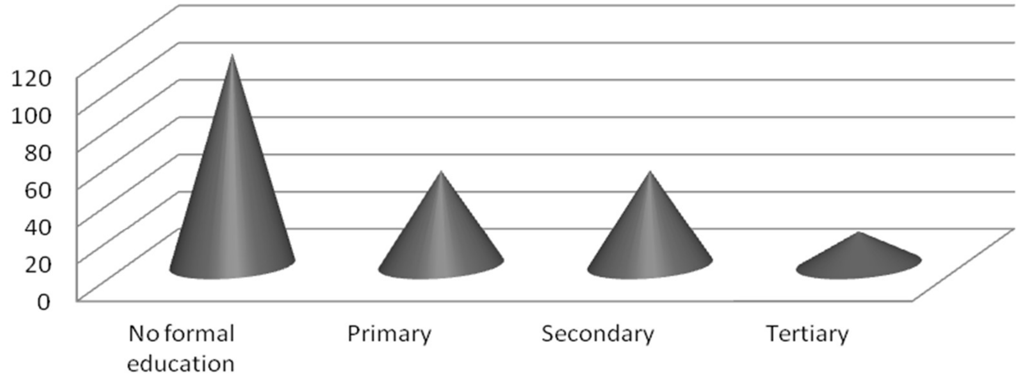

Figure 3: Educational attainments of the rspondents
Source: Fieldwork, 2011/2012

The monthly income levels of the respondents revealed that 70 (29.9%) representing the largest proportion fall within ₦10,000 -19, 000 while 45 (19.2%), 20 (8.5%), 57 (24.4%), 21 (9.0) and 21 (9.0) belong to less than ₦10, 000, ₦20, 000 - 29, 000, ₦30, 000 - 39, 000, ₦40, 000 - 49, 000, ₦50, 000 and above income groups respectively (Figure 4). Thus, 115 (49.152%) of the selected respondents in earn less than ₦20, 000 monthly.

Climate change intensifies inter-annual variability of rainfall which has been recognized as a serious limitation to agricultural sustainability (Kandji *et al*., 2006). In response to the stress posed by the unreliability of rainfall, farmers have employed irrigation where environmental conditions permit. The data for the selected settlements revealed that 118 (50.4%) of the respondents practice irrigation farming as adaptation strategy against climate change. Traditional irrigation which employs crude technology is prevalent due to the inability of the local farmers to afford modern irrigation technology. Irrigation as a climate change adaptation strategy is most practiced in Durbawa with a z-score of 0.98 while it is least adopted in Alkamu with z-score of -0.92. The adoption of irrigation as agricultural adaptation strategy to climate change is significantly different among the selected settlements in Sokoto State (χ^2 = 90.66, P<0.05). The uneven distribution of natural water bodies and dams were identified as the factors which influenced the significant difference of the use of irrigation as agricultural adaptation strategy. Adesina and Odekunle (2011) have therefore, stressed the importance to expand and enhance the efficiency of irrigation facilities to curtail or completely eradicate crop failures owing to drought and increased evaporation.

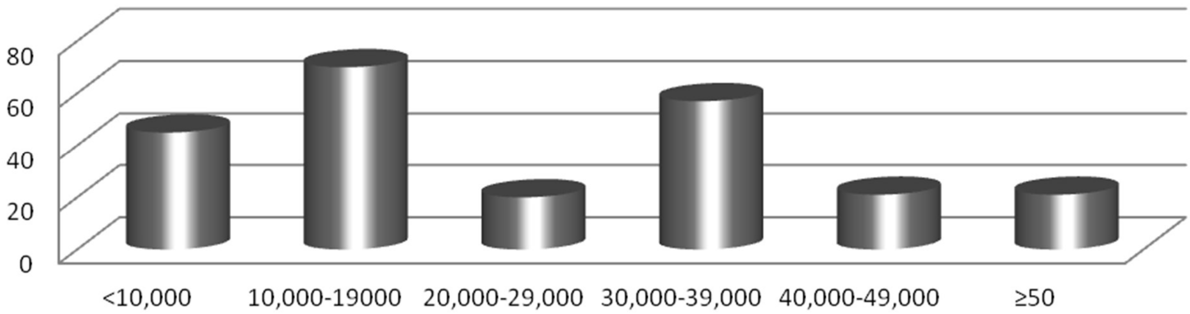

Figure 4: Monthly income (naira) distibution of the respondents
Source: Fieldwork, 2011/2012

Agricultural Adaptation Strategies to Climate Change

Due to erratic rainfall coupled with increasing temperatures in Sudano-sahelian belt of Nigeria, mulching is required to reduce the high evapo-transpiration from the soil (Ekpo and Nsa, 2011). Out of the selected respondents, 166 (70.9%) apply mulch to their seed beds as a climate change agricultural adaptation strategy. Crop residues, especially maize and guinea corn as well as grasses are predominantly applied to seedbeds after cultivation as a moisture preservation strategy. Dalhatu and Garba (2012) have also reported the popular use of crop residues such as maize and millet as mulch in Gusau which is located in the same eco-climatic belt with Sokoto. The data revealed that the application of much is most practiced in Sifawa with a z-score of 1.33 while it is least used in Sabon-Birnin and Alkamu each with a z-score of 0.46. The adoption of mulch is significantly different among the selected settlements (χ^2 = 29.74, P<0.05). The availability of crop residues and grasses may be responsible for the variations in the application of mulch as a strategy against climate change. Besides, settlements that are located in rocky terrains tend to have less grass cover.

The data on changing of planting date as agricultural adaptation strategy to climate change revealed that 224 (95.7%) of the selected respondents alter it based on prevailing climatic conditions. The strategy is most adopted in Sifawa, Bagarawa, Sabon-Birni, Alkamu, Nasarawa and Durbawa each with a z-score of 4.8 but least practiced in Kaura with a z-score of 3.35. The prevalence of alteration of planting date as agricultural adaptation strategy to climate change is significantly different among the selected settlements (χ^2 = 61.47, P<0.05). Since the strategy by the local farmers is a response to unreliable rainfall, improved weather forecast could help farmers to more accurately align their activities with prevailing climatic events rather than rely on foreknowledge (Mustapha *et al*., 2012).

Crops respond differently to climatic stress. Farmers recognize this and therefore cultivate different crops to prevent total loss in the event of extreme weather events. The cultivation of different crops is highly prevalent in the selected settlements with 226 (96.6%) of selected respondents practicing it while 8 (3.4%) engaged in specialize cropping. The cultivation of different crops is most practiced in Sifawa, Sabon-Birnin, Alkamu and Kaura each with a z-score of 5.39 while the strategy is least adopted in Bagarawa a z-score of 4.44. The cultivation of different crops is significantly different among the selected settlements ($\chi^2 = 19.19$, $P<0.05$).

The data on the cultivation of short duration crops as adaptation strategy against climate change revealed that 171 (73.1%) of the respondents practice it. The short duration crops include millets and cowpeas. Ajetumobi and Abiodun (2010) have attributed improved yield of cowpea to significant advances made by the International Institute of Tropical Agriculture (IITA). Out of the selected settlements, the cultivation of short duration crops is most practiced in Bagarawa and Durbawa each with a z-score of 1.59 while it is least practiced in Alkamu with a z-score of 0.45. The cultivation of short duration crop is however significantly different among the selected settlements ($\chi^2 = 29.25$, $P<0.05$). The high percentage of farmers who cultivate short duration crops agree with the findings of Odjugo (2010b) which reported a shift from the production of guinea corn which require high moisture to the cultivation of millet which requires less rainfall. Similarly, in a number of places where farmers formerly grew wet season rice, sorghum or millet are now planted due to the decreased floodwater (Yahaya, 2002)

While 189 (80.8%) of the respondents cultivate cover crops as agricultural adaptation strategy to climate change. The cultivation of cover crops among the selected settlements is most practiced in Sifawa and Bagarawa each with a z-score of 2.08 while it is least practiced in Alkamu with a z-score of 0.79. The planting of cover crops is significantly different among the selected settlements in ($\chi^2 = 55.31$, $P<0.05$). The high proportion of farmers who cultivate cover crops in the selected settlements shows that the farmers are aware of the advantages of cover crops as sources of nitrates to the soil as well as coverage to the soil.

One of the characteristics of the Sudano-sahelian savanna belt of Nigeria is unreliable rainfall. Apart from the late onset and early retreat of rainfall in the region, it is often plagued by drought of different intensities (Ati et al., 2010; Atedhor, 2013). In response to this trend, local farmers cultivate crops that are well adapted to the low moisture content of the soils as well as the high temperatures which in turn promote high evapo-transpiration. Our data therefore, reveal that 186 (79.5%) of the respondents cultivate drought resistant varieties. The large proportion of farmers who cultivate drought resistant varieties of crops agrees with Ajetumobi and Abiodun (2010) which reported improved average yield of cowpea due to the cultivation of drought resistant varieties. The strategy is most prevalent in Alkamu with a z-score of 1.98 while it is least practiced in Bagarawa with a z-score of 0.03. The cultivation of drought resistant crops is significantly different among the selected settlements ($\chi^2 = 29.79$, $P<0.05$).

The data show that 118 (50.4) of the selected respondents weed their farms frequently as a climate change adaptation strategy. Weeding farm more frequently is most prevalent in Alkamu with a z-score of 1.00 while it is least practiced in Sifawa with a z-score of -1.00. The agricultural attraction of floodplains because of their relatively wet conditions and their irrigational advantage, make most farmers to weed their farms frequently since the moist soils also favour the rapid growth of weeds. Weeding farm more frequently is significantly different among the selected settlements (χ^2 = 137.59, P<0.05).

The data revealed that 141 (59%) of the selected respondents combine farming with non-farm livelihoods as climate change agricultural adaptation strategy. The livelihood diversification strategy is most widespread in Durbawa with a z-score of 1.45 and 0.67 respectively while it is least practiced in Kaura with a z-score of -0.53 respectively. The combination of farming and non-farm livelihood is not significantly different among the selected settlements (χ^2 = 12.30, P > 0.05). The flourishing and widespread of petty trading, natural honey making, hunting, selling of firewood and artisan activities, especially during the dry season when most farming activities are impracticable in virtually all the settlements, account for the insignificant variation. According to Edo and Ikelegbe (2014), although farming is the primary livelihood amongst rural settlements in Nigeria, there are relatively few households with agriculture as the sole source of income.

Inaccessibility to credit facilities remains one of the most critical factors militating against agricultural expansion among small-scale farmers in Nigeria. Apart from the fact most financial institutions are domiciled in urban areas, often small-scale farmers are not able to meet up with the conditions for accessing loans in financial institutions. The loan terms which include provision of collateral and fluctuating interest rates hinged on inflation as well as bottle neck procedures are often beyond the local farmers. As Philip et al. (2008) noted these factors often disqualify majority of rural smallholder recipients. Out of the selected farmers, 18 (7.7%) use credit facilities as adaptation strategy against climate change. The use of credit facilities is most widespread in Bagarawa with a z-score of -2.19 while it is least prevalent in Kaura, Sabon-Birnin and Alkamu each with a z-score of -3.41. However, the adoption of credit facilities as climate change adaptation strategy reveal significant statistical difference among the selected settlements (χ^2 = 33.25, P<0.05).

The use of storage facilities as agricultural adaptation strategy to climate change reveals that 95 (40.6%) use it. Although modern storage facilities are beyond the reach of small-scale farmers, it important to note that local storage facilities, such as *rumbu* (see Plate 1), are used by the farmers to store grains especially during years of bumper harvests. Overall, farmers in Dingyadi use storage facilities most with a z-score of 0.22 while those in Kaura least use it with a z-score of -0.82. The use of storage facilities as agricultural adaptation to climate change is significantly different among the selected settlements (χ^2 = 35.12, P<0.05). Enobakhare (2012) has therefore identified post-harvest pests' attacks as a major drawback to agricultural production in Nigeria. The relatively low percentage of farmers who use storage facilities could further reduce the low yields occasioned by upsurge in unfavourable climatic conditions due to climate change.

Plate 1: Rumbu (a traditional storage facility for preserving grains in Sifawa)

The data reveal that only 26 (11.1%) of the respondents use insurance facilities. This shows that the use of insurance facilities is not popular among the local farmers. The concentration of insurance facilities in the urban centres, the high prevalence of illiteracy and low awareness among local farmers may be responsible the high number of farmers who do not use the strategy. The use of insurance as climate change adaptation strategy is most prevalent in Dingyadi with a z-score of 1.84 while it is least adopted in Bagarawa, Alkamu and Kaura each with a z-score of -2.78. The use of insurance facilities is significantly different (χ^2 = 19.62, P<0.05).

Table 2 shows that 132 (56.4%) rear hybrid livestock. Among the selected settlements, Sabon-Birnin and Alkamu favour this adaptation strategy most each with a z-score of 1.12 while Sifawa least adopted this strategy with a z-score of -0.6. The hybrid livestock reared by the local farmers include cattle and poultry. The rearing of hybrid livestock as an agricultural adaptation strategy against climate change is significantly different among the selected settlements (χ^2 = 122.78, P<0.05).

The Sudano-sahelian savanna belt of Nigeria where Sokoto State is located is characterized by relatively sparse vegetation cover compared to the more dense vegetation southward of the Sudano-sahelian belt. Apart from the sparse vegetation which does not favour accumulation of leaf litter, population pressure also hinders the practice of bush fallow. This, among other factors, makes bush fallow system of agriculture unpopular in Sokoto State. Consequently, 60 (25.6%) of the respondents subject their agricultural land to increased period of fallow. The negative z-scores in all the settlements, clearly show that the strategy is not popular although there is significantly different among the selected settlements (χ^2 = 49.84, P<0.05).

The study also reveals that 178 (76.1%) practice livestock diversification as agricultural adaptation strategy to climate change among the selected settlements. Alkamu practice livestock diversification most with a z-score of 1.83 while it is least practiced in Nasarawa with a z-score of 0.67. The livestock popularly raised by the farmers include cattle, sheep and goats. Livestock diversification as an adaptation strategy is significantly different among the selected settlements χ^2 = 37.11, P < 0.05).

The research shows that 175 (74.8%) of the respondents use pesticides regularly with the use of pesticides most practiced in Alkamu and Nasarawa each with a z-score of 1.70 while it is least practiced in Kaura with a z-score of 0.09. According to Oladipo (2010), climate change will trigger the incidence of pests in Nigeria while some species, like grasshoppers or other pests may increase in large quantity or variety. Studies have shown that the Semi-arid belt of Nigeria where Sokoto State is located is already besieged with repeated incidence of migratory pests such as grasshoppers (Omiunu, 1985; Evans and Mohieldeen, 2002). The increasing incidence of pests may have therefore accounted for the large proportion of farmers who use pesticides. The prevalence of the use of pesticides is significantly different among the selected settlements (χ^2 = 97.40, P<0.05).

The data revealed that only 15 (6.4%) use ICT (information and communication technology) as a climate change adaptation strategy. The strategy is most practiced in Durbawa with a z-score of -3.04 while Sifawa, Dingyadi, Alkamu, and Kaura least use ICT as climate change adaptation strategy each with a z-score of -3.76. However, the adoption of ICT is significantly different among the selected settlements (χ^2 = 28.15, P<0.05). ICT such as internet facilities is indispensible as it avail farmers the opportunity of acquainting themselves with the best coping options in the face of climate change stress. However, the low educational attainments of the farmers and the concentration most ICT facilities in urban centres may be responsible for the small proportion of farmers who use it as adaptation strategy against climate change.

The data reveal that 36 (15.4%) use government aids as climate change adaptation strategies and among the selected settlements, Bagarawa use government aids most with a z-score of -0.97 while Alkamu use government aids least with a z-score of -2.36. The use of government aids is significantly different among the selected settlements (χ^2 = 34.63, P<0.05). The presence of traditional rulers and political figures in some settlements were some of the reasons the farmers gave for the differential government aids received among settlements. The variations could also be attributed to the biasness of elected government officials to their electoral strongholds.

The data revealed that 105 (44.9%) of the selected respondents increase their farm sizes as a climate change adaptation strategy. Increase in farm size as a strategy is most practiced in Bagarawa with a z-score of 0.9 while it is least practiced in Sifawa with a z-score of -0.54. The adoption of increase in farm size is significantly different among the selected settlements (χ^2 = 26.80, P<0.05).

The data revealed that 205 (87.6%) apply fertilizer to their farmlands. The popular use of animal dung as measure is partly responsible for the high number of respondents who apply fertilizers to their farmlands among the selected respondents with the practice most adopted in Dingyadi, Bagarawa, and Alkamu each with a z-score of 2.67 while it is least

Table 2: Variations of Agricultural Adaptation Strategies among the Selected Settlements

Strategies	Frequency/Z-score	Sifawa	Dingyadi	Bagarawa	Sabon-Birnin	Alkamu	Nasarawa	Kaura	Durbawa	Total and % of respondents	Classification	Df	χ^2
	Frequency	38	12	5	15	0	21	6	21				
Irrigation	Z-score	0.32	-0.04	0.74	0.74	-0.92	0.16	0.8	0.98	118 (50.4)	Moderate	7	90.66*
	Frequency	55	23	5	9	27	26	5	16				
Mulching	Z-score	1.33	1.22	1.17	0.46	0.46	0.83	0.91	0.96	116 (49.6)	Moderate	7	29.74*
	Frequency	61	19	6	18	54	39	5	22				
Changing planting date	Z-score	4.8	3.3	4.8	4.8	4.8	4.8	3.35	4.8	224 (95.7)	High	7	61.47*
	Frequency	61	23	5	18	54	37	7	21				
Cultivating different crops	Z-score	5.39	4.56	4.44	5.39	5.39	5.11	5.39	5.11	226 (96.6)	High	7	19.19*
	Frequency	49	23	6	12	27	27	5	22				
Cultivating short duration crops	Z-score	1.14	1.25	1.59	0.84	0.45	0.89	0.93	1.59	171 (73.1)	High	7	29.25*
	Frequency	61	23	6	15	27	36	4	17				
Planting cover crops	Z-score	2.08	1.67	2.08	1.64	0.79	1.89	0.97	1.49	189 (80.8)	High	7	55.31*
	Frequency	43	23	2	15	54	26	5	18				
Cultivating drought resistant varieties	Z-score	1.25	1.6	0.3	1.55	1.98	1.15	1.25	1.5	186 (79.5)	High	7	29.79*
	Frequency	0	12	1	3	54	27	5	16				
Weeding farm more frequently	Z-score	-1	-0.12	-0.66	-0.66	1	0.38	0.42	0.46	118 (50.4)	Moderate	7	137.59*
	Frequency	39	15	4	12	27	27	1	16				
Combining farming with non-farm livelihood	Z-score	0.49	0.33	0.55	0.55	0.2	0.59	-0.53	0.67	141 (59)	Moderate	7	12.3
	Frequency	0	4	2	0	0	9	0	3				
Use of credit facilities	Z-score	-2.85	-2.85	-2.19	-3.41	-3.41	-2.56	-3.41	-2.89	18 (7.7)	Slight	7	33.25*
	Frequency	11	19	4	12	27	12	1	9				
Use of storage facilities	Z-score	-0.82	0.22	0.16	0.16	-0.18	-0.56	0.9	-0.36	95 (40.6)	Moderate	7	35.12*
	Frequency	6	8	0	3	0	5	0	4				
Use of insurance facilities	Z-score	-2.47	-1.84	-2.78	-2.25	-2.78	-2.38	-2.78	-2.22	26 (11.1)	Slight	7	19.62*
	Frequency	5	16	1	18	54	24	1	13				
Rearing hybrid livestock	Z-score	-0.72	0.3	-0.54	1.12	1.12	0.36	-0.6	0.3	132 (56.4)	Moderate	7	122.78*
	Frequency	12	11	0	0	27	0	0	10				
Increasing period of fallow	Z-score	-1.23	-0.75	-1.68	-1.68	-0.55	-1.68	-1.68	-0.66	60 (25.6)	Slight	7	49.84*
	Frequency	39	23	5	15	54	20	5	17				
Livestock diversification	Z-score	0.98	1.48	1.43	1.43	1.83	0.67	1.14	1.29	178 (76.1)	High	7	37.11*
	Frequency	21	23	30	12	54	39	20	20				
Use of pesticides	Z-score	0.2	1.36	0.95	0.95	1.7	1.7	0.09	1.5	175 (59.4)	Moderate	7	97.4*
	Frequency	0	0	1	3	0	7	0	4				
Use of ICT	Z-score	-3.76	-3.76	-3.08	-3.76	-3.76	-2.32	-3.76	-3.04	15 (6.4)	Slight	7	28.15*
	Frequency	6	11	3	6	0	6	1	3				
Government aids	Z-score	-2.08	-1.22	-0.97	-0.44	-2.36	-1.94	-1.97	-1.97	36 (15.4)	Slight	7	34.63*
	Frequency	17	15	6	12	27	12	2	14				
Increasing farm scale	Z-score	-0.54	0.02	0.9	0.24	-0.1	-0.48	-0.58	0.18	105 (44.9)	Moderate	7	26.8*
	Frequency	49	27	6	15	54	30	5	19				
Use of fertilizerss/animal dung	Z-score	2.06	2.67	2.67	2.15	2.67	1.97	1.79	2.24	205 (87.6)	High	7	21.42*
	Frequency	50	23	6	15	54	39	7	21				
Use of shelterbelts	Z-score	2.74	2.85	3.41	2.78	3.41	3.41	3.41	3.22	215 (91.9)	High	7	21.16*

* Significant at 0.05 confidence level, percentages in parentheses

practiced in Nasarawa with a z-score of 1.97. The use of fertilizers is significantly different among the selected settlements ($\chi^2 = 21.41$, $P<0.05$).
The data for the selected settlements revealed that 215 (91.9%) of the respondents use shelterbelts. Up to 50% increase in the yield of yield of millet under the influence of shelterbelts due to soil moisture at sowing and the effects of hot dry turbulent air generated by the shelterbelts have been reported in the semi-arid parts of Nigeria (Onyewotu *et al*., 1998). The beneficial attributes of shelterbelts must have been taken into cognizance by most of the local farmers over the years in Sokoto State. The use of shelterbelt is however most practiced in Alkamu, Nasarawa, Kaura and Bagarawa each with a z-score of 3.41 while it is least practiced in Sifawa with a z-score of 2.74. The analysis reveal that the use of shelterbelt is significantly different among the selected settlements ($\chi^2 = 21.61$, $P<0.05$).

Conclusion

The paper examined agricultural adaptation to climate change in Sokoto State, semi-arid belt of Nigeria. The findings revealed that with the exception of the combination of farming with non-farm livelihoods, the strategies revealed significant spatial variations. Out of the strategies investigated, mulching, changing plating date, cultivating different crops, cultivating short duration crops, planting cover crops, cultivating drought resistant varieties, use of fertilizers/animal dung, use of shelterbelts and livestock diversification are highly used, irrigation, weeding farm more frequently, combining farming with non-farm livelihoods, use of storage facilities, rearing hybrid livestock, increasing scale of farming and use of pesticides are moderately used while use of insurance facilities, increasing period of fallow, use of ICT, use of government aids and use of credit facilities are slightly used by the local farmers. The paper concludes that the agricultural adaptation strategies to climate change in Sokoto State vary significantly owing to the uneven spread of environmental and socio-economic resources. While some of these strategies are age long practices, their adoption is further reinforced by intensifying environmental stressors. It is recommended that complementary adaptation efforts should be place-specific taking into consideration the spatial unevenness of environmental and socio-economic challenges and opportunities.

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