ASSESSMENT OF FARMERS' PERCEPTION OF EFFECTIVENESS OF ADAPTATION STRATEGIES TO CLIMATE CHANGE IN NORTHWESTERN NIGERIA

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ABSTRACT

Climate change has become one of the most topical environmental issues in the world today. Agriculture in Nigeria is perhaps the most vulnerable sector to the effects of climate change. Studies have established that adaptation strategy is one of the key solutions to this challenge but how effective these adaptation strategies are in combating climate change needs to be continually analysed. The study therefore assesses the farmers' perception of effectiveness of adaptation strategies to climate change in North-western Nigeria. Multistage sampling technique was used for the study. Three out of the seven states of North-western Nigeria were selected systematically in the first stage. A total of seventeen (17) Local Government Areas were further systematically selected from the three (3) sampled states. Structured questionnaire was used for data collection. Seven hundred and eighty-four (784) smallholder farmers were purposively sampled for the study. The data collected were analysed using Likert Rating Scale and Relative Importance Index (RII). The results were presented using tables, percentages and charts. Results showed that significant number of farmers had a high perception that rainfall is becoming irregular (57.4%), crop infestation by pests is increasing (58.1%) and growth of pasture is dwindling (60.2%). Results further showed high effectiveness level of some adaptation strategies based on farmers' perception, some of the effective strategies are the use of organic/inorganic fertilisers (RII = 0.97), use of irrigation systems (RII = 0.92) and soil/water conservation (RII = 0.89). Based on the results, the study concludes that many adaptation strategies were significantly effective in helping farmers to cope with the impacts of climate change. The study therefore recommended that farmers should be given more capital in form of loans, grants and subsidies on farming inputs to cope adequately with the changing climate.

Key words: Adaptation strategy, Agriculture, Climate change, North-western Nigeria, Perception

INTRODUCTION

World over, climate change has become one of the greatest challenges threatening the existence of all living organisms. The phenomenon brings about changes in the weather patterns which pose serious environmental problems to man and the rest of the ecosystem. It upsets the seasonal cycles, hampers water supply, affects agriculture and farming systems as well as the general food production and causes sea levels to rise. Climate change has also caused floods, landslides, drought, famine, among many other challenges (Intergovernmental Panel on Climate Change

[IPCC], 2007). Although, all evidences have established a global impact of climate change, the effects are being felt more by developing countries, especially those in Africa (Nigeria inclusive) due to their poor social and economic capacity to cope adequately with the change (Oyekale, 2015).

Climate change has been defined by IPCC (2007), as a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that can persist for an extended period typically decade or longer. Climate change is caused by two major factors; the biophysical/biogeographical and human (anthropogenic) activities. The biogeographical factors are natural processes which include changes in the eccentricity of the earth's orbit, changes in the obliquity of the plane of ecliptic and changes in orbital procession while the human factors are urbanisation, population explosion, industrial development, widespread use of land, broad scale deforestation, major technological and socio-economic shifts with reduced reliance on organic fuel and accelerated uptake of fossil fuels (Odjugo, 2010).

Agricultural production is generally controlled by many factors including the genetic characteristics of crops and livestock, soils, climate, among others. Out of all these factors, agricultural production is mostly dependent upon climate particularly in developing countries. Any disruption to the climate will severely affect the agricultural system (Danbaba, 2007; Odjugo, 2010). The entire agricultural processes and food systems, such as soil and water resources, crop, livestock and poultry production, among others, are therefore, very sensitive to climate change (Antle, 2010). Nigeria (North-western region inclusive) as a developing country is plagued by myriad impacts of climate change on agricultural development (Farauta, Idowu, Egbule & Agu, 2011).

With the great challenges of climate change on agriculture, there is need to manage its impact either through mitigation or adaptation strategies. Adaptation strategy is the ability of a system to adjust to climate change (including climate variability and extremes), moderate potential damage, and take advantage of opportunities or cope with the consequences (IPCC, 2001). Studies have proven that climate change will continue to be problematic to agricultural production, unless appropriate adaptation measures are employed. With suitable adaptation strategies therefore, vulnerability of agriculture to climate change can be reduced greatly and numerous opportunities can be enhanced (Smit & Skinner, 2002). Several adaptation strategies to the impact of climate change on agriculture in the semi-arid region of Nigeria (including the North-western region), have been suggested by Adeshina & Adekunle, (2011) as provision of accurate and timely weather forecasting, enhancing agricultural extension services, expanding and optimising existing irrigation infrastructures, among others.

With increasing concern about the deepening effects of climate change on agriculture over the years, several studies have been carried-out about the impact, causes, effects and possible adaptation strategies to the problem in Nigeria (e.g. Abiodun & Olabimpe, 2007; Adefolalu, 2007; Jagtap, 2007; Nwafor, 2007; Ekpoh, 2010 and Ikpe, 2019). However, little or no attention have been paid to deeply study the effectiveness of the adaptation strategies in helping farmers cope adequately with the effects of climate change particularly in the North-western Nigeria. The interests of most of the previous studies were on establishing the numerous adaptation strategies employed by farmers with little attention on the most effective coping strategies applied for crop

production by farmers in the region. It is therefore imperative that empirical study is carried out to ascertain the effectiveness of adaptation strategies used by farmers in coping with the impacts of climate change which this study focuses on using North-western Nigeria as a case study. This will be achieved by examining the effects of climate change in North-western Nigeria and assessing farmers' perception of the effectiveness of adaptation strategies to climate change in the study area.

THE STUDY AREA

The study area which is North-western Nigeria is located between Latitudes 9°N and 14°N as well as Longitude 4°E and 10°E. The area consists of seven (7) states of the Federal Republic of Nigeria which are Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara states. To the north, the area is bounded by Niger Republic, to the south by Niger state and Federal Capital Territory, to the west by Benin Republic and to the east the area is bounded by Plateau, Bauchi and Yobe states (Figure 1).

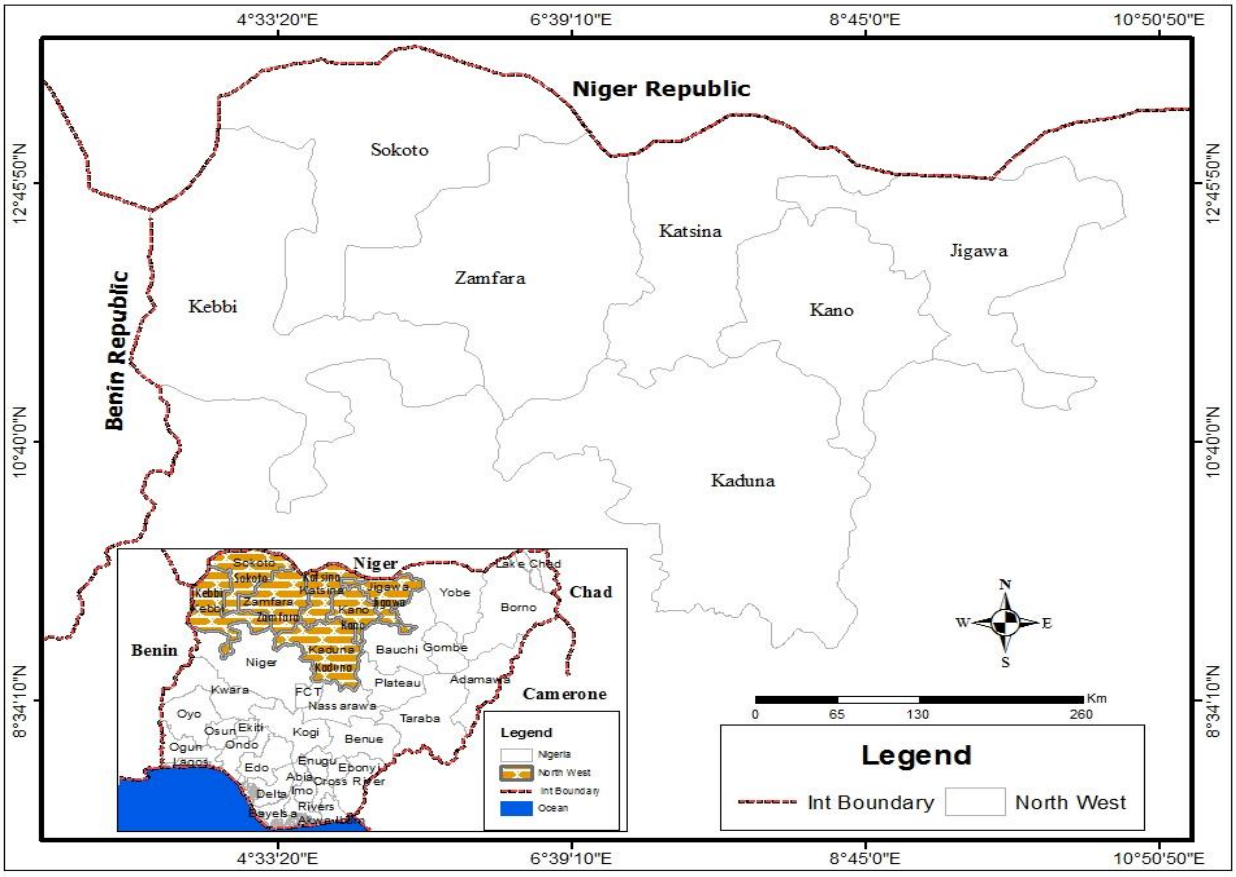

Figure 1: North-western Nigeria: The Study Area
Source: Adopted and Modified from Nigerian Administrative Map, 2021

The climate of the north-western Nigeria is generally tropical continental (tropical wet and dry) represented by Aw and Bs based on W. Koppen's classification (Eltantawi, 2011). The area is hot for most of the year with some months just before the rainy season recording temperatures up to 30°C or more. The general pattern of rain is mainly affected by two principal air masses which are

Tropical Continental (cT) and Tropical Maritime (mT) air masses (Ati & Sawa, 2018). North-western Nigeria is generally located on the high plains of Hausa land (Udo, 1970). Many rivers flow through the study area which includes the Sokoto, Koza, Sabke, Kaduna, among others (Abdullahi, 2016).

The soils of the area are ferruginous in nature in the southern part and sandy (semi-arid) soils at the extreme northern part (Emielu, 2010). The vegetation usually follows the pattern of climatic characteristics. The true Sudan savannah is found in the south and the tropical grasslands of the Sahel in the extreme north of the study area. The population of North-western states of Nigeria based on the 1991 population census was 22, 913, 412 (NPC, 1991) and the 2020 projected population of the area was 46, 010, 131 (National Bureau of Statistics, 2020). The predominant socio-economic activities in the North-western Nigeria are farming, livestock production and marketing of agricultural products with little local crafts (Emielu, 2010).

MATERIALS AND METHODS

In order to achieve the stated objectives, quantitative data was collected with the use of a structured questionnaire. Multistage sampling technique which according to Sedwick (2015), is a process of taking samples in stages using smaller sampling units at each stage was used in the study. In the first stage, systematic sampling technique which according to Ken (2010), is a method where elements are selected from ordered sampling frame and where the first sample is taken at random was employed. The study therefore, arranged the seven (7) states of North-western Nigeria in alphabetical order and selected every second state as a sample (Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara states). In this case, Kaduna, Katsina and Sokoto formed the sampled states. In the second stage, systematic sampling technique was also used to select every 4th Local Government Areas (LGAs) from the three sampled states using senatorial districts of each state. In the third stage, systematic sampling technique was used to select every 4th wards from the sampled LGAs. In the fourth stage, purposive sampling technique was used to select respondents from the sampled wards. Farmers above thirty (30) years of age who must have lived for at least twenty (20) years within the study area were purposively used for the study.

The 1991 census data which provide population figures for localities were used to determine the sample size and number of respondents used for each wards in the study. According to NPC (1991), the study area had a total population of 22,913,412 with annual growth rate of 2.60% (World Population Review, 2020). Therefore, the projected population of the study area at 2020 was 46,010,131. Sample size was based on Krejcie and Morgan's (1970) table which stated that where a population range is between 10,000,000 to 100,000,000, the sample size to use is 784 at 95% confidence level and 3.5 Margin of Error. Therefore, since the total population of the study area (46,010,131) falls within this range, the sample size of 784 was adequate for this study.

Out of the 784 copies of the questionnaire administered, 744 copies (95%) were retrieved and analysed using percentages, frequencies and charts. The various strategies used by farmers in coping with the effects of climate change were assessed and ranked in terms of the level of their effectiveness as perceived by the respondents using Relative Importance Index (RII). The formula for determining RII as provided by Muhwezi and Otim (2014) is given as: $\Sigma W / (A*N)$, where:

W= Weight given to each factor as perceived by the respondents,
A = Highest weight,

N = the total number of respondents.

The higher the value of RII, the higher would be the degree of effectiveness of a given adaptation strategy to climate change in the study area. The RII values were interpreted using the degree of significance or effectiveness provided by Vanduhe (2012) as; Very Significant (0.76 and above), significant (0.67 to 0.75), Fairly Significant (0.45 to 0.66) and Not Significant (0.44 and below).

RESULTS AND DISCUSSIONS

Table 1 shows that majority (75.7%) of the respondents were males and the females were only 24.3%. This implies that farming in the study area was dominated by males. This may be due to restriction of females to carry out some occupational activities including farming which requires hard physical labour in northern Nigeria. The Table also shows that all the respondents were qualified to give information on the nature of climate change based on their age. The results show that majority of the respondents represented by 47.4% were between the ages of 41 – 50 years, followed by those within the age of 30 – 40 years (30.9%).

Table 1: Socio-economic/demographic Characteristics of the Respondents

Parameters	Options	Percentages (%)
Gender	Males	75.7
	Females	24.3
Age	30 – 40 years	30.9
	41 – 50 years	47.4
	51 – 60 years	13.3
	61 – 70 years	6.2
	71 years and above	2.1
Years of Residence	30 – 40 years	25.7
	41 – 50 years	53.2
	51 years and above	21.1

Source: Field Survey, 2020

Table 1 further shows that majority (53.2%) of the respondents had stayed in the study area for 41 – 50 years, followed by those that had stayed for 30 – 40 years (25.7%) and those that stayed for more than 51 years were represented by 21.1%. This implies that farmers were experienced enough to give relevant information as they have lived for at least 30 years with the study environment.

Based on Table 2, it is clear that majority (27.6% and 29.8%) of the respondents agreed and strongly agreed respectively that rainfall is becoming irregular in recent times, 20.6% and 13% disagreed and strongly disagreed respectively on this while 9% had a neutral opinion. This connotes that farmers perceived irregularity of rainfall in the study area and may affect farmers' planning and operations within a particular agricultural year. The Table also shows that 19.2% and 40.7% of the respondents strongly agreed and agreed respectively that flood disasters have been destroying crops in the study area, 18.1% and 9.0% disagreed and strongly disagreed respectively on this while 12.9% of the respondents had a neutral opinion on this. This also means that flood disaster was one of the major effects of climate change on agricultural production as perceived by farmers. The Table further showed that 19.2% and 10.5% strongly agreed and agreed respectively that drought occurrences were increasing while 17.9% and 36.3% strongly disagreed and disagreed respectively on this while 16% were indifferent on the issue. This signifies that majority of the farmers in the study area disagreed that drought occurrences were increasing.

Table 2: Farmers' Perception of the effects of Climate Change in the Study Area

Climate Change Indices	SA (%)	A (%)	I (%)	D (%)	SD (%)
Rainfall has become very irregular recently	27.6	29.8	9.0	20.6	13
Flood disasters destroy crops in this area	19.2	40.7	12.9	18.1	9
Drought occurrences are also increasing	19.2	10.5	16	17.9	36.3
Climate change led to drying of rivers/wells	21.6	41	12.6	15.3	9.4
Climate change causes crop infestation by pests	16.4	41.7	16.1	15.7	10.1
Climate change led to shift in crop(s) cultivated	17.3	40.7	16.9	16.1	8.9
Climate change affects the growth of pasture	17.9	42.3	12.2	19.9	7.7

Source: Field Survey, 2020

Table 2 also indicates that 21.6% and 41% strongly agreed and agreed respectively that climate change has caused the drying of rivers and wells thereby leading to water shortages while 15.3% and 9.4% disagreed and strongly disagreed respectively on this. This means that farmers in the study area perceived the drying up of rivers, lakes and wells easily in the dry season thereby affecting agricultural production and humans as well as animals' water consumption.

Table 2 also shows that 16.4% and 41.7% strongly agreed and agreed respectively that climate change has led to crop infestation by pests, 15.7% and 10.1% disagreed and strongly disagreed respectively on this while 16.1% had a neutral view on the issue. This signifies that many farmers in the study area are aware that climate change causes crop infestation by pests and diseases. Crop pests such as grub worm in many parts of Kaduna State has been seriously destroying sugarcane farms, another example is an insect that farmers in Katsina and some parts of Kaduna state like Zaria called *Sharon* which destroys chili pepper, tomato, and other perishable goods.

It is observed based on Table 2, that majority (17.3% and 40.7%) of the respondents strongly agreed and agreed respectively that climate change leads to shift in crops cultivated in the study area, 16.1% and 8.9% disagreed and strongly disagreed respectively on this while 16.9% were indifferent. This implies that farmers in the study area have been changing the crops they cultivate as a result of the effects posed by climate change. Farmers in Igabi Local Government of Kaduna state for instance have significantly changed production from yam to sweet potato while most farmers across the study area especially those in Katsina and Sokoto states have changed the maize

variety they cultivate with an improved early maturing variety due to the shift in the nature of rainfall. The Table also shows that 17.9% and 42.3% of the respondents strongly agreed and agreed respectively that climate change affects the growth of pasture while 19.9% and 7.7% disagreed and strongly disagreed respectively on this. This means that the growth of pasture for animals was strongly affected by climate change.

From Table 3, the use of organic and inorganic fertilizer was ranked as the most effective adaptation strategy to the effects of climate change in the study area. The strategy has the highest Relative Importance Index (RII) value of 0.97 which was rated based on the degree of effectiveness by Vanduhe (2012) as very significant. As farmers realised the continuous inability of their soils to hold moisture due to high evaporation, the use of manure has become one of the simple solutions. Farmers in areas such as Zangon Kataf and Kagarko in Kaduna state have been using chicken and human faeces while other areas such as Mai'adua and Faskari in Katsina state as well as Wurno, Shagari and Illela of Sokoto state respectively uses cattle dung and human faeces (*Turoso*) as manure in their farms. This helps a lot as it gives the ability to soils to hold moisture especially during dry spells. The second most effective adaptation strategy as perceived by the respondents is the use of irrigation. The irrigation method which is the artificial application of water into farmlands was considered very effective by the farmers with an RII value of 0.92 which means very significant based on the scale of measurement.

Table 3: Farmers' Perception of Effectiveness of Adaptation Strategies to Climate Change

Adaptation Strategies	HE	ME	LE	RII	RANK
Application of weather early information	347	349	48	0.84	4
Soil/water conservation	615	32	97	0.89	3
Use of organic/inorganic fertilizer	697	34	13	0.97	1
Use of early maturing crop varieties	309	313	122	0.75	9
Planting cover crops	272	257	213	0.69	11
Use of irrigation systems	633	54	57	0.92	2
Use of drought resistant crop varieties	327	329	87	0.77	8
Changing the timing for planting	357	323	64	0.80	6
Use of recommended crops	423	207	114	0.81	5
Changing harvesting dates	211	156	377	0.59	13
Out migration from climate risk areas	248	171	325	0.48	15
Access agricultural loans, grants and subsidies	126	230	388	0.55	14
Planting pests/disease resistant crops	309	242	193	0.72	10
Build water harvesting scheme	123	544	77	0.69	11
Diversification of livestock types and varieties	372	308	64	0.80	6

Source: Field Survey, 2020

The third most effective adaptation strategy to climate change in the study area as shown in Table 3 is soil and water conservation. The main reason why soils are conserved is to protect the land and the soils from erosion and preserve the soil nutrients on the land which has suffered from excessive farming and/or damaged by the effects of climate change. Water conservation on the other hand, is the ability of humans to store water and make use of it at the time of scarcity. Based on Table 3, the RII value of 0.89 implies that there is very significant level of effectiveness of soil and water conservation on climate change adaptation in the study area. Some soil conservation

practices carried-out by farmers are the use of cover crops like beans as in the case of Sokoto and Katsina states, the zero-tillage system in some parts of Kaduna state as well as the application of domestic wastes in all parts of the study area. As in the case of water conservation, many small earth dams were constructed across the study area. An example is found in Zaria of Kaduna state, Illela of Sokoto state and where these dams are not constructed farmers use bags filled with sand to block small streams and rivers towards the end of the rainy season for use during the prolonged dry season.

Weather early warning information (*hasashen yanayi*) is broadcasted especially through radio in this area. For instance, forecast information on the total amount of rainfall (daily and seasonal), nature of temperature, warnings for occurrence of floods, heat wave, dry spell among others are frequently provided to farmers. The application of weather early warnings is therefore the 4th most effective adaptation strategy to climate change perceived by the respondents based on Table 3. The Table shows that application of weather early warnings has an RII value of 0.84 which also implies that it is highly effective in helping farmers to cope with the effects of climate change in the study area. The 5th most effective adaptation strategy to climate change based on the Table is the use of recommended crops. The Table shows that the strategy has an RII value of 0.81 which indicates that it is very significant in helping farmers cope with the effects of climate change. Farmers are usually advised by experts either directly by extension agents or through the media (radio) to use early maturing crops varieties like improved maize, millet, sorghum, beans, and so on.

The 6th most effective adaptation strategies as perceived by the respondents were changing the timing for planting and diversification of livestock types and varieties. Farmers in this region were initially into local livestock production such as rearing of local poultry, cattle, sheep, goats and so on, but recently farmers are gradually taking modern poultry, fish farming as an important business too. These strategies had an RII value of 0.80 which is also very significant based on the scale of measuring effectiveness of adaptation strategies in this study. Table 3 further shows that the use of drought resistant crop varieties was perceived by the respondents as the 8th most effective adaptation strategy to climate change in the study area. The RII value of 0.77 implies that the use of drought resistant crop varieties such as the new improved maize and rice (UPIA1, UPIA2 and UPIA3) among others has very significant positive effects on farmers' adaptation efforts to climate change. The local crop varieties such as millet, sorghum and beans are cultivated in areas like Wurno, Mai'adua, and other semi-desert regions of the study area.

The use of early maturing crop varieties like maize, cowpea, soybean among others, is shown in Table 3 as the 9th most effective adaptation strategy to climate change as perceived by the respondents in the study area. The RII value of 0.75 implies that the use of early maturing crop varieties is significant in helping farmers to cope with the effects of climate change. The Table also shows that planting pests and diseases resistant crop varieties such as the improved and treated maize, cowpea, sorghum and so on, is the 10th most effective adaptation strategy to climate change as perceived by the respondents. The RII value of 0.72 connotes that the use of resistant crop varieties is significant in helping farmers to cope with the effects of climate change in the study area. Table 3 further shows that planting cover crops and building of water harvesting scheme were ranked as the 11th most effective adaptation strategies to the effects of climate change in the study area. The RII value of 0.69 indicates that these strategies are significant in helping farmers to cope with the effects of climate change as perceived by the respondents. One local example of how

farmers harvest water is the use of available fits such as those left by road construction companies, mining companies, among others, as a water reservoir for use at the time of need.

Other fairly significant adaptation strategies to climate change in the study area include: changing harvesting dates with an RII value of 0.59, accessing agricultural loans, grants and subsidies with an RII value of 0.55 and out migration from climate risk areas with an RII value of 0.48. The increasing nature of desert encroachment exacerbated by the effects of climate change especially on the frontline areas such as Illela, Zangon Daura and Mai'adua forces people especially farmers to migrate toward the southern part of the country in search of more fertile and moisture-laden lands for agricultural purposes. Based on the result, it is now established that there are many adaptation strategies which are significantly effective in aiding farmers' coping capabilities to climate change effects in the study area.

CONCLUSION

Studies have established that climate change poses a great menace to agricultural productivity especially in developing countries like Nigeria. Studies have also proved that one of the important solutions to these challenges is the application of adaptation strategies. Several adaptation strategies have been reportedly used by farmers especially in the Semi-Arid region of Nigeria where most of the North-western part is located. The study therefore assessed the farmers' perception of the effectiveness of adaptation strategies to climate change in some selected states of North-western Nigeria. Based on the results of this study, it is concluded that there are significant effects of climate change as perceived by farmers among which include irregularity in rainfall distribution, intensity and duration, flood disasters destroying crops, effects on human and animals' health and drying up of river/wells. Others are crop infestation by pests and diseases, poor growth of pasture for animals' consumption, and so on. It is also concluded that, farmers were using many coping strategies to manage the impacts of climate change in the study area; however, the most effective among them were the use of organic/inorganic fertilizers, the use of irrigation systems, changing planting dates and the application of weather early warnings.

However, despite the significant application of some key adaptation options, farmers are still using primitive and traditional methods in coping with the serious effects of climate change in the region. Against this backdrop, there is need for concerted efforts by farmers, governments as well as other relevant and concerned individuals and institutions in raising the awareness as well as providing more improved adaptation strategies which can be achieved through the following:

i. In order to improve the awareness of the effects and controlling mechanisms of climate change among farmers, there is need for government at all levels to pursue serious public enlightenment campaigns on climate change especially with the use of radio which is known to be popular among farmers in this area and in recent times, the social media. Public, private, religious, and traditional institutions should be trained adequately on how to manage climate change locally especially through tree planting which is one of the most important absorber of carbon dioxide (carbon sequestration).
ii. Adequate capital outlay will significantly help farmers to cope with the effects of climate change in the study area. There is therefore the need for farmers to have access to loans, grants and subsidies on farming inputs from the government or other concerned individuals.

iii. There is need for improvement in the water harvesting technique used by farmers in the study area. The government and other concerned individuals should provide a modern water harvesting facilities especially for people in the semi-desert region of the study area.

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