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Research Paper

Rice Farmers' Adaptation Strategies to Climate Change in Minna and Environs, Nigeria

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Rice production in Minna and Nigeria at large is largely rain-fed, which implies that it depends completely on the weather and all the uncertainties that arise as a result of the changing climate. Climate change threatens the production of rice in Minna like it does to every aspect of agriculture in Nigeria. With the current Federal Government ban on the importation of rice to the country through land border and the ever increasing demand for the product, it is necessary for farmers to find most appropriate ways to adapt to the impact of climate change to ensure sustainable production. It is against this background that this study was restricted to determining the perceived causes of climate change and adaptation strategies among rice farmers in some selected rice producing settlements in Minna environs including Chanchaga, Garatu, Birgi and Beji because they produce larger amount of rice than the other settlements in Minna. Simple linear regression was used to analyze a 30 years (1986-2015) climatic parameters data including rainfall and temperature data to understand the changes that have taken place over the years. In addition to the secondary data, a structured questionnaire was used to gather information on adaptation strategies from the respondents. The study shows that the distribution of rainfall and temperature in the study area has not been uniform. They vary from one month to another and annually. The study also revealed that the farmers were using modern adaptation options such as planting early maturing seeds (93%) and the application of herbicides (96%) to complement indigenous adaptation strategies such as seeking divine intervention (75%) and changing planting dates (72%). Lack of adequate knowledge on how to adapt was the biggest challenge the farmers were facing in trying adapt to climate change. It is recommended that government at all levels should improve in the dissemination of information to the farmers by improving the capacity of the extension workers with better understanding of climate change and adaptation options. Their coverage area should also be widened so as to reach more rice farmers.

Key words: Climate change, adaptation strategies, rice farmers, environs, sustainable production

INTRODUCTION

Climate change as defined by the Intergovernmental Panel on Climate Change (IPCC, 2007) is the statistically significant variations that persist for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature. Change is an inherent attribute of climate, which is caused by both human activities (anthropogenic) and natural processes (biogeographical) (Odjugo, 2009). Climate change may occur in a number of ways including: changes in average climatic conditions with some regions becoming drier or wetter on average; changes in climate variability with rainfall events becoming more erratic in some regions; changes in the frequency and magnitude of extreme weather events such as flooding and changes in sea levels.

Climate change is already affecting people, their livelihoods and ecosystems and presents a great developmental challenges for the global community in general and for the poor people in developing countries in particular (Khanal, 2009). Literatures have shown that for the past decades, anthropogenic factors like urbanization, deforestation, population explosion, industrialization and the release of greenhouse gases (GHGs) are the major contributing factors to the depletion of the ozone layer and its associated global warming and climate change (Odjugo, 2009). For example, unsustainable industrialization, which releases greenhouse gases (GHGs), is viewed as the main cause (Odjugo, 2009). In Nigeria, due to the changing nature of climate, some areas like the Niger Delta regions receive more than normal rainfall, while other areas in the Northern region receive less rainfall. As a result, growing season is changing, ecological zones are shifting, and rainfall is becoming more unpredictable and unreliable both in its timing and volume (Brett, 2009).

Climate change impacts are felt on various sectors such as agricultural production, biodiversity, health, social and economic conditions. Climate change impacts affects people and the environment in general. This phenomenon is predicted to worsen drought and desertification incidences with millions of people becoming refugees as a result.

Climate change concern is heightened due to its linkage to the agricultural sector and poverty. The agricultural sector of Nigeria is the main source of food and employer of labour, employing about 60-70 per cent of the population. It is a significant sector of the economy and the source of raw materials used in the processing industries as well as a source of foreign exchange earnings for the country (Muhammad-Lawal and Atte, 2006). Adverse impact on the agricultural sector is expected to worsen the problem of rural poverty. Impacts on poverty are likely to be especially severe in developing countries like Nigeria where agriculture is rain fed and the agricultural sector is an important source of livelihood for a majority of the rural population (Farauta et al., 2011). Scientific literatures predict that in the next decade, high temperatures and variations in rainfall intensities will be witnessed around the globe, which will ultimately lead to low agricultural input (Apata, 2010). Food production system will be adversely affected by the variability in timing and amount of rainfall, frequent outbreaks of crop pests and diseases and heat stress. Johnston et al. (2009) stated that local farmers are concerned about variations in weather due to its impact on food security, availability, stability, accessibility and utilization. The change in weather affects livestock, forestry, fishery and the decreases aquatic plant species including rice.

Rice, which is the probably world's most important crop for ensuring food security and addressing poverty, will be drastically affected as temperatures increase in rice-growing areas (Gumm, 2010). Currently, Nigeria's annual demand for rice is estimated at 5.0 million tons, while production level is 3.0 million tones resulting in 2.0 million tones deficit (Mohammed et al., 2015). Rice yield growth rate during the past 25 years have already cut by 10-20 percent in several locations due to rising temperature (Gumm, 2010). Loss in rice production over the next few decades as days get hotter are expected unless there is a change in the rice production methods or new rice strains that can withstand higher temperatures are developed.

According to Johnston et al. (2009) it is important to build resilient communities that are able to deal with unforeseen changes due to the uncertainties associated with the rate and timing of climate change. Capacity to adapt to climate change is very closely linked to socioeconomic factors, such as poverty, diversification of income sources, level of education, and access to infrastructure and technology. The authors added that the promotion of a broad-based agricultural development that has the capacity of lifting rural communities out of poverty is certainly the most effective adaptation strategy available. Maharjan et al. (2011) opined that efforts to adapt to the impacts of climate change in Nigeria have remained rudimentary especially when compared with the impending threat. Unless appropriate adaptation measures are adopted, climate change will frustrate farmers' efforts to achieve sustainable agricultural production and food security. However, in other to understand such strategies, information from the farmers will be required since the ability to adapt and cope with climate change depends on their knowledge, skills, experiences and other socio economic factors. It is against this background that this study seeks to identify the rice farmers' response and adaptation to the problem in the study area.

The study area

Minna, the capital of Niger state is located in the middle belt region of Nigeria. It lies between latitude 09°61', 09°37' north of the equator and longitude 06°56', 06°32' east of the Greenwich meridian. The town shares boundary with the Federal Capital Territory from the north-west direction (Figure 1). The town became a major collection point for agricultural product in 1915 following the extension of the Lagos-Jebba rail line which attracted investment and people (Mohammed et al., 2015).

The population of Minna was 201,429 (105,803 males and 95,626 females) at the 2006 population census. The projected population of Minna in 2015 at growth rate of 2.85% is 259,642 (National Population Census, 2006).

The highest monthly average temperature is in March at 30.20°C and lowest in September at 24.90°C (Climate-Chart.com, 2016). Temperature varies within the region

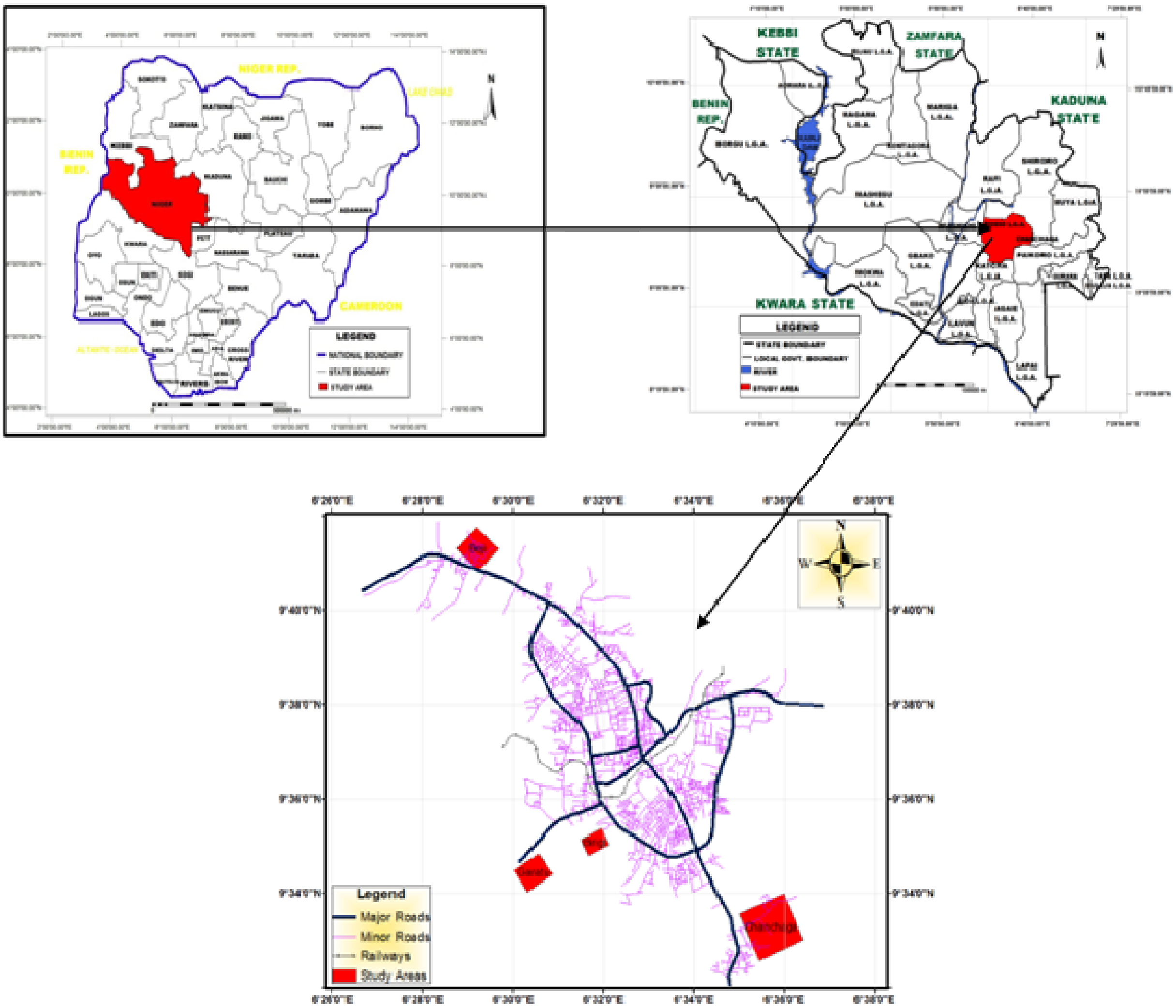

Figure 1. Location of the study area (Minna, Niger State, Nigeria). Source: Niger State Ministry of Land and Survey, 2017.

annually, with the dry season having low temperatures because the sun is at the southern hemisphere. Thus minimum temperatures of below 30°C are recorded during the harmattan period, which is late December and January in the following year, and its maximum temperature often do not exceed 42°C.

Rainfall in the study area usually begins by mid-April and ends in October. The annual rainfall received is usually below 1000 mm in the wet season. Maximum precipitation is usually recorded between the month of June and October (Climate-Chart.com, 2016). Highest relative humidity for Minna is 73% in the month of August, while lowest is 21% in the month of February. The annual mean humidity is 46.83%. During the wet season (May to October), relative humidity is usually high and low during dry season (November to April) (Climate-Chart.com, 2016).

The soil types in Niger State are two: Ku soil and Ya soil. The Ku soil has little erosion hazards, while the Ya soil has better water holding capacity. It is characterized by sand-loamy nature that supports arable farming. The savannah region is characterized by tall grassland which is the city’s common vegetation. Trees are found around regions near river valleys (Mohammed et al., 2015).

MATERIALS AND METHODS

This research employed the use of both primary and secondary sources of data. This is to ensure the study

Table 1. Sample size.

Cell	Number of Registered Rice Farmers	Sample size (40%)
Beji	151	51
Birgi	79	74
Chanchaga	127	60
Garatu	186	32
Total	543	217

Source: Agricultural Development Programme (ADP), 2017.

adequately achieve its aim. Primary data used include structured questionnaires, acquisition of study areas coordinate points, and physical observations during field survey. The questionnaires were administered to 40% of each of the four purposively selected rice farming settlements through a multi-stage sampling procedure. The communities include Chanchaga, Garatu, Birgi and Beji because they produce larger amount of rice than the other settlements in Minna (Table 1). The secondary data used is the climatic parameters data including rainfall and temperature data of Minna for a period of thirty years (1986-2015) was acquired from NIMET. These climatic data are important in the production of rice as they determine its yield in the study area (Table 1).

Method of data analysis

Climatic data including rainfall and temperature data acquired from NIMET was analyzed using simple linear regression to calculate the mean rainfall and temperature for 30 years and a time series analysis to determine their variation over the years. The linear regression equation has the form:

$$Y = a + bX$$

Where:
Y = dependent variable (rainfall, temperature)
X = independent variable (years)
b = slope of the line
a = y- intercept

The statistical package for social sciences, (SPSS), was used to analyze quantitative data acquired through questionnaire administration. The packages enabled the generation of descriptive statistics such as figures and frequency tables and percentages. The results were presented in tables and figures.

RESULTS AND DISCUSSION

Trend in climatic parameters (rainfall and temperature) in the study area

Over the years, annual rainfall distribution in the study area has not been uniform. This is evident in (Figure 2) showing the variability that characterized annual rainfall distribution in the study area over a 30 years period (1986-2015). The highest rainfall, as shown in (Figure 2) was recorded in 2012 with a total of 1540.4 mm, while the lowest rainfall recorded was and 1987 with a total of 823.4mm. Extreme values were recorded in 1987 and 2012 at 823.4 mm and 1540.4 mm respectively. In 1987, low rainfall recorded which could be an indication inadequate precipitation. This gives substance to Ndaki, (2014) where it was found out that 2012 recorded a very high rainfall which explains the flood related disaster recorded in many parts of Nigeria that year including Niger state.

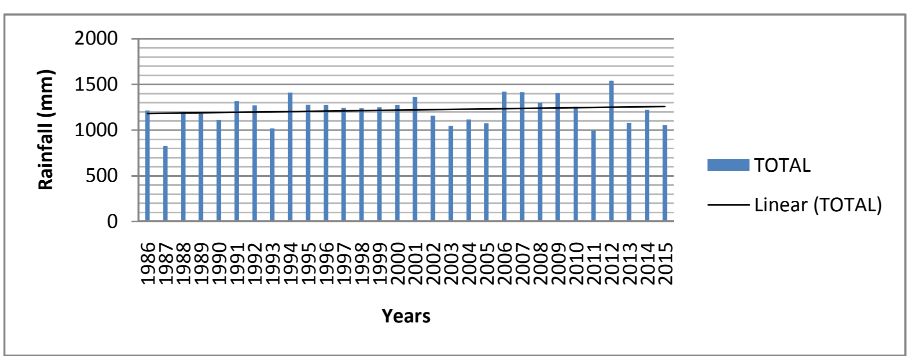

Figure 2. Trend in Annual Rainfall Distribution in Minna (1986-2015). Source: Author's Field Analysis, 2017.

Climate change is already affecting the agricultural sector and food production in the country as a result of more frequent and intense drought or floods (Ndaki, 2014). As shown in (Figure 2), the trend line shows an increase in rainfall with variation between the years at 1% (R^2 = 0.0103). This is an indication of an expected increase in rainfall amount in the future. Although rice crop needs an ample amount of rainfall, high and extended rainfall may lead to flooding of rice farmlands which is detrimental to the crop. The study area however receives an average, evenly spread rainfall of between 1200 and 1600 mm annually. But since the rainfall is not equally distributed monthly, it is possible to witness the flooding of rice farms in some particular months such as August in the years where high rainfall was recorded.

Figure 3 shows the mean monthly rainfall variation in the study area. Rainfall in the study area usually begins between February and April with a very little downpour once or twice a month. By May, study area begins to witness a more ample rainfall. However, the months with the highest rainfall amount are August, September and October with a mean rainfall 8373.2 mm, 10876 mm and 9351.8 mm respectively. Since rice farming in the study area is largely dependent on rainfall, these months may be the most suitable for farming in the study area. By November, rainfall has subsided and, in December, the study area hardly witnessed a drop of rainfall. By indication, rice farming may not be possible within these months except with the adoption of water harvesting.

Figure 4 shows the mean monthly temperature variation in the study area from 1986-2015. Temperature varies from one season to another. The month with the highest temperature is March with temperature reaching 37.86°C. However, temperature seems to begin to drop in the months of April (36.46°C) when the study area begins to witness rainfall. As indicated in (Figure 4),temperature continue to go down up to the month of August (29.0°C), obviously as a result of the significant amount of downpour witnessed in the month. It's important to note that rice farming in the study area usually begin between July and August. However, after the significant drop in temperature in August, the temperature begins to rise again in September (30.2°C), October (31.95°C) and rises up to 34.33°C by December. Which is an increase amounting to about 2°C between August and October. The implication of this is that rice

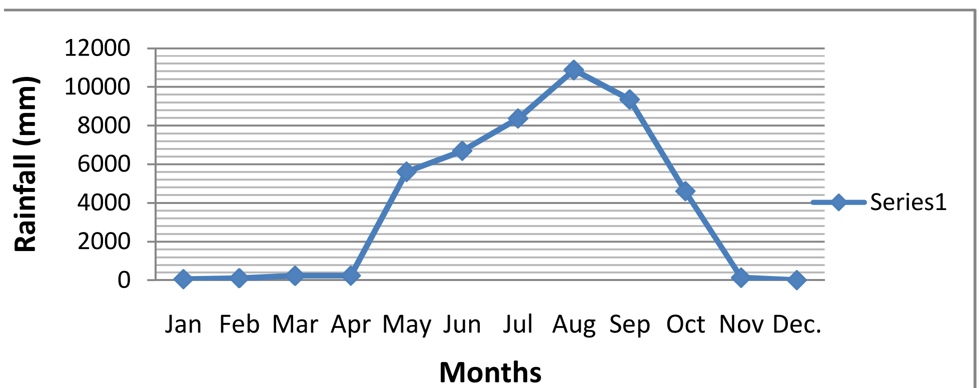

Figure 3. Mean Monthly rainfall variation in Minna (1986-2015). Source: Author's Field Analysis, 2017.

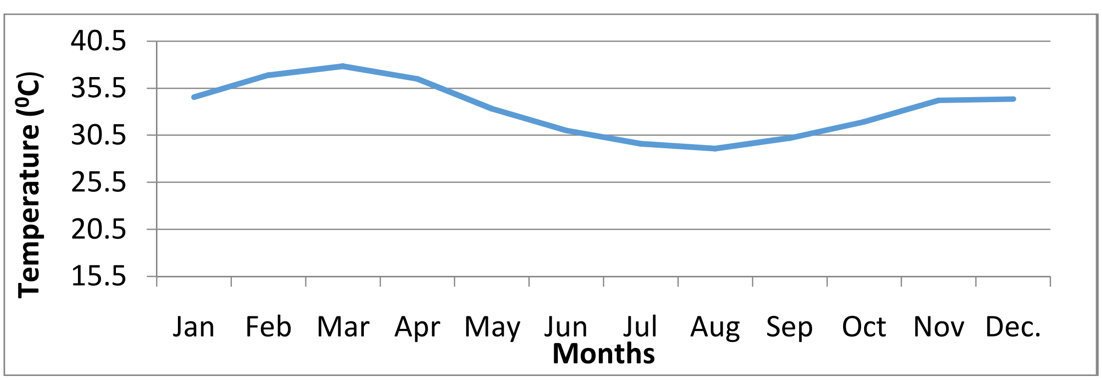

Figure 4. Mean monthly temperature variation in Minna (1986-2015). Source: Author's Field Analysis, 2017.

production is exhausted by 10% when minimum temperature increases by 1°C (Peng et al*.,* 2014).

Indigenous adaptation strategies used by rice farmers in the study area

Farmers have always used their experience to adapt to and mitigate the impact of the changing climate. This was also the same in the study area as rice farmers indicated that they employed a number of strategies to adapt to the impact of climate change on their crops. These strategies may not be very effective as they are not technologically designed but were nevertheless adopted by the farmers based on the experience on rice farming and how they have observed the changes in climatic parameters (rainfall and temperature) which are necessary for the efficient growth of their crops. Like in most rural settlements in Nigeria, the populace are usually religious people. Hence, majority of the respondents (88%) indicated that they seek spiritual intervention which is shown as prayer to God and gods in (Figure 5) as

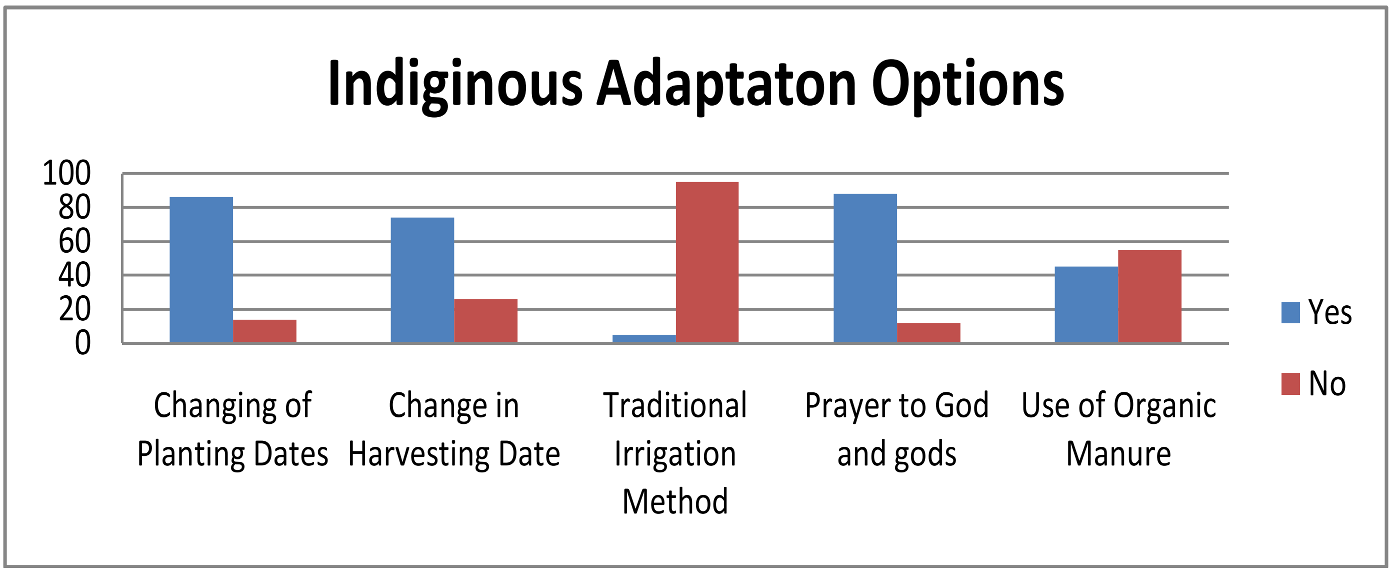

Figure 5. Indigenous adaptation strategies used by rice farmers in the study area. Source: Author's Field Survey, 2017.

remedy for a bumper rice yield. This corroborates the results of Morlai et al. (2011) where they observed that in Sierra Leone, important indigenous climate change adaptation strategies practiced by rice farmers include performance of ancestral ceremony/spiritual invocation. This was followed by change in planting date with 86% while change in harvesting dates had 74% because rice is a crop that requires a substantial amount of water for its efficient growth, and since the farmers mostly depended on rainfall for their water supply, it was seen as a better adaptation option to wait until the rains have started pouring on a daily basis which is usually around August. Figure 6 indicates the reason for the choice of August by the rice farmer as ample rainfall is usually recorded between July and October. Traditional irrigation methods are not mostly practiced in the study area as indicated by 95% of the respondents. It can however be concluded based on the results obtained that rice farmers in the study area used a number of indigenous methods to adapt to the impact of climate change.

Effectiveness of indigenous adaption strategies used

Since rice farmers in the study were adopting indigenous strategies to adapt to the changing climate impact on their crops, it became imperative to find out how effective each of these indigenous adaptation options have been in reducing the impact of climate change on their crops. After prayer to God and gods with 75%, majority of the respondents indicated that change in planting dates (72%) and change in harvesting dates (62%) were effective options in adapting to the impact of climate change on rice crop in the study area. More than half of the respondents (54%) were undecided as regard the effectiveness of traditional irrigation method, while 39%

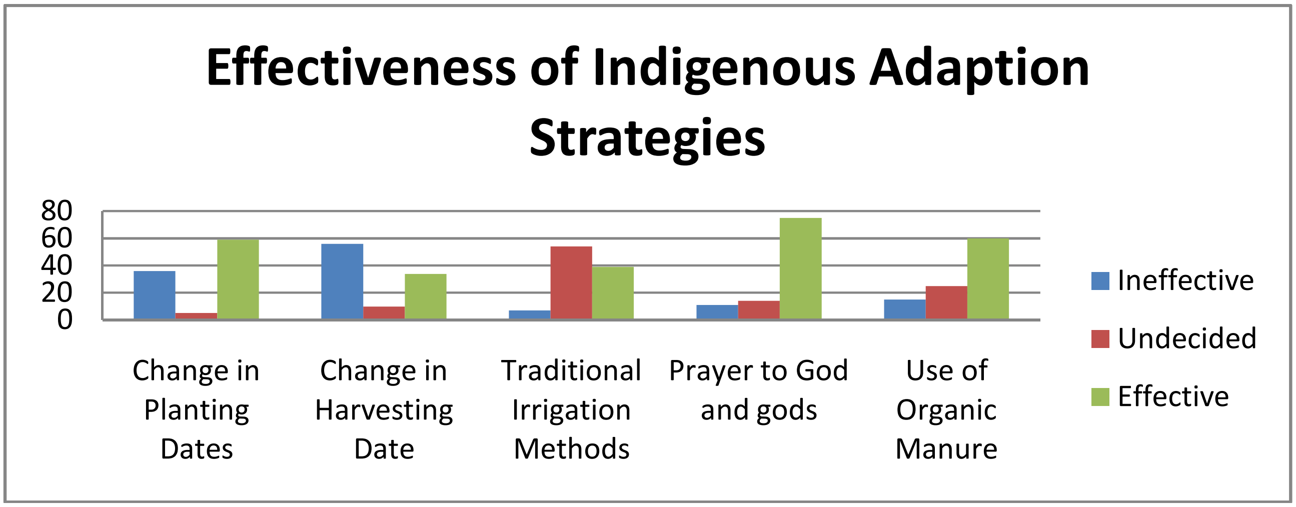

Figure 6. Effectiveness of indigenous adaption strategies used. Source: Author's Field Survey, 2017.

believe it is ineffective, this may be because it is not commonly used in the study area (Figure 6).

Use of modern adaptation strategies to complement indigenous strategies

All the respondents acknowledged awareness of modern complements to indigenous adaptation options. However 92% of them indicated that they use a number of modern adaptation strategies to complement the indigenous strategies. However, their sources of information on modern adaption strategies to use on rice differ as shown in (Table 2). Although the respondents were fairly aware of modern adaption strategies, the sources of information were mostly informal. 91% of the respondents indicated that they got their adaptation information from other farmers. This was followed by respondents which indicated that they got their adaptation information from radio (86%) and markets (58%). The results showed that 41% of the respondents got their information from Government extension workers, this indicates that visits from extension workers to the farmers were either lacking or the information were not effectively passed (Table 2).

Television and internet had the lowest with 8% and 6% respectively. This is an indication that technologies for information and communication (ICTs) for agricultural activities are not widely adopted in the study area. In the same vein, Umar et al., (2013) found out that majority (54%) of the respondents obtained adaptation information from other farmers through conversation. This was followed by cooperative societies (35%) while extension agents (20%) ranked fourth. Figure 7 shows the modern adaption strategies rice farmers in the study area employ to complement the indigenous strategies. Out of the 204 respondents that indicated that they employ the use of modern adaptation strategies, 200 (96%) indicated that they employ the use of herbicides. The high use of herbicides may be an indication of increased weed with the phenomenon of climate change. Herbicides are

Table 2. Sources of Information on Adaptation Strategies.

Adaptation Information Source	Number of respondents (n=204)	Number of respondents (%)	Rank
Other farmers	185	91	1
Radio	176	86	2
Market	118	58	3
Government extension workers	83	41	4
Print media	22	11	5
Television	17	8	6
Internet	12	6	7

Source: Author's Field Survey, 2017.

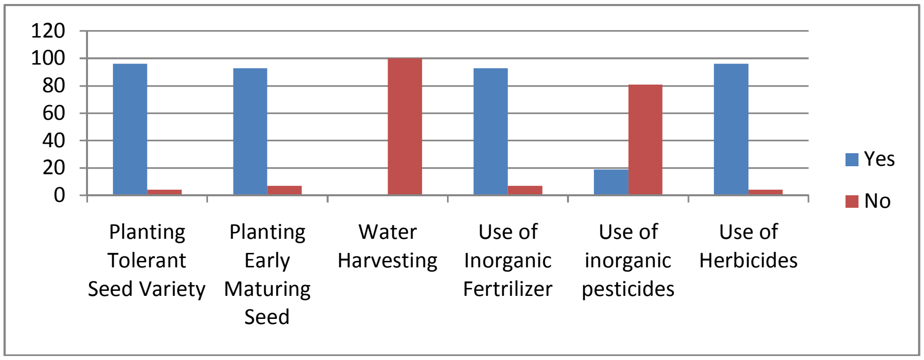

Figure 7. Modern Adaptation Strategies. Source: Author's Field Survey, 2017.

Plate 1. Fertilizer Application on a Rice Farm. Source: Author's Field Survey, 2017.

usually applied as soon as the seeds have been planted. This was followed by planting of tolerant seed varieties as a strategy use by 198 respondents (96%). Commonly used tolerant seeds varieties include pest resistant varieties and drought tolerant varieties. Some tolerant rice seeds can withstand fluctuation in rainfall provided it got a minimum of 30 days rainfall without the plant being affected. This is a necessary adaptation strategy in the study area since the agricultural practices is largely dependent on rainfall which is highly unpredictable (Figure 7). Other important adaptation strategies include planting of early maturing seeds and the use of inorganic fertilizer with 93% each. These early maturing rice seed varieties usually have three months span from planting to harvesting (Plate 1). Commonly used early maturing seed in the study area is the Faro 44 which matures within 90 to100 days. Farmers in the study area did not employ the use of water harvesting as a strategy as in indicated by all the respondents.

Constraints to climate change adaptation among rice farmers

As rice farmers in the study area try to mitigate and adapt to the impact of climate change, they face a number of challenges.

Table 3. Constraints to climate change adaptation.

Constraints	Number of respondents (n=217)	Number of respondents (%)	Rank
Lack of Adequate Knowledge on how to Adapt	204	94	1
Lack of financial resources	196	90	2
Lack of access to weather information	189	87	3
High cost of fertilizer and other inputs	172	79	4
Limited Access to improved crop variety	157	72	5

Source: Author's Field Survey, 2017.

The respondents identified what they believed are constraints militating against efficient utilization of indigenous coping strategies against climate change. As shown in (Table 3), majority of the respondents (94%) indicated that lack of adequate knowledge on how to adapt better was a major challenge they face. The result also show that rice farmers were challenged by lack of financial resources and lack of access to weather information with 90% and 87% of positive response respectively. This supports Salau et al. (2012) where they observed that apart from poverty, poor record keeping and lack of weather information were some major challenges rice farmers faced in climate change adaptation. This results in the fading out of information, or making information to become distorted and lost completely in some cases. Proper documentation is required for effective reference to environmental challenges encountered and best possible remedies tested, thereby enabling transmission to subsequent generations and improvement.

Conclusion

It is evident from the climatic data analyzed that there have been variation in climate over the years and that the climate will continue to change in the future. It is however established that rice farmers in the study area are significantly aware of climate change, its causes and impact on rice crop. It is also clear that even with the numerous challenges they face rice farmers were adapting to the impact of climate through a number of indigenous strategies. These indigenous adaptation strategies include change in planting dates and seeking spiritual intervention. Fortunately, the majority of the farmers were also complementing the indigenous adaptation options with modern strategies such as planting of early maturing seeds, use of improved rice crop varieties and the application of fertilizers and pesticides. Some of the challenges limiting rice farmers' adaption in the study area include inadequate information on how to adapt, lack of financial resources and lack of access to weather information.

Recommendations

Based on the findings of this study the following recommendations are hereby made:

(i) It is established from this study that most rice farmers got their adaption information from informal sources such as other farmers and markets. It is therefore important for government at all levels to improve the dissemination of information to farmers. This can be done by improving the capacity of the extension workers with better understanding of climate change and effective adaption strategies. The coverage area of the extension workers must also be widened to enable them reach out to more farmers.

(ii) Stakeholders in the agricultural sector should consider proper documentation and prioritization of indigenous coping strategies as used by farmers so that they can be further developed and utilized.

(iii) Government should develop supplementary irrigation system, i.e. farming practice that would supply water to rice crops, especially during growing stage. This will help when an unexpected early cessation of rainfall occur.

(iv) Improved rice crop variety should be made available and easily accessible to farmers at a subsidized rate to encourage them.

(v) It has also been established that lack of financial resource is a major constraint limiting proper adaption strategies against climate change. However, this problem can be resolved by pooling resources in form of cooperative groups. Also, access to loans from government and commercial banks should be made easier through cooperative groups.

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