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Climate Change Adaptation and Agricultural Development in Central Africa Republic-Evidence of North-West

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Abstract

Farmers' perceptions ethno-weather climate change in the North-west of Central African local knowledge is based on experiences to explain and understand the recent climate change. These farmers' knowledge on climate change has been capitalized using the tools and techniques of socio-anthropological investigations (interview, questionnaire and focus group). The results show that over 80% of people have noted strong sunlight which is in fact the way to express higher temperatures. Facts suggestive manifestations of climate change including reducing the number of days of rain and the duration of the rainy season, early arrival and late withdrawal of the harmattan, the disappearance of animal and plant species and seasons announcing the disruption of the cropping calendar. These climatic perturbations lead the peasantry to develop strategies to adapt to endogenous consequences of the observed changes. Perceptions ethno-conventional meteorological data observed face can help analyze the real impacts of climate change in the North-western of Central African. A total of 225 small-scale farmers were sampled for survey and 100 key informants were used in focus group discussions. The logistic regression model used in the study indicated that education, transportation, income, inputs cost and extension services were the factors with high tendency of undermining farmers' ability to adapt to climate change. In addition, Weighted Average Index used to measure weather extremes established that drought and temperature had the highest level of occurrence. Change in planting date, improved crops varieties, mixed cropping, and land rotation was the most preferred practices. The study concluded that farmer's resilience could be enhanced if governments and concern organizations intensify adaptation campaigns and train farmers on adaptable practices including, use of improved seeds, subsidies, increasing Agriculture Extension Agents and provision of irrigation facilities were also good interventions to improve climate change resilience.

Keywords: Farmers; Perception; Agriculture; Climate change; Adaptation practices; Ethno-weather

Introduction

Countries and international organizations are making a conscious effort to address climate change threat to humanity. Economic activities including agriculture, mining, and infrastructure development in quest of satisfying global needs continuously degrade the natural ecosystem. In developing countries, farmers are mostly affected by climate change as a result of factors including poor education, poor income, use of obsolete tools, high input cost and poor capacity building [1,2]. Unsustainable natural resource exploitation, especially in developing countries and the industrialization of developed countries for economic growth, has immeasurably triggered global warming, weather extremes, health issues, poor yield and extinction of certain plant and animals species [3,4]. Studies have shown that climate change continuously worsens drought and dry spell issues in most part of Africa hence threatening food security and poverty alleviation on the continent [5]. Other research suggested that Africa vast arable land is a great potential for economic growth if agricultural policies efficiently address climate change threat [6,7]. About 90% of African countries dwell directly or indirectly on agriculture for employment, poverty alleviation and economic growth [8]. Therefore, the slow pace of researchers and policymakers in using pragmatic solutions to militate climate change constraints will probably have ripples effect on the continent. Related findings indicate that Africa governments piecemeal way of implementing climate change policies have affected food security to the extent that countries within Sudan and the Sahel Region are likely to face severe famine and poverty by 2035 [9]. Formation of regional climate change networking system to share adaptation ideas and research findings is of the essence since Africa continent have similar climatic conditions. Central Africa Republic (CAR) being one of the African countries with Agriculture as the economic backbone needs to tackle climate change constraints holistically by bringing on board all stakeholders who invariably contribute to agriculture promotion. There is established empirical evidence that CAR agriculture sector is dwindling as a result of poor sensitization of farmers and inadequate government support to tackle adaptation constraints [10]. Similar research by Armah et al. [11] hinted that climate change impact experienced highly affects farming communities in savanna areas and its environs. Agriculture in CAR is predominantly small scale with most of the farms less than 2 hectares due to a high cost of inputs and inadequate government support. A study by Mabe [8], indicated that subsistence agricultures are highly susceptible to climate change as a result of poor income level farmers and lack of alternative source of employment. Northwest of CAR is noted for producing food crops such as cassava, millet, guinea corn, rice... as a result of good climatic conditions for such crops. However, in recent times, unfavorable climatic conditions have exposed farmers to severe drought, low rainfall, high temperature, and diseases. This compelled most of the farmers to adapt, change planting period from early April to late June to avoid drought by either migrating to the South to look for the nonexistent job during

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the dry season or any unforeseen threat. Late rains in planting period as adaptation strategy have affected productivity and maturity of certain long duration crops [12], but other findings indicated that change is planting period has rather favored farmers using improved and short duration crops over the years [8]. This implies a change in planting periods is dicey issue researchers and stakeholders have not come out clearly to substantiate its benefits in relation to climate change. There are many constraints contributing to farmers' inability to effectively adapt prudent strategies to reduce the impact of climate change on agriculture. A better understanding of how these constraints influence farmers' choices of adaptation strategies would enable researchers to strategically come out with scientific measures that could enhance farmers adaptation strategies. Farmers choices of adapting to climate change strategies depend on many considerations farmers perceived as best decision to improve yield. The effectiveness of farmers' adaptation strategy mainly depends on biophysical and socio-economic factors such as farming experience, farm labor, weather extremes, income, household size, extension services, and access to weather information, input cost, and age.

With regards to the above insight on the impact of climate change on agriculture in CAR, the research is to assess factors influencing farmers' choice of adaptation strategies, the study also aimed at determining adaptation practices suitable for addressing constraints of climate change. The research would also look out for weather extremes affecting crop and livestock production in the study area. The study would also attempt suitable interventions that could help address climate change issues.

Methodology

Study area

The Central African Republic (CAR) is a landlocked country with an area of 623,000 km². of Sudan, to the North by the Republic of Chad and to the West by the Republic of Cameroon. Based on data from the 2003 General Census of Population and Housing and considering an annual population growth rate of 2.5%, the population of the country is estimated in 2017 around 5 000 000 inhabitants, of which 50, 2% of women. The country's population is very young, with 49.4% under the age of 18. Only 4% of the population is 60 years old or older. Life expectancy at birth is 43 in 2003. According to the 2008 UNDP Human Development Indicators report, the Central African Republic ranks 178 out of 179 countries. The population is predominantly rural (62.1%). The distribution of the population by sex and age shows that women represent 50.3% and young people less than 25 years 63.9%.

The northwestern Central African Republic is located between latitudes 3°45' N and 8°35' N and longitudes 14°25 'and 19°00' East. This vast area of more than 167,000 km² represents almost 25% of the national territory. It includes the prefectures of Ouham, Ouham-Pendé, Nana-Mambéré, Mambéré-Kadéi and OmbellaMpoko (Figure 1).

A total number of (61,648) population between ages 18 and 65 in the study area was obtained from Central Africa Republic Statistical Service (ICASEES). The 2017 farmers updated census data which were obtained from the Ministry of Rural Development (MRD) showed that 41,645 of the population between ages 18 and 65 engage in agriculture as a source of employment with the majority being males. Below is the method used to determine the farmers' survey sample size.

Formula: $n = \frac{N}{1 + N(\alpha)^2}$

Where n=sample size, N=sample frame (41,645) and α represented the margin of error which is 0.05 with a confidence level of 95%. By substituting 41,645 and 0.05 into the formula: n=399.

Out of total 399 farmers sample size estimated to participate in the survey, 230 respondents were targeted but 225 farmers responded in the survey. With the help of Agriculture Officers (AOs) 05 farming prefectures (Ouham, Ouham-Pendé, Nana-Mambéré, Mambéré-Kadéi and OmbellaMpoko) were randomly selected and 25 farmers from each of these prefectures were randomly selected to participate in an interview with the aid of designed semi-structured questionnaires. Furthermore, Key Informant Interview was conducted for different organizations comprising of 15 Agricultural Council Members, 15 World Food Program (WFP) staff members, 15 Central African Institute for Agricultural Research (ICRA) staff members, 15 Seed Growers Association members. The rest were 10 Ministry of Environment and Ecology (MEE) staff members and 3 Non-Governmental Organization members (World Vision-10, Central African Agency for Agricultural Development (ACDA)-10, and German Technical Cooperation -10). This was to assess diverse opinions from technical officers and expertise working closely with farmers on climate variation challenges.

Seven field officers were trained to facilitate data collection as well as translate or interpret the questionnaires to the farmers without any form of formal education. The period for collecting the data was between February and June 2017. The data collected on climate change effects were analyzed with version 25 of the SPSS software and illustrated as tables and charts to give a clear view of respondents' opinions. Logic regression model which was used to determine the factors influencing adaptation was also analyzed with SPSS. Weighted Average Index was again used to analyze farmer's climate change adaptation strategy, adaptation constraints, and weather extremes. Weighted Average Index (WAI) was also employed as analytical tool to assess farmers' climate change constraints and frequently occurred weather extremes in the study area. WAI used in previous studies to evaluate farmers' climate change adaptation strategy had proven to be efficient and in determining the likelihood of an event [13]. Farmers perceived factors influencing adaptation including agroforestry practice, use of drought-resistant crops, use of fertilizer, farmyard manure/mulching, planting season variation, irrigation and use of fertilizer were also ranked on the scale of 0-4 (0-agree, 1-strongly agree,

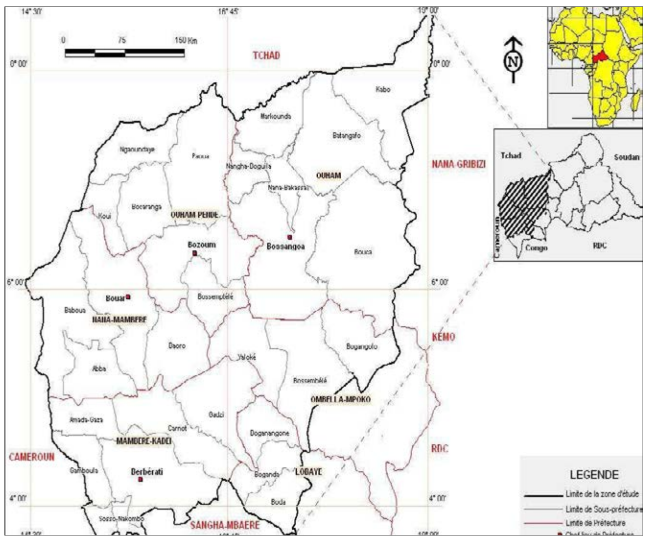

Figure 1: Location of the area study.

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2-disagree, 3-strongly disagree). Weather extremes were also placed on the scale of 0-2 (0-low, 1-moderate, 2-high). A different scale was used in the ranking of variables as a result of diverse opinions obtained when the questionnaire was pre-tested before the actual survey was carried out. The formula below was used to analyze the weighted average index (WAI) of the survey participants;

$$WAI = \frac{FV_0W_0 + FV_1W_1 + FV_2W_2 + FV_3W_3 + FV_4W_4}{FV_0 + FV_1 + FV_3 + FV_4}$$

$$WAI = \frac{\sum Fv_iW_i}{\sum Fv_i}$$

Where W=weight of each examined variable on the scale, Fv=variables frequency, i=the scale used to measure responses (e.g. i=0=poor, 1=good, 2=very good).

Model of the research

Multiple logistic regression models: Logistic (logic) regression analysis is quantitative analytical tool similar to the linear regression analysis except that with the logistic analysis the outcome involves two opposing ideas or answers (e.g. agree/disagree, yes/no, true/false). Logic regression is used for examining the tendency of an even outcome been true or false. It was used to determine factors having the possibility of influencing farmers' climate change response. Logical regression model was proved to be good analyst of an event when it used to examine the likelihood of breast cancer prevention among some groups of women in the US [14]. The result of logic regression analysis is often recorded as 0 or 1, where 1 indicates that the outcome of a finding is true and 0 indicates that the outcome of the finding is false. If P in the equation is the possibility that the outcome of an event is 1, the logic regression model can be stated as:

$$P = \Pr ob(Yi = 1)\frac{1}{1 + e^{-(\alpha + \alpha 1X1i.....1...\alpha kXki)}} = \frac{e^{\alpha + \alpha 1X1i.....\alpha kXki}}{1 + e^{-\alpha + \alpha 1X1i.....\alpha kXki)}} \quad (1)$$

Similarly $P_i = \Pr ob(Yi = 0) = 1 - \Pr ob(Y_i = 1)\frac{1}{1 + e^{\alpha + \alpha 1X1i.....1...\alpha kXki)}}$ (2)

Divide equation 1 by 2 $\frac{\Pr ob(Yi = 1)}{\Pr ob(Yi = 0)} = \frac{P_i}{1 - p_i} = e^{(\alpha + \alpha 1X1i.......\alpha kXki)}$ (3)

Where Pi is the probability that Y takes the value 1 and then (1-Pi) is the probability that Y is 0 and e the exponential constant. P is the expected probability that an outcome has the potential of being true or false. X1i, X2i, X3i up to X are independent variables which predict P outcome; α1, α2 up to αk are regression coefficients of the independent variables. To predict the odd outcome of an event with known characteristic, substitute applicable values into the independent variables and take the log of the expected outcome of the odds express as:

$$\frac{P_i}{1 - p_i} = e^{(\alpha + \alpha 1X1i.......\alpha kXki)}$$

From the model equation, Pi represents the probability of adaptation to climate change and (1-Pi) represents the probability of non-adaptation. The questionnaire used to elicit information from respondents and focus groups (FGDs) is shown in Table 1 below. The collected information was analyzed with SPSS, Logic regression model and WAI.

Results and Discussion

Determinants of climate change adaptation response

Farmers' climate change adaptation approach is mostly undermined by socio-cultural issues, economic policies, and technological challenges. Research findings indicated that biophysical, economic and social factors contribute immensely in determining farmer's climate change adaptation response [2,15]. The study assessed various factors influencing farmers' decision in responding to impact of climate change in the study area. The study showed that farm distance with 1.025 coefficients was considered as a factor with the highest tendency of influencing timely farmers' climate change response so as to avoid unforeseen consequences. In the course of the survey, it came to light that farmers mostly pay more attention to farms near their homes than those further away. The researchers' observations made during the survey showed that farms close to farmers' settlement receives the needed daily cultural practices than the further ones. This implied that proximity of farms to settlement is very sensitive to farmers' adaptation response. Related studies using the same farm size and labor on distant and farms nearby settlement revealed that nearness of farms to settlement encourages effective working hours than farms far from the settlement [16]. This suggests that further farms from settlement receive less attention than farms close to a settlement (Table 2).

The study also indicated that farmers' income with the coefficient of 0.938 has a high probability of influencing farmers to adapt to climate change. Further inquiry revealed that farmers with disposable income could easily engage labor, as well as employ new technology including fertilizer application, improved seeds and the use modern implements to advert impact of climate change than poor handicap farmers [17]. Education with the coefficient of 0.86 suggested that farmers with education have the high tendency of understanding consequences of climate change impact on agriculture and livelihood than farmers who have no any form of formal education. This implies that education enhances farmers' knowledge and skills in predicting the likelihood of climate variation impact on their farms so as to use appropriate countermeasures to prevent crop failure. Farmers with formal education have the enthusiasm of looking out for effective strategies or technologies to militate against unfavorable climatic condition [18]. Alternative livelihood with 0.814 coefficients was perceived as a factor with high possibility of influencing farmers to adopt measures in curbing climate variability impact on the ecology as well as farming. Discussion with the farmers suggested that other reliable sources of generating income and food aside farming put farmers in a better position to quickly respond to undesirable climate change threat likely to affect cropping. This suggests that alternative source of income generation activity including beekeeping, livestock rearing, and trading could increase farmers' climate change resilience than relying solely on farming for a livelihood. Extension service (0.606) was perceived as a factor capable of influencing farmers adaptation to climate variations to enhance improve yield. Extension officers build farmers capacity with modern technology and skills and update them with weather information to enhance adaptation as well as reducing vulnerability [13,19]. The study revealed that cost of input (0.516) also have the tendency of influencing adaptation decisions of farmers. The high cost of inputs such as fertilizers, weedicides, pesticides and tractor services could affect farmers' climate change adaptation response. On the other hand, low cost of inputs has a high tendency of compelling farmers to access the best adaptation options which come with using effective farm inputs [20]. The research indicated that high temperature and low rainfall could influence farmers' willingness to adopt measures to avert uncertainties which could hamper farm yield. The logit analyses also indicated that access to weather information (0.428) was perceived as a factor with the significant possibility of influencing farmers to take prompt climate change adaptation action. Access to weather information according to researchers enables farmers to plan ahead of the farming season to avoid weather extremes such as flood, high temperature, and drought and dry [21]. Discussions with the farmers

Variables	How Variables Were Coded
[*]***Determinants of adaptation response***	1=adapted, 2=not adapted (dummy variable)
Age	1=below 20, 2=21-30, 3=31-40, 4=41-50,5=51-60, 6=above 60
Education	1=literate, 2=illiterate
Farm income	1=high income, 2=low income
Household size	1=1–5, 2=6–10,3=above 10
Access to weather information	1=yes, 2=no access
Alternative livelihood	1=yes, 2=no access
Input cost	1=high, 2=low
High temperature and low rainfall	1=increasing, 2=decreasing
Transportation access	1=good access to transportation 2=poor access to transportation.
[*]***Nature of weather extremes***	
High temperature Drought	1=high, 2=low, 3=moderate, 4=do not know 1=high, 2=low, 3=moderate, 4=do not know
Dry spell	1=high, 2=low, 3=moderate, 4=do not know
Dry stale air	1=high, 2=low, 3=moderate, 4=do not know
[**]***Factors influencing adaptations***	
Poor weather information	1=agree, 2=strongly agree, 3=disagree, 4=strongly disagree
High cost of input	1=agree, 2=strongly agree, 3=disagree,4=strongly disagree
Inadequate extension officers	1=agree, 2=strongly agree, 3=disagree, 4=strongly disagree
Inadequate credit facilities	1=agree, 2=strongly agree, 3=disagree,4=strongly disagree
High rate of deforestation	1=agree, 2=strongly agree, 3=disagree, 4=strongly disagree
Inadequate government support	1=agree,2=strongly disagree,3=disagree, 4=strongly disagree
Unpredictable weather	1=agree, 2=strongly disagree, 3=disagree, 4=strongly disagree
Poor adaptation strategy	1=agree, 2=strongly agree, 3=disagree, 4=strongly disagree
High rate of deforestation	1=agree, 2=strongly agree,3=disagree, 4=strongly disagree
[**]***Adaptation practices***	
Livestock rearing	1=most efficient, 2=somewhat efficient, 3=less efficient, 4=not sure, 5=not efficient
Migration	1=most efficient, 2=somewhat efficient, 3=less efficient, 4=not sure, 5=not efficient
Changes in planting date	1=most efficient, 2=somewhat efficient, 3=less efficient, 4=not sure, 5=not efficient
Use of fertilizer	1=most efficient, 2=somewhat efficient, 3=less efficient, 4=not sure, 5=not efficient
Improved crop varieties	1=most efficient, 2=somewhat efficient, 3=less efficient, 4=not sure, 5=not efficient
Land rotation	1=most efficient, 2=somewhat efficient, 3=less efficient, 4=not sure, 5=not efficient
Mining	1=most efficient, 2=somewhat efficient, 3=less efficient, 4=not sure, 5=not efficient
Irrigation	1=most efficient, 2=somewhat efficient, 3=less efficient, 4=not sure, 5=not efficient

[*]Determinants of climate change response, [*]weather extremes, [*]climate change effects-questionnaires for farmers. [**]factors influencing adaptation, [**]adaptation strategies questionnaire for focus group discussions (FGDs) comprising Ministry of Environment and Ecology (MEE), World Food Program (WFP), District Assembly, Crop Research Institute, non-governmental organizations (NGOs), and Seed Growers Association (SGA).

Table 1: Definition of variables used to elicit information in the study area (*N*=225), focus group discussions (FGDs) (*N*=100).

Variables	coefficient	Standard error	P value
constant	1.115	.341	0.001
Age	-0.47	0.62	.453
Education	0.86[*]	0.93	.001
Extension services	0.606[*]	.098	0.002
Gender	-.30	0.90	.740
Farming income	0.938[*]	.088	.000
Household size	0.200	.053	.000
Access to weather information	0.428[*]	.134	.091
Alternative livelihood	0.814[*]	.102	.000
Cost of inputs	0.516[*]	.108	.000
High temperature and low rainfall	0.473[*]	.106	.003
Transportation	1.025[*]	.136	.002

Source: Field survey (2017).

Table 2: Determinants of climate change adaptation barriers (N=225).

suggested that regular access to weather information reduce farmer's susceptibility to climate change impact. Age and Gender with negative coefficient were perceived as factors with no tendency of influencing farmers' climate change adaptation prompt response. Further inquiry showed that farmers perceive age as an inefficient factor in determining the efficiency of response to climate variation. This is contrary to research findings by Dasgupta and Baschieri [22] which suggested that energetic youth are proactive in adopting labor-intensive measures efficient in sustainable environmental management than older farmers. Gender was also not considered as an issue owing to the fact that most of the farms are family owned thus husband, wives, and children work on the same family farm. Household size was not perceived as a sensitive factor capable of influencing adaptation because according to the farmers, the topography of the area does not support mechanized farming. Therefore, the larger the household, the larger the labor size for a bigger farm. On the contrary, the smaller the household sizes the smaller the family labor hence the smaller the farm size. This implies, whereas bigger household tends to have more labor to work on large farms to curb climate variability effect, small household produce less labor to manage small farms effectively (Table 3).

Weather extremes

Climate change has trigger weather conditions to the extreme that its adverse impact on the environment causes disaster [21]. Information gathered from the farmers' and data from Ministry of Rural Development (MRD) supported in evaluating weather extremes often affecting crop and livestock production in the study area. The study established that High temperature (WAI-1.6) mostly affect crops, livestock, and lives in the study area. Previous studies reported that North-west CAR is prone to Cerebrum spinal meningitis (CSM) due to poorly ventilated structures coupled with excessive heat and dry air in the dry season [11,23]. The dry season, spanning November to May in North-west CAR pre-exposes the indigenes especially children to CSM epidemic due to poor ventilation of houses, heat stress and dehydration [23]. The extensive system of livestock rearing in the area where the animals are on a free-range expose livestock to adverse weather conditions and this goes a long way affecting feeding, reproduction, and health of animals. The study also showed that high temperature increases water loss from plants and soil through evapotranspiration. Scorching and drying of leaves as a result of high temperature compels farmers to prune crop branches and leaves to reduce evapotranspiration. Drought (WAI-1.5) was also seen as weather extremes with high tendency of affecting crop yield. The study indicated that frequent drought in the area affects crop growth and productivity. Notably among the staple food affected by droughts were maize, millet, guinea corn and groundnuts. Interactions with the farmers suggested that loose and dry nature of the soil due to the area topography enables most seedlings to be blown or washed away during heavy rains and strong winds. Dry spell (WAI-1. 3) was also seen as a hindrance to good yield. According to the respondents, prolong dry spell which mostly occurs in the area affect crop maturity and fruit bearing. Discussions with the farmers hinted that dry spell during a fruit-bearing stage or tasseling stage eventually affect yield. Research findings by Calzadilla et al. [24], which revealed that dry spell during fertilizer application stage hinders proper leaching of fertilizer nutrients to the subsoil for good nutrient absorption. This condition eventually increases cost as more quantity of solid fertilizer would be needed for good yield (Table 4).

Factors influencing climate change adaptation

Group formation occurs when more than one individual effort is needed to achieve aimed objectives [25]. Most farmers in Africa have long history of carrying out farm activities as voluntary informal group than as individuals due to use of rudimentary tools for labour intensive agriculture [8]. Group formation (WAI-2.3) was assessed as a factor which highly influences farmer's adaptation strategies. The farmers were of the opinion that group formation promotes cohesion among farmers and encourage sharing adaptation ideas, skills and farm experience. Similarly, farmer base organization (FBOs) promotes reciprocal labour, common interest and shared responsibilities to support farmers with activities including planting, harvesting, transportation and fertilizer application [26]. Access to a road (WAI-12) was also considered a factor with high possibility of influencing adaptation. The study revealed that easy access to road enhance farmers in deprives communities to easily transport their inputs such as fertilizers and bulky manures to their farms without much stress and labour issues. In addition, other studies established that access to road is of the essence in harvesting, handling and transporting commodities and highly perishable crops to storage facility to avoid post-harvest losses [27]. Furthermore, the farmers were of the view that access to road enable farmers to travel far distance to clear new area for farming while the old infertile farm lies fallow. This implies access to road could promote land rotation as good adaptation strategy.

Access to phones (WAI-2.3) was also seen as factor likely to influence farmers to adapt to climate change. Interactions with the farmers indicated that farmers with mobile phones easily share information concerning, weather, marketing, disease outbreaks and other relevant information from the Agricultural Extension Agents (AEAs). This mode of information dissemination helps farmers to come to each other's aid when necessary. Farm insurance (WAI-2.13) was also realized as good incentive with high tendency of positively influencing farmers to adapt to climate change so as to improve their

Variables	Evaluation of responses			WAI	Rank
	Low	moderate	high		
High Temperature	4	94	130	1.6	1
Drought	26	52	147	1.5	2
Dry Spell	26	78	121	1.4	3
flood	50	58	117	1.2	4
Strong Wind	21	48	156	1.1	5
Dry stale air	118	83	24	0.61	6

Source: Field survey (2017).

Table 3: Weather Extremes in the study area.

		Evaluation of responses				
Variables	Agree	Strongly Agree	Disagree	Strongly disagree	WAI	Rank
Extension services	11	20	48	146	2.6	1
Access to weather info	17	37	81	90	2.4	2
Group formation	13	12	122	78	2.3	3
Access to road	13	31	72	98	2.2	4
Access to phones	16	14	103	92	2.14	5
Farm insurance	15	36	83	91	2.13	6
Input subsidies	12	29	122	62	2.04	7
Capacity building	21	35	105	64	1.94	8
Access to market	8	47	133	37	1.9	9
Superstitious beliefs	10	145	43	27	1.4	10

Source : Field survey (2017).

Table 4 : Factors influencing climate change adaptation.

livelihood. Discussions with the farmers revealed that farmers would feel more secured when trying different adaptation measures with the notion that in the event of any crop failure especially for cash crops they are covered by insurance. This implies farm insurance would empower farmers to risk trying different adaptation strategies until they find the most suitable one. Cost of inputs mostly affects cost of farming and subsequently prices of farm commodities [28]. The study revealed that input subsidies (WAI-2.04) have the possibility of motivating farmers to adapt to climate change. The farmers were of the view that low-cost inputs would enhance adaptation strategies involving use of farm inputs such as fertilizer, weedicides, insecticides and tractor services. Capacity building (WAI-1.94) was seen as good intervention in helping farmers to acquire skill and adequate knowledge in climate change mitigation strategies. The study indicated that most of the farmers had no formal education hence lack modern farming skills and technology. Interactions with the farmers hinted that capacity building would broaden their knowledge and equip them with suitable adaptation skills to face challenges of climate change. Access to market (WAI-1.91) was perceived by some farmers as relevant in climate change adaptation. The farmers were of the opinion that access to market can easily enhance marketing of fresh vegetables and crops to minimize post-harvest losses. Access to market could also help farmers to venture into other trade to create an alternative source of income to avoid over-dependent on the farm. Research findings by Lobell et al. [7] suggested that access to market would promote easy access to inputs acquisition for timely planting of crops to avoid drought, dry spell and other uncertainty. Superstitious believes (WAI-1.4) was considered as the least perceived factor influencing climate change adaptation though most of the farmers are traditionalist who believes in deities and ancestral spirits. Interactions and personal observations indicated that while most farmers believe climate change is as a result of human activities and population growth, others associate climate variation to wrath of ancestral spirits. This implies few farmers perceive superstitious believes as factors influencing farmers' decision to adapt to climate change (Table 5).

Perceived effective climate change mitigation strategies

Mitigation strategy involves developing and using different methods to make people and the environment less susceptible to climate variation impact. Impact of climate change on the ecosystem cannot be underestimated as it is been manifested through natural disasters, drought, high temperature, erratic rain and constant changes in humidity. The assessment of mitigation strategies suitable for improving living standard in the study area suggested numerous strategies. Focus group discussion comprising private organizations, government officials and NGOs indicated that access to alternative livelihood (WAI-2.6) was seen as the best mitigation strategy suitable for improving livelihoods of the farmers. Discussions with farmer base organization (FBOs) indicated that alternative livelihood such as beekeeping, dry season gardening, handicraft, and trading has good potential for improving the livelihood of the farmers. Mulching (WAI-2) was also seen suitable for improving soil moisture and preventing seedlings from heat stress. According to Ochieng et al. [29] research has shown that mulching improves the soil structure, soil organisms, root penetration, soil aeration, water retention capacity and reduce evapotranspiration. Other studies have also indicated that aside improving fertility, mulching has lower risk cost hence in case of any partial or total crop failure in the wake of weather extremes poor farmers would not be much indebted [30]. Afforestation (WAI-2.31) was perceived as long-term mitigation strategy with potentials for improving micro-climate of the area as well as soil fertility. Discussion with the farmers suggested that afforestation could serve as windbreaks, reduce erosion and provide shed for crops grown in the alleys between trees. Research has shown that afforestation as prospective for carbon sequestration, biomass conservation, soil and endangered species protection. Change in planting date (WAI-2.24) has high chances of reducing the impact of weather extremes such as drought and dry spell mostly affecting soil moisture, fertility, microorganism activities and crop growth. Suggestion from FGDs indicated that variation in planting period to reduce the adverse impact of climate change has the tendency of changing the length of the farming season which certainly could affect prices of highly demanding foodstuff on the market. The focus group discussions further indicated that using improved crop varieties (WAI-2.23) would promote crop resilience to harsh weather conditions prevailing in the area. Observation of the farms and soils in the study area showed that many years of continuous farming on the same piece of land without consistent re-fertilization have rendered the soil extremely infertile, therefore using improve crops varieties as mitigation strategy could significantly improve yield compared to the unimproved seeds used over the years. Improve seeds reduce the risk of crop failure, improve productivity, eradicate hunger, improve drought resistant, and minimize pest and disease infestation [31]. Other studies revealed that improve crops have the good tendency of increasing productivity per unit acre of land to bridge the gap between food security and population growth [11,32].

Use of fertilizer/compost (WAI-2.20) was perceived as a strategy which can significantly improve yield and soil fertility. According to the FBOs, top soils including nutrients are easily washed away during heavy rains as a result of sloppy nature of the study area topography.

Variables	Evaluation of Responses					
	Not efficient	Less efficient	efficient	More efficient	WAI	Rank Perceived practices
Alternative livelihood	1	6	46	69	2.6	1 hunting, bee keeping, dry season garden
mulching	5	3	42	72	2.5	2 farm residues for mulching
afforestation	2	1	77	42	2.31	3 growing drought resistant trees and shrubs
Change in planting date	2	13	61	46	2.24	4 planting when the rainfalls
Improved short season varieties	5	10	59	48	2.23	5 short growth drought resistant seeds
Use of fertilizer/compost	5	13	56	48	2.20	6 Use of inorganic/organic fertilizer
Crop diversification	4	22	73	23	1.94	7 mixed cropping/crop rotation/new varieties
agroforestry	5	1	15	101	1.92	8 inter cropping trees with crop
Land rotation	7	27	64	24	1.90	9 old land allowed to fallow
Livestock rearing	12	14	74	22	1.8	10 cattle, sheep, goat, local fowl breed

Source: Field survey (2017).

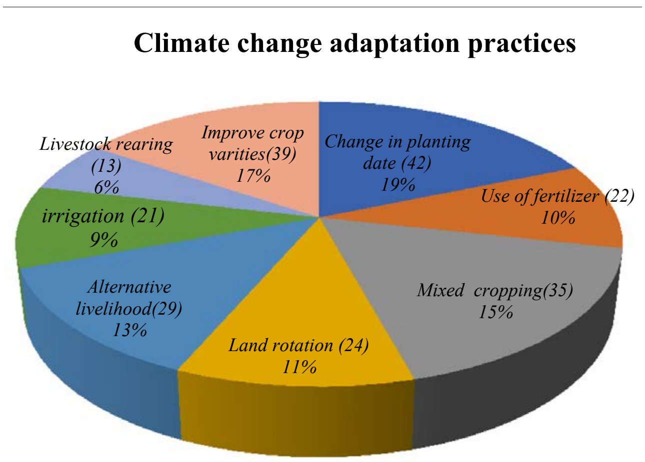
Table 5: Assessment of perceived effective climate change mitigation practices.

The high cost of Nitrogen fertilizer coupled with emissions of N_2O to the environment does not augur well for using inorganic fertilizer as adaptation practice [33]. Furthermore, heavy use of chemicals as such pesticides and inorganic fertilizers destroy the ecosystem and threaten human health [34]. Nevertheless, other research indicated that difficulties in gathering scattered droppings as a result of the extensive system of livestock rearing in Africa coupled with challenges of transporting bulky animal droppings to distant farms make use of organic fertilizer unreliable mitigation strategy for large hectares of land [10]. Other research findings have established that use of crop residues on the farm as compost could help improve soil fertility at a lower cost better than animal droppings and nitrogen fertilizer [19].

Crop diversification (WAI-1.94) was perceived to be a good strategy to improve farmers' income and livelihood. The study indicated that introduction of new crops other than the staple crops commonly cultivated in the area could help farmers to obtain a good yield. Crop diversification reduce incidence of weeds, pest and disease infestation in monoculture, as well as enhance utilization of nutrients in different layers of the soil [35]. Accordingly, crop diversification helps leguminous crops to reduce erosion, soil water evaporation, improve biodiversity conservation and soil temperature [8,15]. Agroforestry (WAI-1.92) ranked 9th was seen as a good strategy for improving soil fertility, improving microclimate and preventing direct impact of high sunlight on crops. In addition, agroforestry provides woodlot, fresh fruits and foliage for livestock in the dry [4]. Land rotation (WAI-1.90) as climate mitigation strategy was assessed and perceive as viable practice that could allow infertile lands to fallow for some years to regain fertility. On the contrary, clearing virgin and conserved areas for agriculture to meet growing demand for food affects the environment and creates repercussion for humanity. Further deliberation in the course of the discussions showed that rate of population growth in the district would create land tenure issues in the future thus land rotation was not encouraged as good mitigation practice. Assessment of livestock rearing (WAI-1.8) as mitigation strategy showed good prospects in transforming lives of poor farmers who have severe challenges in crop yield as a result of poor soil fertility and the high cost of farm inputs. The study showed that availability of pasture and foliage for grazing could help in livestock production if farmers give attention to the livestock sector. Empirical studies have indicated that government policies to strengthen and develop capacity of livestock farmers, including incentives and livestock adaptation research would create favorable platform for using livestock as mitigation strategy [36].

Farmers adaptation climate change strategies in the area

Strategies for adaptation should be pragmatics strategies capable of improving farmers' resilience and reducing vulnerability to climate variation [15]. The study as shown in Figure 2 indicates assessed adaptation practices commonly used by the farmers in mitigating the impact of climate change as well as improving yield. Among the strategies for adaptation assessed, change in planting date (19%) was mostly used by the farmers as the area mostly experience irregular rainfall. In the course of the field survey, it was noticed that due to poor access to weather information farmers mostly rely on their farm experience in predicting when the rains set in so as to prepare their land and inputs accordingly before the rain starts. The research also showed that farmers mostly used improved crop varieties (17%) which are resistant to drought, diseases, and pest even though most of the improved seeds are expensive and not easily accessible. The survey indicated that most of the farmers living in abject poverty buy few improved seeds and mix with their own stored seeds to reduce cost



Source: Field survey (2017).

Figure 2: Adaptation practices in the study area.

as well as avoid complete crop failure. Mixed cropping (15%) was also seen as adaptation strategy commonly used in the study area. The farmers were of the view that mixed cropping reduces weed invasion and drought impact. Information gathered from the farmers indicated that using leguminous crops and cereal such as maize, millet, guinea corn and sorghum improves soil nutrient and moisture content. Other studies have indicated that unlike mono-cropping which does not support efficient utilization of soil nutrient due to the similar root structure, mixed cropping enhances utilization of soil nutrient located in different layers of the soil profile [35]. In addition, similar studies have shown that mixed cropping reduces the risk of pest and disease spreading due to resistant characteristics of different crops than monoculture [34]. The study revealed that 13% of the respondents engage in alternative livelihood activities including artisanal mining, petty trading, and local beer brewing (gbako) and hunting in the dry season to earn additional income so as to meet family needs. In addition, the study also indicated that some of the rural dwellers migrate down south during the dry season to engage in temporal jobs such as trading and other labor-intensive jobs and in forestry companies for additional income.

Accordingly, land rotation (11%) was used by farmers who had no money to regularly purchase fertilizers and other necessary inputs to improve their land fertility. The respondents showed that most farmers abandoned old infertile lands and travel miles away from their homes to clear virgin lands in order to adapt to climate change. The farmers were of the view that lack of access to transport coupled with inaccessible road makes farming further away from home tedious. Most of the farmers perceived land rotation as suitable adaptation practices due to high-cost of inputs to improve yield. The research also indicated that some of the farmers perceive using fertilizer (10%) and livestock rearing (6%) as good adaptation practices to improve their living condition. Farmers were of the opinion that vast grassland coupled with abundant crop residues serve as good potential for livestock rearing though sometimes very dry pastures and crop residues affect livestock feeding. The research showed that irrigation (9%) was also one of the good practices gaining attention in the area. Most of the farmers use watering cans to irrigate vegetable gardens, to supply their family with fresh vegetables whilst they sell the surplus for income. Observation and interactions with the farmers indicated that farmers who engage in irrigation produce crops throughout the year thus obtaining additional income and food to supplement yield of the main farming season.

Conclusion and Recommendations

The study established that high cost of farm inputs affects most farmers' income and response to climate change adaptation. Farmers without disposal income would be reluctant in making formidable decisions to respond to climate change even if climate variations adversely affect yield and productivity. Easy access to low-interest rate loan could boost farmers' income levels to enhance adaptation involving the use of inputs and improved technology. The study further established that farmers with some level of formal education have strong capacity and resilience to climate change vulnerability than uneducated farmers. Encouraging the youth in agriculture to seek formal education could serve as good prospects for future unwarranted climate change threat. Extension services have the tendency of making farmers proactive to climate change adaptation. Agricultural extension agents' regular interaction with farmers would enhance capacity building intellect as well so as to make quick pragmatic decisions when early warnings signs of climate change are obvious. This can be achieved if the current gap between AEAs and farmers is bridged to a suitable farmers-AEA ratio. Among weather extremes assessed, drought, dry spell, high temperature, were the most occurrences. These weather extremes affect farmers because of poor access to weather information. The poor link between MRD and MSD impede access to timely weather information for preparation against uncertainties. Variation in planting season adopted by farmers to curb weather extremes affects cropping season and prices of most needed foodstuff on the market. The adverse effect of weather extremes could be minimized if farmers' access to weather information is improved.

Group formation which creates the opportunity for sharing labor, skills, technology and other intelligence in relation to climate change enhance preparedness for adaptation. Adaptation strategies such as timely planting and other labor-intensive farm practices could be enhanced if groups' formations are encouraged. Poor road network coupled with lack of transportation in rural areas affect regular farm visits, harvesting, marketing and daily hours spent on the farm. Therefore, access to good road network and means of transport would boost regular farm visit, and daily work output to tackle adaptation strategies rigorously than usual. As farmers in the study are classified as poor farmers due to their income level and living standards, incentives in a form of farm insurance, input subsidies, and capacity building would enhance farmers' security and willingness to adopt mitigation measures that would reduce farmers' vulnerability to climate change. Using mobile phones as means of communication is one of the convenient and fastest ways of information dissemination. As means of transport and poor road network impede movements, farm produce transportation, and regular farm visit as stated earlier, provision of a good telecommunication network in rural areas would enhance rapid sharing of farm information including weather reports, an outbreak of diseases and new adaptation technology. Therefore, the use of phones would reduce communication barriers among rural farmer to enhance resilience to climate change.

Lack of alternative sources of livelihood increases rural farmers' susceptibility to climate change effects. The study indicated that drought, heat and low rainfall affect yield and food security in the study area. Alternative livelihood such as beekeeping, handicraft, irrigation for dry season gardening would reduce reliance on rain-fed agriculture for food security and poverty alleviation. Education and campaign on the use of adaptation strategies including crop diversification, improve seeds, agroforestry, and change in planting season could save farmers from total crop failure. Climate change campaign without inputs subsidies and access to a loan may not put farmers in the position to acquire needed inputs for adaptation. Availability of grasses and fodder in the study area is a good potential for farmers to easily combine livestock and crop production to improve livelihood. In the event of seasonal crops failure due to extreme weather conditions, farmers could rely on livestock for income and food.

The researchers' detected possible limitation of certain adaptation practices used by the farmers hence recommended that further research to test the actual viability of the adaptation practices used would be relevant so as to incorporate them into national and international agriculture policies and farming systems.

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