American Journal of Environmental Sciences

Original Research Paper

Maize and Cashew Farming in the Face of Climate Change Variability in the Transitional Zone of Ghana: A Case Study of Nkoranza South Municipality

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Article history
Received: 17-09-2018
Revised: 23-01-2019
Accepted: 31-05-2019

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Abstract: The main aim of the study was to find out reasons behind the widespread conversion of maize farmlands to the production of cashew by most of the farmers in the transition zone of Ghana. The nature of the study necessitated the use of both primary and secondary data to achieve the objectives. Qualitative and quantitative approaches were used for the study. Twelve key informants were interviewed. Three hundred and twenty questionnaires were administered. Meteorological (rainfall and temperature) data were critically analysed. Most of the farmers had the intention to shift their resources (farmlands) to cultivate cashew as according to them, the trees were resistant to irregular rainfall unlike maize. The major threat pushing maize farmers from business was the changing climate, a situation worsened by the interaction of 'multiple stressors', occurring at various stages and low adaptive capacity.

Keywords: Conversion, Climate Change, Variability, Dry Spell, Deficit

Introduction

There is now enough evidence that the earth's climate has warmed since the pre-industrial era and most of the warming over the last 50 years is most likely to have been as a result of a rise in Greenhouse Gases (GHGs) [Intergovernmental Panel on Climate Change (IPCC), 2007]. This has come about as a result of combustion of fossil fuel, agriculture and land-use change (IPCC, 2007).

According to United Nations Framework Convention on Climate Change (UNFCC, 2003), anthropogenic activities such as industry, mining, transport, construction, deforestation and habitations (development of new human settlements) are responsible for the warming on the surface of the earth (Mawunya and Adiku, 2013).

Rockström *et al*. (2004) point out that the agricultural sector is the most vulnerable to the adverse effects of the climate variability and change as 97% of agricultural land in sub-Saharan Africa is rain-fed. Three major physical impacts of the changing climate according to IPCC (AR4) in Ghana are: rising of temperature, changing rainfall trend towards a long dry season and disappearing wet season. Owusu *et al*. (2008) highlight a change of rainfall regime over the entire country resulting in a longer dry season and vanishing of dry spell between the major and minor farming seasons (Major season starts from April to July and Minor from September to November). Therefore, the Ghanaian agricultural-dependent economy has thus been assessed to suffer severe economic consequences (Kyekyeku Nti, 2008).

Maize yields in Ghana are low when compared to developed countries. The national average yield is estimated at about 1.6 metric ton (mt) per hectare (ha) as compared to a country like Brazil (6.10 t ha-1). It is projected that [Environmental Protection Agency (EPA), 2000] maize yields would drop from its then level (2000) 0.5 to 6.9 in the year 2020. This is due to the insufficient input of fertilisers and non-existing irrigation facilities (WABS Consulting, 2008) in the maize production. Oldeman and Saudi (1976) underscore that maize crops require a mean monthly rainfall of 100 to 140 mm. Maize principally take 3.3-5 months for optimum growth and would need an average of 300-500mm of rainfall during this period. According to International Institute of Tropical Agriculture (IITA, 1982), maize is an efficient crop as far as the use of water is concerned.

The study of Lobell *et al*. (2008) indicates that each day's temperature above 30°C would reduce the final yield by 1% under optimal rain-fed conditions and by 1.7% under drought conditions.

The main objectives of this article are to find out the perception of the changing climate among farmers, statistically analyse the trend of the changing climate in the Municipality and ascertain the dynamics of maize and cashew production in the area.

Materials and Methods

The study was conducted in the Nkoranza South Municipality in the Brong Ahafo Region of Ghana. The Municipality lies within the wet semi-equatorial region of Ghana. It is located in the transitional zone between the savannah woodland of northern Ghana and the forest of the south. The Municipality lies within longitudes 1°10W and 1°55W and latitudes 7°20"N and 7°55"N (Ghana Districts, 2007). It shares common boundaries with Nkoranza North District to the north, Techiman Municipality to the west, Offinso North to the south and Ejura-Sekyeredumase to the south-east (Ghana Districts, 2007). The area has a mean annual rainfall level ranging between 800-1200 mm, relative humidity 55-90% and average annual temperature of 26°C (Ghana Districts, 2007).

Agriculture is the major occupation among the people of Nkoranza and this forms the bedrock of the Municipal economy. In the major season, maize is cultivated in early April and harvested somewhere in July whereas in minor season, sowing is done in September and harvesting, December.

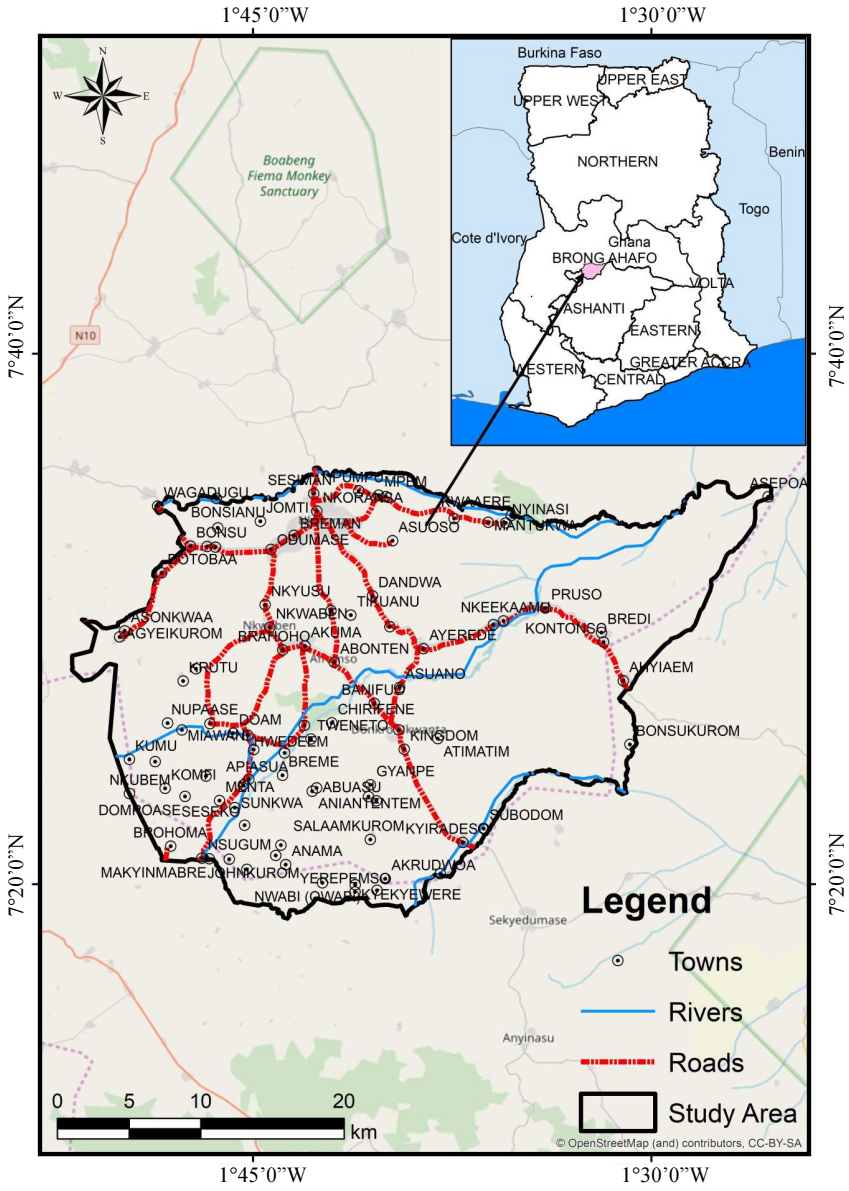

Fig. 1: Map of the study area

Research Approach

The nature of the study demanded the use of both primary and secondary data to achieve the objectives. Qualitative and quantitative approaches were used for the study. Twelve key informants were interviewed. Seven farmers, two sub-chiefs, a meteorologist from Ghana Meteorological Agency (GMet)-Wenchi branch, one agricultural extension officer from Nkoranza South Municipal Assembly and a former best farmer (2015) of the Municipality. Meteorological data consisting of rainfall and temperature from GMet which covered 1960 to 2014 was extensively analysed.

However, another data of rainfall and maize covering 2010 to 2015 were obtained from Nkoranza South Municipal Assembly (Agricultural dept.) to boost the study.

The study relied on a questionnaire survey from selected farming communities such as Donkro Nkwanta, Kupong, Kyeradeso, Deduase, Barnofour, Aboasu, Akropong, Asuoano, Kyekyewere and Salam Krum. About 320 questionnaires were administered. The questionnaire basically covered perception on climate, dynamics of maize and cashew production etc. The respondents were mainly cashew (100) and maize (220) farmers. Sampling techniques used were accidental and purposive. One Focus Group Discussion (FGD) was organised at Donkro Nkwanta.

Data Management and Analysis

The data gathered through the interviews were analysed qualitatively by transcribing the recorded interviews into word formats. Key themes such as challenges of maize, cashew production and so on were identified and isolated and developed into major headings of the findings of the study. Statistical Package for Social Sciences (SPSS) was used to analyse the quantitative data gathered from the field and cross-tabulation was extensively used as the researchers wanted to compare and contrast more than one variable. Bar chart, histogram and tables were used to project the data on climate (rainfall) which showed the pattern of rainfall in the study area.

Results

This section presents the outcome of data obtained on climate, maize and cashew production.

From Table 1, most of the respondents were Bonos (71.6%), the indigenes. Sixty two percent of the respondents were male farmers whereas 38% were females. Regarding education of the farmers, 66% of the respondents had obtained basic education with 20% without any formal education. About 57.5% of the respondents were natives of their respective communities while 42.5% were non-natives.

Perception among Farmers on the Changing Climate

Farmers in the Municipality had observed changes in temperature. About 86.8% of the respondents believed that the air temperature had risen whereas few (7%) were not aware whether the air temperature had gone up or not. Figure 2 shows the responses of the farmers.

With regard to reduction in rainfall (Fig. 2), farmers (100%) confirmed that the amount of rainfall had dropped over the past five years (85.9%) that is from 2010 to 2015 and the nature of the change was 'erratic' (77.7%). According to a meteorologist at Wenchi branch, the change had been felt over the past 10 years (2005-2015) only that it had become intense and drastic over the five years ago (2010-2015). This, according to the farmers, had shifted the growing of seeds in the major season from March to April. About 79% of the respondents cultivated their seeds (maize) in April and few in March (18%).

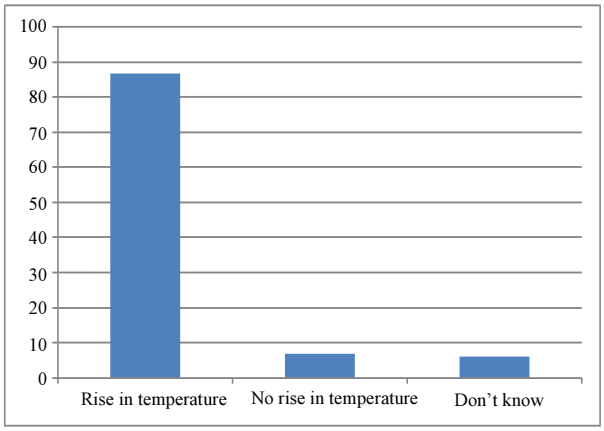

Fig. 2: Farmers' perception on temperature

Table 1: Demographic data of respondents

	Tribe			Education				Residence	
Gender	Bono %	Ashanti %	Northerner %	None %	Basic %	Second cycle %	Tertiary%	Native %	Non-native %
M (200)	134	6	61	41	119	29	11	101	99
F (120)	97	7	15	23	92	4	1	83	37
Total		320			320			320	

Precipitation Trend

The various Tables (2, 3 and 4) show monthly average rainfall from January to December. The total rainfall for the entire regime was also computed and averaged. Some rainfall figures were deepened for comparison. The month of March (1960-82 & 1988-2015) had reduced drastically whereas August (1960-82 & 1988-2015) had appreciated. The average monthly rainfall over the last five years (2010-2015) had dropped.

Maize Production in the Municipality

The common variety of maize cultivated among respondents was "aburohoma" (86.8%). Among the male farmers, 87% cultivated this traditional variety against 86.4% of their female farmers.

Major challenge militating against maize farming was rainfall (39%) followed by financial problem (30%). 'Labour' (1.4%) problem was the least among the farmers' challenges. The major problem among the male farmers was rainfall (40.9%), but among their female counterparts, capital (34.8%) was ranked first.

Major Threats to Maize Production

Respondents indicated that (key informants) the rapid expansion of cashew on arable lands in the Municipality at the expense of maize (and other crops) is a threat to food security. About 84% of respondents believed that the precarious state of maize production as a result of the changing climate (98%) coupled with unfavourable market price (96%) endangers maize production. The majority of the respondents (79%) increased their cashew lands every year. Greater number of farmers (94%) had the intention of converting their maize lands to cashew production.

Table 5 shows the effects of rainfall amount and rainy days on maize yields. The data covers 2010 to 2015 farming seasons. The highest rainfall amount was recorded in 2013 (1487.2mm) which yielded 2.0 mt/ha of maize on 62494 ha with 70 rainy days. The lowest rainfall amount however was also recorded in 2010 (812.3mm) with 85 rainy days and it had 2.0 mt/ha on cultivated land of 59616 ha. The lowest maize yield was recorded in 2015 (949.0mm) with 44 rainy days which yielded 1.5 mt/ha on 42500 ha.

Cashew Plantation in the Municipality

Most of the aged cashew farmers farmed on their own farmlands (93.1%) which contrast with the youth with 53% farming on family lands. Respondents did not plant cashew on rented lands (1.0%). Most of the respondents planted cashew on their own land (66.0%) in the Municipality. Both male (43.5%) and female farmers (47.0%) were involved in the production.

Challenges of Cashew Production

The major problem among respondents regarding cashew production was theft cases (92%). The aged (89.7%) suffered thieving more than the active labour force (67.2%) and the youth (30.8). Apart from theft issues, other challenges among farmers were pest and diseases infestation (75%) and bush fire (61%).

Table 2: Average monthly rainfall 1960-1982 (in mm) for Nkoranza

month	J	F	M	A	M	J	J	A	S	O	N	D	Avg.
mm	10.8	46.0	**114.7**	129.8	154.0	154.0	116.6	**72.7**	192.2	169.9	37.0	11.4	**100.7**

Source: Computed from GMet data

Table 3: Average monthly rainfall 1988-2015 (in mm) for Nkoranza

month	J	F	M	A	M	J	J	A	S	O	N	D	Avg.
mm	7.1	35.1	**71.0**	148.2	159.0	174.0	97.7	**79.9**	162.1	141.1	20.7	6.8	**91.9**

Source: Computed from GMet data

Table 4: Average monthly rainfall over the past 5yrs (2010-2015) for Nkoranza

Month	J	F	M	A	M	J	J	A	S	O	N	D	Avg.
mm	5.0	34.9	**64.5**	121.0	147.5	158.8	80.8	**88.5**	138.3	90.9	8.1	0.0	**78.2**

Source: Computed from GMet data

Table 5: Impacts of the changing climate on maize production (2010-2015)

Year	Rainfall intensity (mm)	Rainy days	Average yield (mt/ha)	Production level (mt)	Total cultivated area (ha)
2010	812.3	**85.0**	**2.0**	119232.0	59616
2011	1270.8	**51.0**	**1.9**	116338.9	61231
2012	1110.7	**57.0**	**2.1**	124452.0	59263
2013	1487.2	**70.0**	**2.0**	124899.0	62494
2014	1131.3	**65.0**	**1.9**	115250.0	60658
2015	949.0	**44.0**	**1.5**	83570.0	42500

Table 6: Years involved in cashew farming * Effects of the changing climate

		Effects of the changing climate			
		Rains	High temperature/heat	None	Total
Years involved in cashew farming	1-2yrs	60.0%	0.0%	40.0%	100.0%
	3-5yrs	32.3%	35.5%	32.3%	100.0%
	6-10yrs	17.2%	79.3%	3.4%	100.0%
	11yrs & above	3.3%	93.3%	3.3%	100.0%
Total		22.0%	62.0%	16.0%	100.0%

Another phenomenon that threatened cashew plantation was conflict. Nkoranza South Municipality had few challenges with land dispute (8.6%) when it comes to cashew farming. The respondents (78%) believed that cashew plantation could not bring conflict within either in a family or in a community.

On climate variability and change, the problems centred on both rising air temperatures and erratic rainfall. Table 6 shows the various challenges that cashew farmers were going through with respect to the changing climate. Each stage of the tree/plant had its own problem, ranging from erratic rains (among the young ones) to rising air temperatures (among the mature trees). The young plants between the ages of 1-2 years suffered from scarcity of rainfall whereas rising air temperatures reduced flowering of the plants (FGD).

Discussion

This section discusses the result obtained from respondents on climate, maize and cashew production.

Perception among Farmers on the Changing Climate

Most of the respondents believe that air temperatures have risen over the past few years. They believe that temperatures are high of late throughout the year and even the cold climate which characterises the dry season (harmattan) is now short-lived (Focus Group Discussion). Some old men (key informants) highlight that in the old days, people normally warm themselves around logs (fire) but currently, within the same period (climatic condition), people even fan themselves in their rooms and this phenomenon has detrimental effects on their cashew plantation. Temperatures over the entire country have risen by 1°C over the last 60 years (EPA, 2000; Adiku *et al*., 2013).

With regard to rainfall, there is a conviction among farmers that rainfall has changed drastically. Old men (key informants) are certain that the rainfall within the Municipality has totally shifted. According to them, the month of March which they used to cultivate their crops or seeds before 20/30 years ago has shifted to April. The torrential rains in the minor seasons which is referred to as "*obremponsuo*" in the local parlance (Twi) is presently non-existing. This (obremponsuo), according to the old farmers, caused some water bodies to overflow their banks and would prevent most of the farmers from going to their farms for couple of days. The respondents maintain that the amount of rains has diminished, but what is pushing them out of business (farming) is erratic nature of rainfall (96%).

The timing of the rains has become more unpredictable even though drought is not experienced among the farmers as this supports a study by (Yaro *et al*., 2010) who indicated that the transition and forest belts do not experience drought but rather variations in rainfall especially deficits in the number of rainy days and this poses new problem to farmers. There is late onset of rains, compounded by early cessation of it. This paradigm shift of the rainfall regime in the Municipality (transitional zone) made known by respondents also agrees with a study by (Asante and Amuakwa-Mensah, 2015) who pointed it out that all ecological zones in Ghana have been characterised by temperature rise and erratic rainfall.

Trend of the Changing Climate in the Municipality

A data was sought to analyse the claims of farmers that there has been some changes in rainfall pattern in the study area. It was divided into two periods from 1960 to 1982 and from 1987 to 2015. It is obvious from Table 2 and 3 that the total amount of rainfall within the Municipality from 1960 to 1982 is higher than from1987 to 2015.

On the other hand, the monthly average rainfall tabled for the two regimes substantiates that the mean amount from 1960 to 1982 (100.7mm) is higher than that of 1987 to 2014 (91.9mm). On monthly analysis, the month of March which has monthly rainfall of 114.7mm for the former has dropped to 71.0mm (1987-2014). It can also be observed that rainfall intensity for the first quarter (January, February, March) and the last quarter (October, November and December) of the year has been experiencing deficit. The short dry spell between the major and minor season has become wetter as rainfall in August has been progressively increasing (with a percentage increase of 21.7%) supporting studies by (Owusu and Waylen, 2009; Yaro *et al*., 2010; Yaro, 2010). This shows that the major and minor seasons are gradually merging which would result in single maxima.

Table 3 also confirms that over the past 5 years (2010-2015) as perceived by the farmers (FGD), the

intensity of the rains has reduced, most especially in the months of March, September, October and November. The total amount of the rains over the last five years (2010-2015) has reduced by 22% when it is compared to 1960-82 regime; the month of March has also decreased by 43%. The average annual rainfall over the last five years (2010-2015) has dropped from 100.7mm (1960-82) to 78.2mm (2010-2014).

Maize Production in the Municipality

The common variety of maize cultivated by the farmers in the Municipality is 'aburohoma'. Most of the respondents indicate that abrohoma which is a traditional variety is comparatively tasty, has more grains and it is also storage friendly. It is, however, very vulnerable to erratic rainfall as compared to the new hybrids such as *omankwa* and *obaatanpa* (FGD) which were available on the market.

On challenges associated with maize farming, rainfall was ranked first followed by capital. Because of the presence of weedicides and pesticides on the market, the farmers have little worry on labour, pest and disease infestation. Most of the farmers (96%) believe that what would push them from maize farming are deficit and erratic rainfall. For instance, one interviewee reported that he harvested only three bags of maize from 6 hectares (15 acres) during 2015 farming season. According to him, he harvests at least 8 bags of maize from one acre on the same land.

Major Threats to Maize Production

As a matter of fact, cashew farming in the Municipality threatens the survival of maize production as well as other food crops. Nkoranza South Municipality is the second largest producer of maize in Ghana after Ejura-Sekyeredumasi in the Ashanti Region (Ghana Statistical Service). Looking at the pace cashew farming is expanding in the Municipality, maize farming will collapse as most of the respondents (96%) 'swore' to convert their resources (arable lands meant for production of maize) to cashew farming. Most of the farmers on the Focus Group Discussion underscored that maize farming was making them 'poorer and poorer'. According to them, what worsens their plight is when they use the little capital on them to purchase fertiliser to improve the fertility of the soil but afterwards, 'the rains would not even fall to dissolve it (fertiliser)'.

The data from Nkoranza Municipal Assembly-Department of Agriculture show that both rainfall amount and rainy days have detrimental effects on maize production but the impacts of the latter is very crucial. The number of the rainy days determines the success of production in a given year. If the rainy days spread out (are many), it favours yields. However, if the intensity of rainfal is extremely high and the rainy days are few, it ends up destroying the plants (informants) and the data support the claims of the respondents. For instance in 2010, the intensity of rainfall was 812.3mm with 85.0 rainy days and yield was 2.0 mt/ha on 59616 ha but in the following year (2011), the rainfall amount rose to 1270.8mm with reduced rainy days (51.0) on 61231 ha and yielded 1.9 ma/ha. In 2015, the rainy days were too few (44 days) whereas the intensity was 949mm which was higher than what was realised in 2010 (812mm). The crop yield (2015) was only 1.5 mt/ha. and this scanty number of rainy days might have prevented most of the farmers from sowing their seeds (maize) hence the total cultivated land for the farming season (2015) was 42500 ha and this clearly shows that 'rainy days' is a major determiner rather than rainfall amount (intensity) when it comes to crop (maize) yields.

Cashew Production in the Municipality

Cashew farming started somewhere in 2005/6 farming season in the Municipality with the arrival of Adventist Relief Agency (ADRA). According to the farmers (FGD), the presence of ADRA was a blessing to the communities because they (ADRA) embarked on numerous projects of which cashew plantation was one. In the initial stage, ready market for the cashew nuts became a big challenge to the farmers but later on, expatriate buyers started exporting the nuts which started booming the business. Currently, it is one of the lucrative farming occupations in the Municipality from which farmers accrue a lot of income.

Cashew business environment in Nkoranza South Municipality has really improved greatly in recent years with demand for raw nuts by several countries around the world increasing a sprint pace. This has generated ready markets and improvement in farm-gate prices (informants). This has resulted in rapid expansion of the plantation on farm lands which were previously meant for maize production and other food crops.

Challenges of Cashew Production

Even though cashew production is supporting a lot of households, it has numerous challenges ranging from pest and diseases infestation, labour (for collecting nuts and pruning), changing climate (rainfall irregularity and rising air temperatures), theft and conflict over lands. Among the problems, theft cases rank first as thieves are not giving the farmers 'a breathing space'. Currently, thieves who are competing with the farm owners have become nocturnal workers. They 'hunt' for the cashew nuts during the night with their torches (FGD). Most of the farmers whose plantations are more than 3 years have problem with theft cases (69%), followed by bush fire (61%).

The changing climate is also a threat to the cashew occupation. Inadequate rains 'endangers' the young

plants (60%) between 1 to 2 years. The mature trees (those more than 3 years.), however, battle with rising air temperatures and this destroys flowers of the plants (62%). According to the farmers, when cold weather (decreased temperatures) becomes short-lived in the dry season, it reduces the quantity of flowers that the plants bear (FGD) and this phenomenon has become recurrent of late.

Last, conflict which is one of the most common problems of cashew farming at most part of the globe is unusual in the Municipality. The reason might be that most of the farmers (66%) cultivate cashew on their own pieces of land.

Conclusion

Maize production has been the main stay of the agricultural economy of Nkoranza South Municipality since time immemorial. The results of the study show that farmers had observed changes in climate in the form of decreasing rainfall, rising air temperatures and seasonal changes in rainfall trend which were affecting their maize farming operations. Both rainfall and maize data had proven that irregular rainfall in the transitional zone of Ghana had significant impact on yields of crop (maize). Cashew farming threathened food security as the plantation expanded rapidly on arable lands in the Municipality at the expense of food crops.

Acknowledgement

In performing our exercise, we had to take the help and guideline of some respected persons (or bodies), who deserve our greatest gratitude. The completion of this assignment gives us much pleasure. We would like therefore to show our gratitude to the Department of Climate Change and Sustainable Development of University of Ghana, Legon.

We also have to express our appreciation to the opinion leaders, Nananom (chiefs) and the people of Nkoranza South Municipality for sharing their pearls of wisdom with us during the course of this research. Our heartfelt thanks also go to Mr. Edmond Ewusi of Ghana Meteorological Agency-Wenchi Branch, and not forgetting Mr. Philip Datuah of Nkoranza South Municipal Assembly-Agricultural Dept.

We would also like to expand our deepest gratitude to all those who have directly or indirectly guided us in writing this paper and such people include Dr. Rosina Kyerematen, Dr. Robert Ahenkan (all of Univ. of Gha.), Mad Hagar Danquah, Eld. Sarfo Frank, Ms. Faustina Amoh (all of Nkoranza), Mr. Kwame Obeng-Appiah and Mr. Francis Atta Boansi (all of Ahafoman Snr. High Sch.-Eng. Dept). We say GOD bless you all abundantly.

Author's Contributions

Victor Adjei: Contributes to conception, design, acquisition of data, analysis and interpretation of data.

Louis Kwantwi Boafo: Contributes in drafting the article and reviewing it critically for significant intellectual content and gives final approval of the version to be submitted.

Ethics

We ensured quality and integrity of our research. We sought informed consent from the people of the study area before the interaction of any form took place. We respected the confidentiality and anonymity of our research respondents. We ensured that our participants participated in the study voluntarily. We avoided harm to our participants. We obeyed relevant laws and institutional and governmental policy duly.

We tried as much as possible to do away with any harm or risk to the human subjects but rather maximised benefits with respect to how they could cope with the changing climate. We took special precaution with the vulnerable population; and strived to distribute the benefits and burden of the research fairly.

References

Adiku, S.G.K., M. Yangyuo and D.S. MacCarthy, 2013. Assessing the potential impact of climate change on maize production in two farming zones of Ghana using the CERES-maize model. Ghana Journal Policy 5 Climate Change in Ghana: Impacts on Agriculture and the Policy Implications.

Asante, F.A. and F. Amuakwa-Mensah, 2015. Climate Change and Variability in Ghana: Stocktaking. University of Ghana, Legon, Ghana.

Environmental Protection Agency, Ghana (EPA), 2000. Climate change vulnerability and adaptation assessment of coastal Zone of Ghana. Accra: Ministry of Environment Science and Technology.

Ghana Districts, 2007. District Profiles. http://www.ghanadistricts.com.

Intergovernmental Panel on Climate Change (IPCC), 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom, pp: 1000.

International Institute of Tropical Agriculture (IITA), 1982. Maize production manual: Annual Report, International Institute of Tropical Agriculture, Ibadan, Nigeria.

Kyekyeku Nti, F., 2008. Climate Change Vulnerability and Coping Mechanisms among Farming Communities. MSc Thesis, Department of Agricultural Economics College of Agriculture, University of Ghana, Legon.

Lobell, D.B., M.B. Burke, C. Tebaldi, M.D. Mastrandrea and W.P. Falcon *et al*., 2008. Prioritizing climate change adaptation and needs for food security in 2030. Science, 319: 607-610.

Mawunya, F.D. and S.G.K. Adiku, 2013. Climate change in Ghana: Impacts on agriculture and the policy implications: Implications of climate change for agricultural productivity in Ghana: An agrometeorological perspective. Ghana Policy J., 5: 1-11.

Nkoranza South Municipal Assembly composite budget 2015/17 fiscal year (2014) (Retrieved on (14th 335February, 2016).

Oldeman, L.R. and D. Suardi, 1976. Climatic determinants in relation to cropping patterns. Climate Department of Patterns, Los Banos, Philippines.

Owusu, K. and P. Waylen, 2009. Trends in spatiotemporal variability in annual rainfall in Ghana (1951–2000). Weather, 64: 115-120.

Owusu, K., P. Waylen and Y. Qiu, 2008. Changing rainfall inputs in the Volta basin: Implications for water sharing in Ghana. Geo J., 71: 201-210.

Rockström, J., C. Folke, L. Gordon, N. Hatibu and G. Jewitt *et al*., 2004. A watershed approach to upgrade rain-fed agriculture in water scarce regions through water system innovations: An integrated research initiative on water for food and rural livelihoods in balance with ecosystem functions. Physics Chemistry Earth, 29: 1109-1118.

WABS Consulting, 2008. Draft Report: Maize value chain study in Ghana: Enhancing efficiency and competiveness. WABS Consulting Ltd. Accra.

Yaro, J.A., 2010. The social dimensions of adaptation to climate change in Ghana. The World Bank Discussion paper no.15. Washington: The World Bank.

Yaro, J.A., T.D. Dogbe, L. Bizikova, P. Bailey and G. Ahiable *et al*., 2010. Development and climate change: The social dimensions of adaptation to climate change in Ghana. Washington, DC, World Bank.