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Climate change implications for crop farming in Ghana's semi-arid guinea savanna

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Abstract

The purpose of this paper is to investigate the performance of existing adaptation strategies against climate change impacts in the Semi-Arid Guinea Savanna of Ghana. The trend of rainfall (1985-2014) is declining. Rainfall pattern is erratic throwing farming calendar into disarray. Temperature trend for the same period is rising. This paper answers the question: how are existing adaptation measures to climate change influencing crop farming? The paper uses mixed method approach. Rainfall, temperature and crop production data are analysed quantitatively. Crop production data are correlated and regressed with rainfall and temperature data. Qualitative data are gathered through the use of questionnaire administered to 148 farmers, eight focus group discussions and five key informant interviews. The effects of variable rainfall and temperature (climate change) include reduced water availability for farming, increased difficulty in deciding when to begin planting of seeds, reduced number of local crop landraces, low crop production/output as well as dwindling farm sizes. Farmers identified loss of crop biodiversity, especially, crops used in producing spices. The prospects of extensive irrigation farming during the dry season and small gardening have reduced as the main adaptation strategies. Improving resilience of small-scale irrigation and hand dug well support for gardens is warranted.

Keywords: Climate Change; Rainfall; Temperature; Smallholder Farmers; Adaptation

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1. Introduction

Impacts of climate change on agriculture are various; amidst negative repercussions and positive ramifications. However, global observations of the past 50 years show more adverse impacts than positive outcomes (IPCC, 2013). With special reference to Ghana, climate change implies increasing temperature and rainfall deficiency in which the actuals indicate temperature increase of 1 ^{o}C and rainfall decline of 2.4% using the 1960 as base year (World Bank, 2011). The semi-arid guinea savanna agro-ecological zone suffers the largest bane of climate change in the country (Dittoh et al., 2013). Population of the area is progressively exploding, climate is changing as well as land use (Mdemu et al., 2009). The populace mainly smallholder farmers make living from rain-fed agriculture; perhaps, dry season irrigation provides the largest livelihood option; although, the irrigation system is described as 'bucket and calabash' rudimentary irrigation (Dittoh et al., 2013). Farm holdings are relatively smaller ranging from 1.6 ha to 2.4 ha (Faulkner et al., 2008, Annor et al., 2009). Water productivity of the land is generally low (Mdemu et al., 2009). Small reservoirs are created to supply water for livestock drinking, irrigation, fish production, brick making and domestic use (Faulkner et al., 2008). The wet season is variable in terms of commencement and cessation of rainfall as well as duration and intensity (Annor et al., 2009). The smallholder farmers are generally poor operating below basic need poverty line (IFAD, 2007).

The paper attempts to address the overarching research question: how are existing adaptation measures to climate change influencing crop farming? Specifically, the paper answers a number of sub-research questions with regards to:

- How is the concept of climate change understood amongst famers in the Kassena-Nankana East Municipality?
- How does climate change affect the activities of farmers?
- How are existing adaptation strategies impacting on cropping?

The significance of the paper lies in the fact that climate change is occurring and it is consequential. For helpless indigenous smallholder farmers, changing to accommodate climate change is the immediate and right thing to do. In such an adjustment, research is warranted to help bring out and mainstream good/best practices of the adaptations. The bearing on national climate change policy is implied. The paper uses definition of adaptation as "adjustments made by individual producers (farmers) to reduce the risks or take advantage of the opportunities provided by climate change" (Tarleton and Ramsey, 2008:50).

The paper is structured into six sections. The introduction defines climate change in terms of increasing temperature and decreasing rainfall over the past 30 years. The second section peruses climate change adaptation literature, particularly, farmers' responses. Section three details the methodology and sub-divides it into three: conceptual framework, geographic scope and methods of the study. Results and discussion form the fourth and fifth sections respectively. The final section draws conclusions from the study results.

2. Literature Review

Agricultural production is the primary source of direct and indirect employment and income for many people in the developing countries (Ringler, 2007). The FAO posited that agricultural production in developing countries would have to increase by 70% to match food security needs by 2050 (Falloon and Betts, 2010). Unfortunately, climate change poses serious threats to the current need to increase agricultural production in developing countries. As the negative impacts of climate change on agriculture continue to increase, the fear of reduced food productivity and increased food insecurity is widespread (IPCC, 2007). In Ghana, the Environmental Protection Agency's (EPA) estimate indicates reduction in total rainfall from 1.1% to 20.5% for 2020 to 2080. The impact will be felt in reduction in agricultural productivity, especially, yields in root and tuber crops by about 40% by 2080" (Tetteh et al., 2014:80). Ghana's central government has directed the local government systems to integrate adaptation strategies into district assembly development plans (Niang et al., 2014). The country has developed a national climate change policy in 2013 to focus on six critical areas. A major concern of the policy focal areas is climate resilience required in agriculture and food security among others. The rest of the climate change focal areas are built infrastructure, communities and climate-related risks, increase carbon sinks, management of water and land ecosystems as well as access to water and sanitation (Ministry of Finance, 2016). Under climate change, there is increased suitability for cocoa in southern Ghana, cashew in the middle of the country and decreased suitability for cotton mainly grown in the savanna northern Ghana (Niang et al., 2014).

The repercussions of climate change on agriculture surpass any positive impacts; and, shortage of food is eminent (Farauta et al., 2011). Climate change impacts on agriculture primarily through reduced light, low photosynthesis, low oxygen, high carbon dioxide and less primary productivity (Ahmed and Diana, 2015). Climate change combines with land degradation to adversely affect food security (Araya et al., 2015). In Australia, it was found that rainfall and temperature relationship are critical for yields of several crops (described as the main drivers of productivity). Climate change's negative effects are seen in annual net primary production, ground cover and water use efficiency. Particularly, in Western Australia crop yield will not be sustainable in 2030 due to climate change except in areas with moderately high rainfall (Ghahramani and Moore, 2016). In Botswana, drought were associated with low disease prevalence and heavy rainfall with increased disease incidence. Climate change impacts are felt by humans, livestock and wildlife in which adaptation is a matter of survival (Ngwenya et al., 2016). Rice production in Vietnam is threatened by the incidence of climate change. Future climate change will reduce rice yield by 2.7 million tons by the year 2050. Therefore, the need to limit farmer risks through adaptation. This can be best achieved by integrating climate change into long term strategic planning which will consider the workability of strategies to fit local conditions (Yu et al., 2010).

Elsewhere in China, farmers adapt to climate change through changes in timing of cultivation, variety choice, soil tillage practices, crop protection, altering irrigation management, optimization of crop rotation and use of plastic film for soil cover (Yin et al., 2016). Africa has made good progress in community initiated adaptation based on local adaptive capacity (Niang et al., 2014). Here, collective adaptations are supported by kinship networks, local institutions and historical trends in adaptation (Ngwenya et al., 2016). In three regions of Uganda, encroachment of swamps and crop-livestock integration are the traditional adaptation strategies used by farmers to cope with the harsh impacts of climate change (Bagamba et al., 2012).

Adaptation is an important component in climate change policy making. This is because adaptation helps limit the adverse negative effects of climate change on livelihood while taking advantage of the opportunities accompanying this change as vulnerability is reduced and resilience built (Acquah and Onumah, 2011). Farmer adaptation to climate change is directly related to national development status and symbiotically related to adaptive capacity. Farmers in advanced countries possess more knowledge on climate change, are less vulnerable and have high adaptive capacity (Tarleton and Ramsey, 2008). The opposite is true. In developing countries such as Ghana, although, farmer perception of the occurrence of climate change is high, farmers are highly vulnerable because of lack of data on predictability of climatic elements, particularly, rainfall (Anim-Kwapong and Frimpong, 2010, Boon and Ahenkan, 2012, Codjoe et al., 2013, Asante and Amuakwa-Mensah, 2015). Adaptation strategies of farmers in developing countries are based on the age old formulae of 'tried and error' (Benneh, 1990). However, within the specific countries, climate change impacts on human systems depend on the level of exposure, sensitivity and capacity to adapt. Due to human differences, the impacts are experienced relatively. Nonetheless, indigenous communities, particularly, peripheral communities are highly vulnerable (Green et al., 2010). In Ghana, Upper East, Upper West and Northern Regions are the worse hit by climate changes as a result of the semi-arid nature of the land (Pinto et al., 2012). Hence the need to formulate specific policies targeted at helping vulnerable groups (Antwi-Agyei, 2012). In the absence of scientific proofs of climate change, risk management strategies should be adopted to deal with the undeniable impacts (Green et al., 2010). In so doing, the perception of risk is very important in achieving successful risk management. Risk perception is influenced by so many factors found within the victims' environment which are mainly cultural, political, economic, technological and environmental in nature (Tarleton and Ramsey, 2008). With special reference to the economy, poverty and lack of cash or financial facility limit ability and capacity of farmers to adapt to climate change, a situation very common in Ghana (Niang et al., 2014). However, these obstacles can be overcome with "concerted effort, creative management, change of thinking, prioritization and related shifts in resources, land uses, and institutions" (Acquah, 2011:4). Farmer adaptive capacity can be enhanced if already existing adaptation measures employed by farmers in response to impacts of climate change are supported by national policies (Ogalleh et al., 2012).

3. Methodology

3.1. Conceptual issues

The study builds on a conceptual framework of farm-level adaptation to climate change impacts (Tarleton and Ramsey, 2008:51). Farmers are required to manage risks associated with climate change. The framework centres on risk management; located at the mid-point of climate change stimuli and climate change adaptation. The aim of the framework is to use adaptive capacity to manage climate change risk. As a consequence, adaptive capacity is influenced by risk perception held by the farmers undergoing climate change impacts. Subsequently, risk perception is also affected by a number of factors namely: socio-cultural, political, economic, environment and technological setting in which the farms and farmers are located. The higher the information and knowledge of climate change possessed by the farmer, the higher the adaptive capacity of such a farmer. The reverse is true as is the case of the farmers under study. Based on farmers' adaptive capacity, farm-level responses are engendered as autonomous, planned, reactive or anticipatory. Mal-adaptation occurs when adaptation goes bad. Research is used to evaluate the adaptive capacity in order to improve upon risk management. Nonetheless, farmers evaluate their performance based on changes experienced in the farmers' socio-cultural, political, economic, environment and technological setting.

3.2. Study area

Spatial scope of the study covers Kassena-Nankana East Municipality located within latitude 11°10' and 10°3' North and longitude 10°1' West. There is single rainfall regime occurring between May and October with annual rainfall of 1000 to 1150 mm. Temperature ranges between 36^{o}C in March and 27^{o}C in August. Dry season's relative humidity hovers around 20% increasing to 90% in the raining season. The vegetation is the guinea savannah type dominated by tussock grass with different heights intersperse with fire resistant and deciduous trees (Dickson and Benneh, 1988). Major edaphic factors are lixisols, acrisols, luvisols and gleysols.

3.3. Study methods

A mixed method approach was used. Secondary data from Ghana Meteorological Agency (rainfall and temperature data) and Ministry of Food and Agriculture (crop production data) were complemented with primary data from socio-economic questionnaire survey. Purposive sampling techniques was used to select four farming communities from the four cardinal points of the District as including Manyoro to the north, Bui (south), Doba (east) and Bonia (west). A total of 235 farmers were involved in farmer associations and a sample size 148 derived for questionnaire administration based on formulae Israel (Israel, 2009). On the day of questionnaire administration, list of members of the farmer groups in the communities was used and members present responded to questions in the questionnaire till the group quota sample size was exhausted. The farmer-respondents were aged between 32 and 70 years. Eight (8) focus group discussions were conducted using male and female groups with two discussions per study community. Five structured interviews were conducted including two relevant state institutions (Ghana's Ministry of Food and Agriculture and General Agriculture Workers Union), as well as three NGOs (Tread Aid Integrated, Organization for Indigenous Initiative and Sustainability and Centre for Social Mobilization and Sustainable Development). Temporal scope of the study relies on the long-term impact using 30 years for climate data and 22 years for crop data constraint by availability of data. In terms of subject scope, three areas were key to the study: smallholder farmer perception of climate change, impacts of climate change on farming activities and farmer adaptation strategies. As regarding data analysis, recordings of the group discussions were transcribed into hard copies. Descriptive statistics tool of Statistical Package for the Social Sciences (SPSS) was used to analyse the questionnaire data.

4. Results

Figure 1 depicts rainfall trend for a period of 30 years (1985-2014) indicating a decreasing trend as shown by the equation (1): $y = -2.9876x + 1036.3$. The intra-annual fluctuation is also vivid with 1999 recording the highest annual rainfall. Figure 2 displays six months of dry season rainfall and six months of rainfall received during the raining season. During the dry season representing October, November, December, January, February and March, the trend of rainfall is slightly increasing as indicated by the equation (2): y = 0.2461x + 67.649. The raining season represented by April, May, June, July, August and September shows a decreasing rainfall trend as depicted by the equation (3): y = -3.2232x + 968.61. The net of equations (2) and (3) gives equation (1).

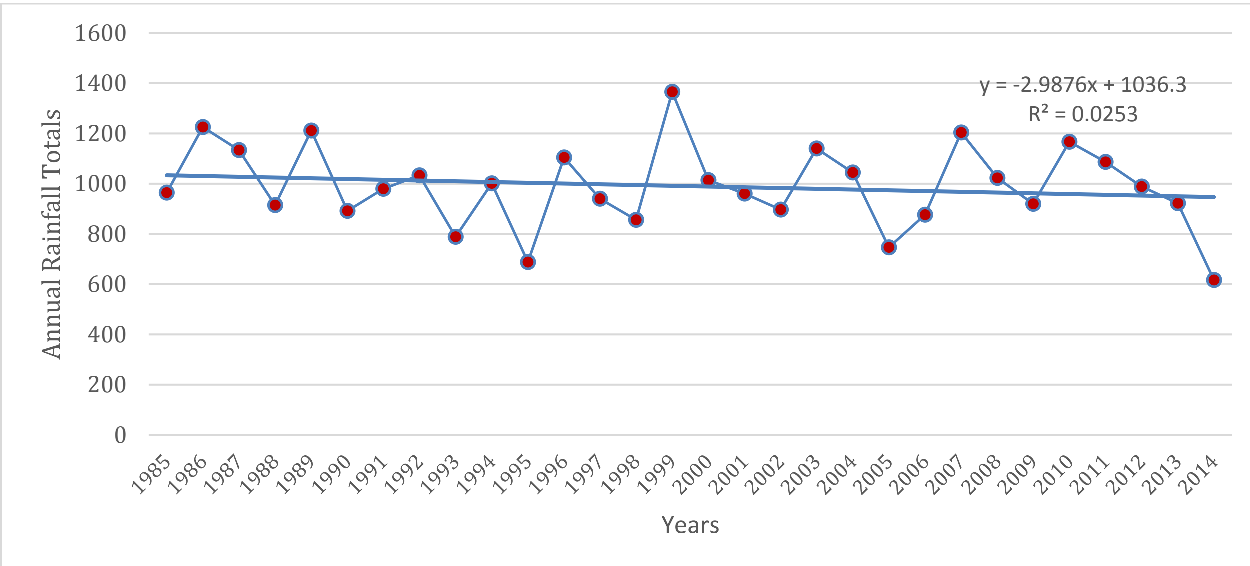

Figure 1. Annual Rainfall (mm) for 30 Years

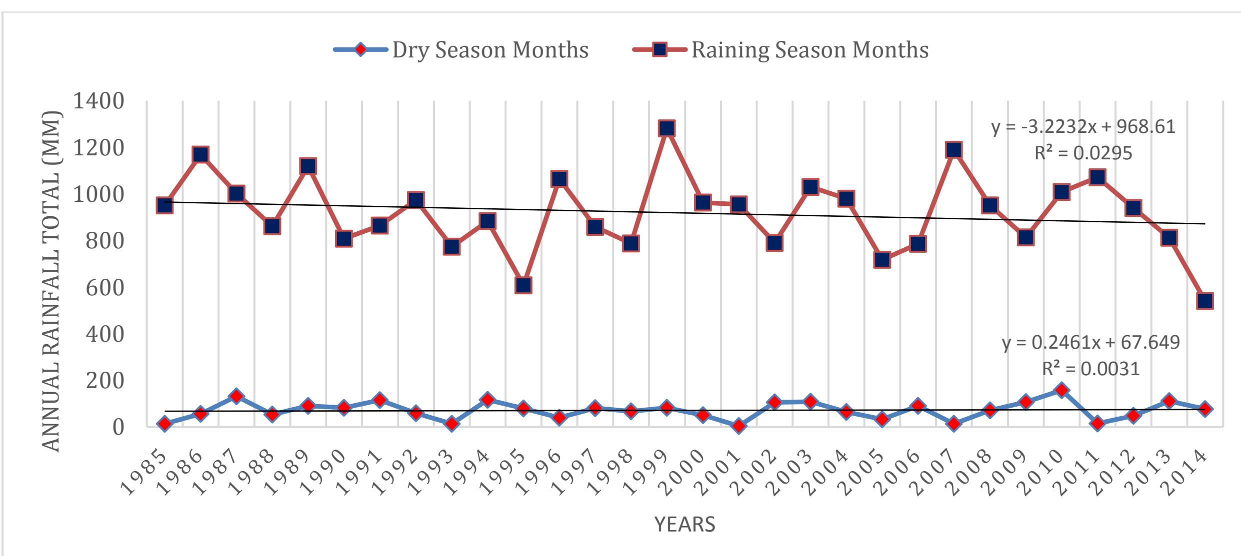

Figure 2. Six Months Dry and Six Months Wet Rainfall Annual Total

Figure 3 shows rainfall and temperature distribution across the 12 months of the year. Single peak rainfall regime is clearly portrayed with the peak in August and January as the driest month over the 30 years (1985-2014). From the lowest temperature in August, the increase begins from October and peaks in March.

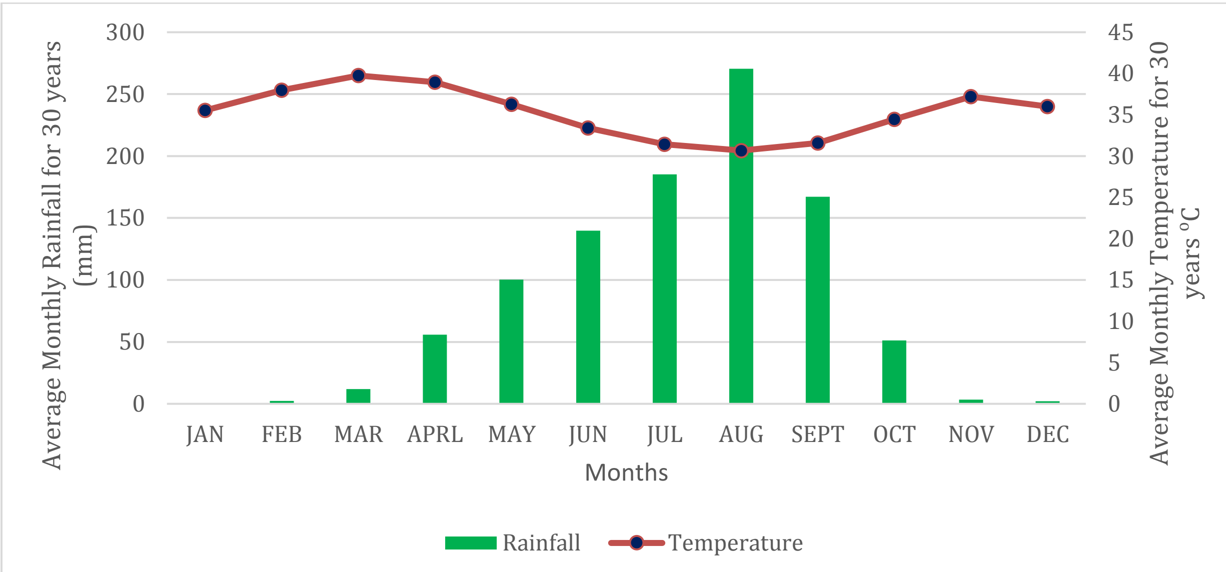

Figure 3. Monthly Rainfall pattern for 30 years (1985-2014)

Figure 4 shows the trend of temperature for the 30 years (1985-2014) indicating increasing temperature as depicted by the equation (4): y = -0.0177x + 35.496.

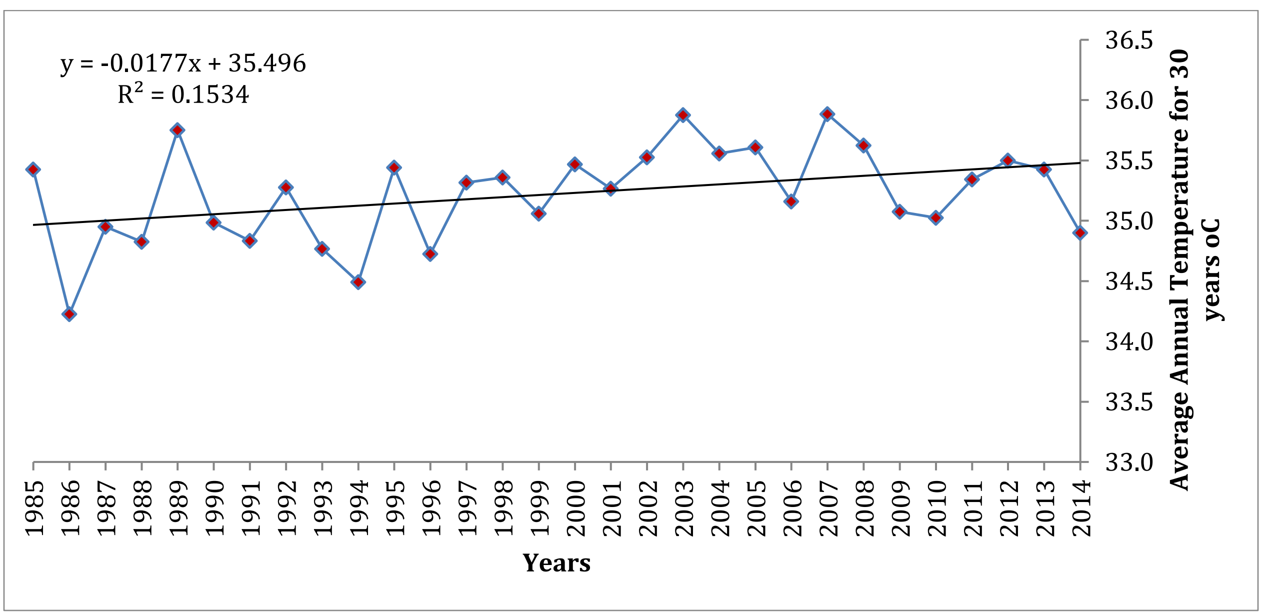

Figure 4. Average Annual Temperature for 30 Years (1985-2014)

Table 1 indicates that the yield of millet and groundnut display inverse linear relationship with rainfall. The decreasing rainfall affects the yield of millet and groundnuts. However, rainfall explains about 7.1% of the variation in millet yield and 11.3% of the variation in groundnut yield. The statistical significance for millet was 0.213 and groundnut indicated 0.127 higher than the alpha value of 0.05. Guinea corn rice and maize continue to show positive relationship with the decreasing rainfall. The decrease in rainfall is not affecting the yield of guinea corn, rice and maize presently. Rainfall explains about 0.8% of the yield of guinea corn, 15% of the yield of rice and 0.3% of the yield of maize. In all the three cases, the significance levels were higher than 0.05.

Table1. Implications of Decreasing Rainfall for Crops by Correlation and Regression

Crop	R	R^2	Sig.	Direction	Regression Equation
Millet	-0.266	0.071	0.231	Inverse linear relationship	Millet = 1.332 + 0.000 (Rainfall)
Guinea Corn	0.090	0.008	0.691	Positive linear relationship	Guinea corn = 0.877 + 0.000 (Rainfall)
Rice	0.375	0.150	0.086	Positive linear relationship	Rice = 0.382 + 0.002 (Rainfall)
Groundnut	-0.336	0.113	0.127	Inverse linear relationship	Groundnut = 1.491 + (-0.001) (Rainfall)
Maize	0.058	0.003	0.798	Positive linear relationship	Maize = 0.971 + 0.000 (Rainfall)

Table 2 shows that increasing temperature has positive linear relationship with all the five crops. Temperature explains crop yield between the minimum of 0.2% (maize) and 14% (rice). In all the cases, the significance levels were higher than 0.05.

Table 2. Implications of Increasing Temperature on Crops by Correlation and Regression

Crop	R	R^2	Sig.	Direction	Regression Equation
Millet	0.208	0.043	0.353	Positive linear relationship	Millet = -5.153 + 0.170 (Temperature)
Guinea Corn	0.316	0.100	0.152	Positive linear relationship	Guinea corn = -10.096 + 0.317 (Temperature)
Rice	0.015	0.140	0.213	Positive linear relationship	Rice = -8.670 + 0.253 (Temperature)
Groundnut	0.245	0.060	0.271	Positive linear relationship	Groundnut = -5.617 + 0.185 (Temperature)
Maize	0.049	0.002	0.830	Positive linear relationship	Maize = -0.649 + 0.050 (Temperature)

The socio-economic questionnaire survey shows smallholder farmers viewpoints on the decreasing rainfall and increasing temperature constituting smallholder farmer perception on climate change. Table 3 shows that rainfall change is observed by majority of farmers (51.3%) and represents the most significant indicator of climate change by the smallholder farmers. About 24.3% of the farmer-respondents consider the climate change as the world coming to an end. Pearson's R of 0.069 indicates that the positive linear relationship between ages of farmers and the perception held on climate change. However, the approximate significance of 0.404 is higher than the alpha value of 0.05.

Table 3. Smallholder Farmers Viewpoints on Climate Change

Age	Farmer Perception of Climate Change				Total
	Change in Rainfall	Changes in Weather Elements	The World is Coming to an End	Shift in Planting Season	
30-50 years	31 (20.9%)	8 (5.4%)	13 (8.8%)	3 (2%)	55 (37.1%)
51-70 years	40 (27%)	14 (9.5%)	20 (13.5%)	6 (4.1%)	80 (54.1%)
70 + years	5 (3.4%)	4 (2.7%)	3 (2%)	1 (0.7%)	13 (8.8%)
Total	76 (51.3%)	26 (17.6%)	36 (24.3%)	10 (6.8%)	148 (100)

Table 4 shows the various signs that farmers associate with climate change. About 32.4% relates climate change to low rainfall, 21.6% to severe harmattan and 19.6% to low rainfall and high temperature. As per the operational definition of climate change for this paper, the 19.6% appropriately captures climate change. There is inverse linear relationship between farmers' age and signs of climate change as indicated by Pearson's R of 0.030. However, the approximation significance of 0.721 is higher than 0.05.

Table 4. Signs Farmers Associate with Climate Change (Indicators)

Age	Signs that Farmers Associate with Climate Change (Indicators)						Totals
	Low Rainfall	Prolonged Dry Season	High Temperature	Low Rainfall with Strong Winds	Severe Harmattan	Low Rainfall High Temperature	
30-50 years	17 (11.5%)	6 (4.1)	1 (0.7%)	6 (4.1%)	11 (7.4%)	14 (9.5%)	55 (37.2%)
51-70 years	28 (18.9%)	9 (6.1%)	7 (4.7%)	6 (4.1%)	15 (10.1%)	15 (10.1%)	80 (54.1)
70 + years	3 (2%)	0 (0%)	1 (0.7%)	3 (2%)	6 (4.1%)	0 (0%)	13 (8.8%)
Total	48 (32.4%)	15 (10.2%)	9 (6.1%)	15 (10.1%)	32 (21.6%)	29 (19.6%)	148 (100%)

Table 5 portrays climate change events observed by farmers over the past 30 – 60 years. Majority of farmer-respondents (50%) has observed drought – water shortages that affects water users' needs. Some 21.6% has experienced windstorm. Pearson's R of 0.082 indicates positive linear relationship between age of farmers and climate change events observed. However, approximation significance of 0.324 is higher than 0.05.

Table 5. Climate Change Events Observed by Farmers over the Past 30 – 60 Years

Age	Climate Change Events Observed by Farmers Over the Past 30 – 60 Years						Totals
	Flood	Drought	Windstorm	Rainstorm	Drought and Windstorm	Rainstorm and Windstorm	
30-50 years	2 (1.4%)	31 (20.9%)	13 (8.8%)	4 (2.7%)	5 (3.4%)	0 (0%)	55 (37.2%)

51-70 years	4 (2.7%)	37 (25%)	15 (10.1%)	6 (4.1%)	15 (10.1%)	3 (2%)	80 (54.1)
70 + years	1 (0.7%)	6 (4.1%)	4 (2.7%)	1 (0.7%)	1 (0.7%)	0 (0%)	13 (8.8%)
Total	7 (4.8%)	74 (50%)	32 (21.6%)	11 (7.4%)	21 (14.2%)	3 (2%)	148 (100%)

The trend of the climate change observed by farmers was measured on the nominal scale of increasing, decreasing and fluctuation as shown in Table 6. Majority of farmer-respondents (68.2%) shows that climate change is increasing unabated. However, some 25.7% has observed increasing and decreasing representing fluctuations. Pearson's R of 0.099 implies positive linear relationship between age and responses to trend of climate change by farmers. However, approximation significance of 0.323 is higher than 0.05.

Table 6. Trend of Climate Change as Observed by Farmers

Age	**Trend of the Climate Change**				**Totals**
	Increasing	Decreasing	Fluctuation	No Idea	
30-50 years	36 (24.3%)	0 (0%)	16 (10.8%)	3 (2%)	55 (37.2%)
51-70 years	62 (41.9%)	2 (1.4%)	14 (9.5%)	2 (1.4%)	80 (54.1)
70 + years	3 (2%)	0 (0%)	8 (5.4%)	2 (1.4%)	13 (8.8%)
Total	101 (68.2%)	2 (1.4%)	38 (25.7%)	7 (4.7%)	148 (100%)

Table 7 shows the various climate change impacts experienced by farmers on the farms. Majority of farmer-respondents (50%) has suffered from water scarcity on the farm and some 25.7% battles with pest and disease. Pearson's R of -0.010 implies inverse relationship between age of respondents and responses on impacts of climate change experienced so far. However, approximation significance of 0.902 is higher than 0.05.

Table 7. Climate Change Impacts Observed by Farmers

Age	**Climate Change Impacts Observed by Farmers**				**Totals**
	Water Scarcity on the Farm	Pest and Disease	Post-Harvest losses	Water Scarcity and Pest and Disease	
30-50 years	25 (16.9%)	17 (11.5%)	7 (4.7%)	6 (4.1%)	55 (37.2%)
51-70 years	40 (27%)	19 (12.8%)	7 (4.7%)	14 (9.5%)	80 (54.1)
70 + years	9 (6.1%)	2 (1.4%)	0 (0%)	2 (1.4%)	13 (8.8%)
Total	74 (50%)	38 (25.7%)	14 (9.5%)	22 (14.9%)	148 (100%)

Table 8 displays the various ways farmers manage with climate change impacts. The largest percentage of farmer-respondents (69.6%) simply relies on harvest from the farm no matter how meagre. Some 14.9% of farmers combines the harvest with incomes received from artisanal skilled trade, particularly, carpentry. Pearson's R of -0.051 shows an inverse relationship between age and farmers coping strategies. However, approximation significance of 0.534 is higher than 0.05.

Table 8. Farmers Coping Strategies to Climate Change Impacts

Age	**Farmers Coping Strategies**					**Totals**
	Manage with the Harvest	Harvest plus Income from Sale of Labour	Harvest plus Income from Petty Trading	Harvest plus Income from Carpentry	Harvest plus Income from Sale of Livestock	
30-50 years	39 (26.4%)	1 (0.7%)	5 (3.4%)	0 (0%)	10 (6.8%)	55 (37.2%)
51-70 years	54 (36.5%)	9 (6.1%)	6 (4.1%)	1 (0.7%)	10 (6.8%)	80 (54.1)
70 + years	10 (6.8%)	1 (0.7%)	0 (0%)	0 (0%)	2 (1.4%)	13 (8.8%)
Total	103 (69.6%)	11 (7.4%)	11 (7.4%)	1 (0.7%)	22 (14.9%)	148 (100%)

Table 9 displays on-farm adaptation strategies employed by farmers in order to adjust to impacts of climate change. Several mechanical practices are carried out by farmers to turn the soil and make same ready for the next planting season. Often, mounds or beds are raised by farmers as attested to by 45.3% of farmer-respondents. There appears to be positive linear correlation between age of farmers and responses on adaptation strategies shown by Pearson's R of 0.005. However, approximation significance of 0.951 is higher than 0.05.

Table 9. On-Farm Adaptation Strategies to Climate Change Impacts

Age	**On-Farm Adaptation Strategies to Climate Change Impacts**						**Totals**
	Dry Season Farming	Raising Mounds/Beds on the Farm	Planting Trees at the Edge of the Farmland	Multiple Cropping	Fertilizer Application	Manure Application	
30-50 years	26 (17.6%)	5 (3.4%)	2 (1.4%)	6 (4.1%)	9 (6.1%)	7 (4.7%)	55 (37.2%)
51-70 years	36 (24.3%)	2 (1.4%)	11 (7.4%)	9 (6.1%)	10 (6.8%)	12 (8.1%)	80 (54.1)
70 + years	5 (3.4%)	2 (1.4%)	2 (1.4%)	2 (1.4%)	0 (0%)	2 (1.4%)	13 (8.8%)
Total	67 (45.3%)	9 (6.1%)	15 (10.1%)	17 (11.5%)	19 (12.8%)	21 (14.2%)	148 (100%)

Table 10 displays farmer responses in terms of adaptation strategies to climate change impacts. Adjustment in planting date are carried out based on farmer forecast of commencement of rainfall as reported by 41.2%

of respondents. Some 25% and 23% resort to soil fertility conservation practices and crop diversification respectively. A combination of the adaptation strategies are carried out by farmers. A correlation between farmers' age and adaptation strategies depicts inverse linear relationship (-0.059). However, approximation significance of 0.476 is higher than the alpha value of 0.05.

Table 10. Farming Systems Adaptation Strategies to Climate Change Impacts

Age	Adaptation Strategies of Farming Systems to Climate Change Impacts						Totals
	Crop Diversification	Changing Planting Date	Soil Fertility Conservation	Crop Diversification and Changing Planting Date	Crop Diversification and Soil Fertility Conservation	Changing Planting Date and Soil Fertility Conservation	
30-50 years	15 (10.1%)	20 (13.5%)	12 (8.1%)	3 (2%)	4 (2.7%)	1 (0.7%)	55 (37.2%)
51-70 years	18 (12.2%)	31 (20.9%)	23 (15.5%)	3 (2%)	2 (1.4%)	3 (2%)	80 (54.1)
70 + years	1 (0.7%)	10 (6.8%)	2 (1.4%)	0 (0%)	0 (0%)	0 (0%)	13 (8.8%)
Total	34 (23%)	61 (41.2%)	37 (25%)	6 (4.1%)	6 (4.1%)	4 (2.4%)	148 (100%)

Table 11 shows the source of the adaptation knowledge. The importance of farmer technique of 'tried and error' is brought to the fore as 43.2% of farmer-respondent claim the adaptation strategies are based on farmer initiatives. Some 32.4% trace the source of adaptation to interactions with agricultural extension services provided by Ghana's Ministry of Food and Agriculture. Non-Governmental Organizations have also contributed some adaptation strategies. A varied combination of the three main sources of knowledge on farmer adaptation strategy to climate change are used sometimes. Pearson's R of -0.178 indicates inverse linear relationship between age and factors determining choice of adaptation. The approximation significance of 0.030 is higher than 0.05.

Table 11. Factors Influencing Farmers' Choice of Aadaptation Strategies to Climate Change

Age	Factors that Influence Choice Farmer Adaptation Strategy to Climate Change						Totals
	Self-Initiative	Extension Service from MoFA	NGOs	Self-Initiative and Extension Service from MoFA	Self-Initiative and NGOs	NGOs and MoFA	
30-50 years	23 (15.5%)	12 (8.1%)	6 (4.1%)	8 (4.1%)	3 (2%)	3 (2%)	55 (37.2%)
51-70 years	34 (23%)	32 (21.6%)	5 (3.4%)	6 (4.1%)	2 (1.4%)	1 (0.7%)	80 (54.1)
70 + years	7 (4.7%)	4 (2.7%)	1 (0.7%)	0 (0%)	1 (0.7%)	0 (0%)	13 (8.8%)
Total	64 (43.2%)	48 (32.4%)	12 (8.1%)	14 (9.5%)	6 (4.1%)	4 (2.7%)	148 (100%)

5. Discussion

The decline in rainfall affects agricultural activities negatively, especially, from April to September. During this period, farmers carry out cultivation in large quantities. There is also a confirmed shift in the time for the onset of rains and the duration of the raining season. Success of the cropping season is based on whether farmers get the dates right. Smallholder farming has become a gamble due to variability of rainfall. The intensity of the rainfall is divided into two parts. Heavy down pour with wind storms and associated floods that destroys farms and other property. This is followed by drizzling for a number of days with little or no sunshine for crops. The soil gets heavily soaked and crops get damage due to too much water and low temperature. At the end of the raining season, the sun heat dries the soils faster than usual. Hence, the farmers complaint about insufficient water availability for farming. The combined effect of rainfall and sunshine is responsible for fading out of cultivation of early millet. The use of improved seeds in the case of guinea corn, rice and maize has brought about increase in crop production. An indication that the farmers enjoying good production in the three crops are getting the cropping calendar right. During the dry season, farmers do gardening depending on the ability to create wells and dugouts supported by spring water. The success of such gardens relies on sustainability of the wells and dugouts. The adaptation measures employed by farmers to manage climate change risk constitute gamble schemes due to lack of climate information, poverty and low level of farmer education.

6. Conclusion

Climate change manifests in variable rainfall and decreasing temperature. The consequences on crop farming are borne by smallholder farmers. Adaptation is inevitable because the alternative is hunger and starvation of the farming family. The modus operandi is "tried and error". The most important adaptation is to make water available for dry season gardening. The main source of water is underground (ground) water. Rudimentary tools are used to dig wells and dugouts using smallholder farmer labour or hired labour. Availability of water in the wells and dugouts depends on intensity of sunshine in the dry season. Sunshine is progressively hotter with increasing temperature. Smallholder farmers located in good proximity to the Tono Irrigation Scheme do not suffer water unavailability in the dry season. Provision of dams or water holding cisterns for dry season farming is the way to go. However, such waters should be available in good quantity for the number of farmers in the arable land area. Control of evaporation and seepage are keys to maintaining the water quantity. Since, crop farming will reduce the water quantity, sustainable replenishment must be taken into consideration. A further research will have to investigate the strength of underground (ground) aquifers in relation to supplying water for crop farming as climate change adaptation and possibility of replenishing such aquifers during the raining season. The conceptual framework could be improved by disaggregating risk management. In so doing, emphasis should be placed on level of climate information available, level of farmer education and farmer financial wellbeing.

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