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Research Article

Farmers' Perceptions on the Impacts of Climate Change (CC) on Crops Output

Isaac Verberk Mensah [1,*], Samuel Kingsford Twene [1], Eric Kofi Adjei [2]

[1] Department of Social Science, St. Ambrose College of Education, Dormaa-Akwamu, Ghana
[2] Department of Social Science, Seventh-Day Adventist College of Education, Agona-Ashanti-Ghana

*Correspondence: Isaac Verberk Mensah (vmensah80@gmail.com)

Abstract: The study aimed at examining farmers' perceptions on the impacts of climate change on food crops and the farming practices that contribute to climate change (CC) in Bibiani – Ahwiaso – Bekwai municipality of Western North Region of Ghana. Qualitative and quantitative methods were used for this study. The population of the study consisted of the number of households in six communities (Hwenampori, Wenchi, Tanoso, Awaso-Asempanaye, Kunkumso, and Sefwi Bekwai), officials from MoFA, GMA, and heads of households who are food crop farmers from the study area. Simple random and purposive sampling techniques were used to select respondents for the study. 231 respondents were selected and contacted for information to aid them in the study. The main instruments for data collection were the administration of questionnaires to farmers, organization of focus group discussions with key informants, the use of structured interview guides on MoFA directorates and direct observation of some farms. The primary and secondary data were sourced mainly from household heads from the study communities who are in the production of maize, cassava, and plantain. Pearson Chi-Square and Cross-tabulation of the IBM SPSS Version 20 were also used in performing descriptive statistical analysis. The study revealed that the output of maize, cassava, and plantain have all proved to be negatively impacted by changes in rainfall and temperature patterns with a more significant impact observed from maize responses to temperature. The study also indicated that the impact of climate change may affect the crops at any stage of the production process right from the land preparation to the maturity stage of crops but the more profound effect is observed at fruit development and maturation stages. The study indicated that changes in temperature affect crop yield, especially during the fruit/seed development stage. The study revealed that most farmers (about 92.2%) have observed climate change in the study area and indicated events like unpredictable rainfall patterns, excessively high temperatures and strong winds. It is recommended that capacity building and awareness creation should be enhanced by GMA and MoFA through the media to ensure that communication about climate change and food security is meaningful. This means that education on diversification of farming methods has not been enough if there is any at all in the area. Awareness creation, therefore, allows people to make informed and responsible decisions toward sustainable farming practices which will lead to food security and also environmental sustainability.

Keywords: Farmers, Perceptions, Impacts, Climate Change, Crops

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1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) defined climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". To them climate change involves a change in climatic variables (such as rainfall, temperature and wind speed) which is caused by both anthropogenic and natural factors over longer time periods. The most mentioned climatic variables identified to have direct relationship with crop production and which affect output of various crops are temperature, precipitation and extreme weather events such as flood, windstorm and drought [1]. This implies that information on micro-weather conditions in the area that could assist farmers to make informed decisions regarding adaptation measures against climate change from the local meteorological agencies have not been available [2]. Thus, climate change is considered as gradual but noticeable changes in regional or global-scale patterns of ancient climatic variables (particularly rainfall and temperature) induced by man or natural means which usually results in sporadic but progressively recurrent dangerous impacts [2].

Food security occurs when individuals have continuous physical or economic access to adequate, harmless, and nourishing food to meet their dietary needs and food preferences for an active and healthy life [3]. But the problem is that food security in the face of global climate change has become highly threatened since over one billion people around the world are underfed because they lack easy and constant access to affordable food [4]. It must also be noted, that the quantity produced (availability) of a particular crop which is also a function of food security is dependent on other factors such as land area, soil fertility and agronomic practices other than climatic factors of rainfall and temperature. It therefore becomes imperative for this study to take into account (besides rainfall and temperature) the impact of the size of the land area used for cultivation (which data was readily available at the time of this study unlike soil fertility and agronomic practices) since food security is being studied. Food production can increase by expanding agricultural area. In other words, to be able to satisfy future food demand, then per-area productivity must increase [5]. All the four dimensions of food security are affected in one way or the other by climate change: that is food availability, food accessibility, food utilization and food systems stability [6]. However, the observed impacts indicate high effects on production aspects of food security rather than access or other components of food security [7]. For the purpose of this study, food security focused mainly on production (availability) component. Since agriculture (crop production) relates directly to or depends largely on climatic proxies of rainfall and temperature, changes (variations) in the pattern of these climatic proxies' impacts crop production hence to food security.

In Africa, low levels of food security and economic development conspire with high levels of climate risk [6, 8]. This is because agriculture systems in most countries in sub-Sahara Africa such as Ghana, Uganda, Cote d'lvoire and Nigeria depend solely on rainfall. Therefore, a slight delay in rainfall or unusual changes in rainfall pattern affect productivity levels greatly hence food security [7]. This has resulted in conscious effort on the part of farmers in these countries to adapt to such changes in rainfall pattern and temperature extremes through diversity of means ranging from irrigation to undertaking non-farm activities.

Using the projected climate scenarios yields of cassava is expected to reduce with the rate of reduction increasing with time or rise in temperature. Cassava productivity or yields are expected to reduce by 3%, 13.5% and 53% in 2020, 2050 and 2080 respectively in Ghana [9]. Further results also show that under climate change, crop yield changes are in the range of minus 17% to plus 6% at the national level. The implication is that climate change has empirically proven to have a non-linear relationship with output produced of food crop even though the negative effects outweighs the positive effects. A study conducted in India that temperature has a non-linear effect on crop yields [10]. This implies that whereas some crops would be significantly affected by changes in temperature, others would not.

Climate change is considered the greatest contemporary threat to food crop production especially in a developing country like Ghana. It is considered as one of the greatest environmental, social and economic threats the world has ever faced [7, 11]. It is real and happening faster than we previously thought with serious devastating impacts in developing countries, particularly on the Africa continent [7]. The poor countries in particular are the most vulnerable because of their high dependence on natural resources and their limited capacity to adapt to a changing climate [6, 7-13]. These impacts are expected to deepen poverty, food insecurity, poor livelihoods, dysfunction of infrastructural facilities, environmental resources and unsustainable development [6, 7].

A study concluded that changes in the world's climate will bring major shifts in food production [14]. In some places, temperatures will rise and rainfall will increase; in others, rainfall will decrease. Such change, which affects soil temperature and moisture levels, also determines the vitality of both beneficial organisms and pests. Global warming is likely to alter the production of rice, wheat, corn, soybeans, and potatoes which serve as staples for billions of people and major food crops in both North America and Africa [14].

While climate change will have global impacts on agriculture, regional variations will be significant. Africa and North America exemplify the regional variations that may occur. These differences underscore the difficulty in proposing general strategies for adapting new agricultural technologies to deal with the climate change. By 2030, according to one scenario, atmospheric carbon dioxide concentrations will be doubled in concentrations and other greenhouse gases will increase substantially, and temperatures in North America and Africa will rise by approximately 2℃ [14]. So if these changes occur, projected average rainfall in central North America will be 10 percent lower than now; in eastern and northern Africa, it may be 10 percent higher. While more rain holds the promise of increasing African agricultural productivity, higher temperatures may offset this advantage by decreasing soil moisture. As a result, dry agricultural regions may continue to suffer the effects of inadequate water supplies, even if levels of rainfall increase.

Agricultural production will be affected by the severity-and pace-of climate change. If change is gradual, there will be time for political and social institutions to adjust. Slow change also may enable natural biota to adapt [14]. However, even a minor change (for example, one-tenth of a degree per decade) could spark significant changes in the frequency of climate extremes, including heat waves, floods, and droughts [14]. Rapid climate change could jeopardize agriculture, forestry, and biodiversity worldwide [14]. Compounding this problem is the fact that some African societies lack the capacity to adapt to these changes on their own [14]. Moreover, because of climate change from global warming, the world may experience a dramatic change in food production regions: whereas some prime agricultural areas, such as the lower Midwest of North America, may suffer because of increased dryness, other areas, namely the Russian steppes, may actually become better suited for agriculture [14]. Although it is too early to tell when these changes may occur, there is little question these climate changes will have a dramatic effect on human settlement and world food supplies [14].

Matters concerning climate change and agriculture have attracted the attention of a number of researchers and research institutions globally [7, 15]. This therefore affirms the existence of CC as a serious problem of concern for developing countries like Ghana since agricultural activities are dependent largely on climatic variables like rainfall and temperature, hence more research work must be conducted. However, literature on climate change has largely focused on the broad impact of climate change on livelihoods, adaption and mitigation strategies. For instance, studies revealed that the broad effects of climate change on agriculture as a whole as well as various adaptation measures employed by farmers to cope [16-18]. Notwithstanding, climate change (CC) impacts on agriculture is silent on the actual impacts of climate change on individual crops as well as the stage or point in the production process where these impacts are greatly felt [16-18]. The impacts of land area on quantity produced of a particular crop in the face of CC and the use of mixed method to study climate change impacts on crop production are also ill-explored. These therefore leaves a lacuna in the area of investigating the impact of climate change on various crops individually hence this study. The study examined farmers' perceptions and impacts on farming practices that contribute to CC. The study was guided by this research question - What are the perceptions of farmers on local indicators of climate change and the point/stage in the production process at which CC affects crops?

2. Materials and Methods

Qualitative and quantitative methods were used for this study. The population of the study consisted the number of households in six communities (Hwenampori, Wenchi, Tanoso, Awaso-Asempanaye, Kunkumso and Sefwi Bekwai), officials from MoFA, GMA and heads of households who are food crop farmers from the study area. Simple random and purposive sampling techniques were used to select respondents for the study. 231 respondents were selected and contacted for information to aid the for the study. Table 1 gives a summary of the sample size from the various communities which was proportionately determined.

Table 1. Details of Sample size.

	Total No of Households		Sample Size			
	Communities	Household Heads	Questionnaires	FGD/Interview Males	FGD/Interview Females	Total
Bib. TA	Hwenampori	824	19	7	5	31
	Wenchi	617	14	7	8	29
Ahw. TA	Tanoso	647	15	7	5	30
	Kunkumso	439	10	6	7	23
Bek. TA	Awaso-Asempanaye	1473	34	5	5	44
	Sefwi Bekwai	2759	64	6	5	72
	MoFA Direc.		0	2		02
Total		6723	156	75		231

Source: GSS, 2014

In all, 156 respondents out of the total sample size (231) were presented with questionnaires for information to aid quantitative data analysis and 75 respondents were also engaged in Focus Group Discussion (FGD) and or interviewed for information also for qualitative data analysis. The main instruments for data collection were administration of questionnaires to farmers, organization of focus group discussions with key informants, the use of structured interview guides on MoFA directorates and direct observation of some farms. The crop yield data (for maize, cassava and plantain) against the land area cropped was obtained from the Ministry of Food and Agriculture (MoFA) department in the district. The climate data was also sourced from the Ghana Meteorological Agency (GMA), Accra. Other secondary data like the total household data was obtained from Ghana Statistical Service (GSS) published reports and articles.

The primary data consist of information on the perceptions of farmers on micro indicators or manifestations of climate change over time in the area and how these indicators affect their activities. Specific information includes farmers' perceptions on farming practices that contribute to climate change, how changes in rainfall and temperature patterns and other locally observed extreme climatic events (such as drought, floods and windstorm) affect the annual production of the major staple crops (specifically maize, cassava and plantain) in the area. Again, information on the specific stage or point in the production process which the perceived climatic changes affect their crops and how they adapt to these changes were also sought for. Information on the determinants of the various adaptation measures and whether or not they are effective were also obtained. Finally, information on the existence of institutional adaptation or mitigation strategies or otherwise in the area were also sought for.

The primary data was sourced mainly from household heads from the study communities who are into production of maize, cassava and plantain. Since the focus of the study was on these specific staple crops, farmers who produced such crops were considered ideal for information bearing in mind their experience in the production of such crops and their continuous dependence on rainfall for production. Other stakeholders such as officials from the district MoFA directorate and the Districts Chief Farmer were also contacted for information. The primary data was analysed using Content Analysis (CA). using CA, common themes were drawn from the responses and direct quotes from the Focus Group Discussions (FGD). Through the FGD, opinion of respondents on such indicators as farmer's perception on climate change, perceived impacts on their activities. In addition, statistical tools such as Pearson Chi-Square and Cross tabulation of the IBM SPSS Version 20 were also used in performing descriptive statistical analysis. The Chi-Square test was used to determine the level of significance between the perceptions of farmers on changes in rainfall and temperature patterns and their effects on the cultivation of their crops as well as the determinants of adaptation strategies. A significant Chi-Square test results ($P < 0.05$) implies that the proportion of respondents in favour of an observed situation is significantly different from the proportion of respondents for the alternative observation.

3. Results and Discussion

This section of the study presents results and discussion of the primary data obtained from the field. Cross tabulation, and Pearson's chi-square were the main tools used to test the levels of significance in terms of association of farmers' responses concerning their perceptions on climate change (CC), farming practices that contribute to CC, aggregate impact on their activities, farmers' adaptive strategies, determinants of adaptation and effectiveness of institutional mitigation strategies. The results obtained from the statistical analyses have been supported with findings and concerns through direct quotations and generalization of ideas from farmers during the focus group discussions. Appropriate literature that are consistent or otherwise with the results have also been used to support the findings obtained.

3.1. Perception of Farmers on the Kind of Observed Climate Change Event/ Local Indicators of Climate Change (CC).

Table 2. Cross tabulation of observed CC and the kind of climate event

			Kind of climate change			**Total**
			floods	**Dry spells**	**Strong winds**	
Observed CC	Yes	Count	30	57	55	142
		% of Total	19.5%	37.0%	35.7%	92.2%
	No	Count	3	3	6	12
		% of Total	1.9%	1.9%	3.9%	7.8%
Total		Count	33	60	61	154
		% of Total	21.4%	39.0%	39.6%	100.0%
Pearson chi square		P – value (0.582)				

Source: Author's field data (2015).

Cross-tabulation of whether or not there has been a change in the local climatic variables (rainfall, temperature and wind) and the kind or specific observed climate change showed that 92.2% of farmers have observed climate change with 37% and 35% specifying dry spells and strong winds as climate change events respectively (Table 2). There was no significant difference among the responses of the farmers regarding climate change and specific observed CC events ($P > 0.05$). Since majority of farmers (92.2%) have observed climate change in the study area and indicated events like strong winds, floods and dry spells, it concludes and clarify the point that farmers have knowledge about climate change and its impacts.

In addition to the events indicated earlier as representing climate change, other findings from farmers during the focus group discussions showed that locally, there are other indicators that proved to them that the climate has indeed changed. For instance, indicators such as excessive solar radiation which raises local temperatures, delayed rainfall, heavy clouds that do not produce rains and heavy windstorms were mentioned. All these were emphasised because according to them their respective intensities and patterns have changed. Consistent with the above locally observed climatic pattern is the results from MAKESENS trend test which showed a significantly increasing trend in temperature pattern. These observable changes in patterns of climatic variables have observable impacts on crops. To the delayed rainfall in particular, all farmers during the focus group discussions in all the communities unanimously supported an observed assertion by the sub district chief farmer, that:

> *"the normal rains have been observed to fall as early as February and sometimes March (if it delays), by which time farmers (maize, cassava and plantain farmers) start to cultivate their crops, but everything has changed since the rains now delay till May ending and even June which makes the planting time highly unpredictable. Furthermore, we have also been relying on sounds of some animals [insects (cricket or Ketekre in the local palance) and amphibians (frog)] and sprouting of the flowers of some plants as helpful indicators for the commencement of the rainy season that prompt farmers to get prepared for cultivation. Now the timing of all these local indicators have changed and even if they occur at the expected time the rains never fall as it ought to. Indeed, the climate has changed".*

3.2. Contribution of Farm Practices to Climate Change (CC)

This section looks at farmer's perception about farming practices that contribute to climate change. It has been highlighted in the DPSIR model which is underpinned by the Neo-Malthusian theory, that high population growth results in man's interaction with the environment by means of agriculture to feed the growing population thereby deteriorating the quality of the environment (deforestation and slash and burn) which contribute to climate change. The study discovered that there are various farming practices that farmers are aware of as contributing to changes in the local climate. Among the notable anthropogenic factors constituting the pressure component of the framework that contribute to climate change which was emphasised by farmers include deforestation, bush burning and slash and burn method of farming.

3.2.1. Deforestation

Table 3. Cross tabulation of deforestation as a contributing factor to CC

			Deforestation			Total
			Yes	No	No idea	
Observed climate change	Yes	Count	135	6	1	142
		% of Total	87.7%	3.9%	0.6%	92.2%
	No	Count	12	0	0	12
		% of Total	7.8%	0.0%	0.0%	7.8%
Total		Count	147	6	1	154
		% of Total	95.5%	3.9%	0.6%	100.0%
Pearson chi square		P – value (0.734)				

Source: Author's field data (2015).

Majority of farmers (87.7%) noted that deforestation (which is otherwise referred to as logging or cutting down of trees in the process of clearing the land for crop cultivation) leads to climate change. There was however no significant difference ($p > 0.05$) among the responses of the farmers (Table 3).

3.2.2. Slash and burn

Table 4. Slash and burn as a contributing factor to climate change (CC)

			Slash and burn			Total
			Yes	No	No idea	
Observed climate change	Yes	Count	132	10	0	142
		% of Total	85.7%	6.5%	0.0%	92.2%
	No	Count	11	0	1	12
		% of Total	7.1%	0.0%	0.6%	7.8%
Total		Count	143	10	1	154
		% of Total	92.9%	6.5%	0.6%	100.0%
Pearson chi square		P – value (0.002)				

Source: Author's field data (2015).

Majority of farmers (85.7%) affirmed that slash and burn as a farming method contributes a great deal to climate change (Table 4). There was a significant difference ($p < 0.05$) among the responses of farmers regarding slash and burn contributing to climate change. This means that the proportion of farmers who perceive that slash and burn as a farming practice in the study area contributes to CC differs significantly from the proportion of farmers who perceive other alternatives.

3.2.3. Bush burning

Table 5. Cross tabulation of bush burning as a contributing factor to CC

			Bush burning			Total
			Yes	No	No idea	
Observed climate change	Yes	Count	133	8	1	142
		% of Total	86.4%	5.2%	0.6%	92.2%
	No	Count	11	1	0	12
		% of Total	7.1%	0.6%	0.0%	7.8%
Total		Count	144	9	1	154
		% of Total	93.5%	5.8%	0.6%	100.0%
Pearson chi square		P – value (0.893)				

Source: Author's field data (2015).

From Table 5, majority of farmers (86.4%) indicated that bush burning (deliberate burning the vegetation of an area either under controlled or uncontrolled supervision by farmers as ways of clearing the land for farming or other purposes) have contributed to climate change in the area. However, there was no significant difference among the proportions of the responses ($P > 0.05$). This implies that the proportion of respondents who indicated bush burning as contributing to climate change is not significantly different from the proportion of respondents who did not see bush burning as a contributing factor to climate change.

3.2.4. Fertilizer application

Table 6. Cross tabulation of fertilizer application as a contributing factor to CC

			Fertilizer application			Total
			Yes	No	No idea	
Observed climate change	Yes	Count	20	121	1	142
		% of Total	13.0%	78.6%	0.6%	92.2%
	No	Count	2	10	0	12
		% of Total	1.3%	6.5%	0.0%	7.8%
Total		Count	22	131	1	154
		% of Total	14.3%	85.1%	0.6%	100.0%
Pearson chi square		P – value (0.932)				

Source: Author's field data (2015).

Majority of farmers (78.6%), indicated that the use of fertilizer for farming purposes does not in any way contribute to climate change (Table 6). There was no significant difference ($p > 0.05$) among the proportions of responses by farmers. Farming activities to a large extent contribute to the problem of climate change since it adds up to the greenhouse gas emissions. A previous study supported the findings of the current research and emphasised that land use and land cover change through agricultural activities add up to nearly one-third of greenhouse gas emissions [19] . It is obvious that most farmers perceive that farming practices such as slash and burn, deforestation and bush burning actually contribute to climate change based on their observations.

From the findings, majority of farmers indicated that deforestation, slash and burn and bush burning which are mostly practiced by farmers lead to climate change. These practices thus constitute the driving-forces component of the DPSIR framework. However, fertilizer application according to them does not lead to climate change. This notion indicates that not all farming practices that contribute to climate change are known by farmers especially when it has some scientific underpinnings. This is because, fertilizer, right from the production point of compost making to the application point also contribute indirectly to climate change especially the inorganic fertilizers (N_2O). The production of mineral fertilizer (N P K) implies the use of energy and other materials like nitrous oxides and methane which result in emissions of GHG [20]. This means that the more farmers use fertilizers for production, the more they encourage its production. Typical GHG emissions per kg of nutrients produced in Denmark alone are 4.75–13.0 kg CO_2-eq. for N fertilizers, 0.52–3.09 kg CO_2-eq. for P and 0.38–1.53 kg CO2-eq. for K [20]. Most practices that cause climate change usually increase the levels of CO_2 concentration in the atmosphere or decrease its removal or use by plants. Food systems contribute 19%–29% of global anthropogenic greenhouse gas (GHG) emissions, releasing 9,800–16,900 megatonnes of carbon dioxide equivalent ($MtCO_2$-eq) in 2008 [21]. Agricultural production, including indirect emissions associated with land-cover change, contributes 80%–86% of total food system emissions, with significant regional variation [21].

3.3. Perceptions of Farmers on Effects of Changes in Rainfall Pattern on Output of Crops

Table 7. Cross tabulation of point of effect of changes in rainfall pattern on crops

			Changes in rainfall pattern		Total
			Yes	No	
Point of effect	land preparation	Count	15	0	15
		% of Total	9.7%	0.0%	9.7%
	germination and growth	Count	26	2	28
		% of Total	16.9%	1.3%	18.2%
	fruit development	Count	64	2	66
		% of Total	41.6%	1.3%	42.9%
	Maturity	Count	41	4	45
		% of Total	26.6%	2.6%	29.2%
Total		Count	146	8	154
		% of Total	94.8%	5.2%	100.0%
Pearson chi square		P – value (0.405)			

Source: Author's field data (2015).

Cross-tabulation on point (or stage in the production process) of effect of changes in rainfall pattern on crops showed that 94.8% of farmers observed changes in rainfall pattern and how it affects crop production with 41.6% indicating its impact on fruit development stage (Table 7). There was however no significant difference among the responses on the point of effect ($p > 0.05$). This implies that changes in rainfall pattern equally affects land preparation, germination and growth, and fruit maturity to similar extents. Changes in climatic variables such as rainfall, temperature and windstorm may invariably affect the output of crops. The impact may affect the crops at any stage of the production process right from the land preparation to maturity stage of crops. From Table 5.6, most farmers indicated that changes in rainfall pattern affects crop production (especially maize and plantain) negatively especially at fruit development stage. Most farmers linked the effects of changes in rainfall pattern to at least one stage of crop production process. It became clear from the Focus Group Discussion (FGD) that variability or changes in rainfall pattern in the form of delayed rainfall affect crops especially maize, cassava and plantain at their critical stage of developing fruits thereby resulting in drastic reduction of output which is a major function of food security.

As an affirmation, the impact of the delayed rains on plantain and maize outputs was further stressed by one of the farmers which met a unanimous support from all others during the FGD. He remarked:

> *"my son, this your climate change has really caused us great harm because, the delayed rains of recent years result in development of small sizes of plantain fruits to the extent that even a little child can easily lift it, meanwhile this wasn't so some years past. I can say confidently that this can never be attributed to soil infertility or other factors, because the soil is fertile enough since we allow land to fallow for years. Sometimes too, when the rain ceases (for about a month or more) after few days of early showers, it becomes disastrous to the maize crop especially after germination since it doesn't get enough water to develop and mature the corn in time".*

A similar observation was made by previous studies concerning how unpredictable and unreliable rainfall has become a threat to agricultural activities. During the field observation an ideal maize farm at its critical and vulnerable stage (fruit development stage) was shown to us, that all things being equal, the maize will produce the required quantity of corn (see Figure 1). However, that stage or point in the life span of maize crops is so critical, that it is highly vulnerable to instances of delayed rains or outright rain failure, and since fruits are developing at that stage, it can cause deficiency to crop yield and a reduction in output or complete loss of productivity. Again during extreme weather events such as strong winds and floods, a whole maize and or plantain farms are pulled down leading to complete loss of the entire farm during the fruit development stage. It was explained that the crops at that stage become heavier in weight because of the fruits they bear and so easily fall down during such extreme weather events as windstorm. When this happens the yield is greatly reduced or leads to total loss.

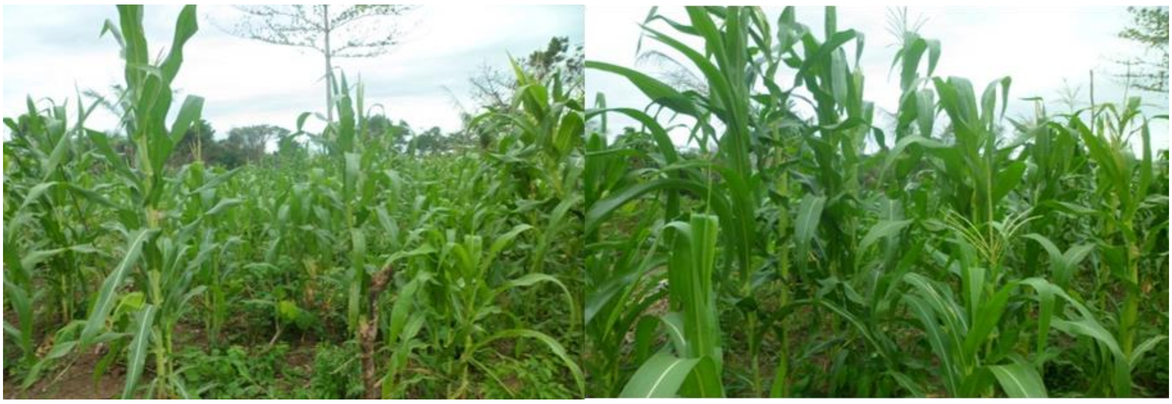

Figure 1. Maize farm at its critical and most vulnerable stage in developing fruits (corn); a shot from a farmer's farm at Awaso-Asempanaye community. (Source: Field survey)

It is worth noting from the regression results in chapter four that the overall impact of rainfall on maize and cassava output over the 31-year period was negative even though not significant. Farmers have also observed a reduction in output of maize and plantain due to extreme weather events like windstorms which mostly accompany heavy rainfalls.' Perceptions of farmers connote more of a great loss, but their observations are informed from variability of climatic elements' point of view rather than a change of climatic elements over the 31-year period. With this food security per this study is highly threatened since at every point in time such extreme weather events could result in output loss if appropriate adaptation measures are not put in place.

The trend analysis in chapter four also showed a non-significant monotonic increasing trend in rainfall pattern over the period which is also consistent with the coefficient of variation of the rainfall data set. In like manner, the output of maize and plantain were highly elastic to changes in rainfall amount and if farmers also noticed a negative impact on maize output, it means there is consistency in the findings from both the secondary data and the empirical primary data.

3.4. Perceptions of Farmers on the Effects of Changes in Temperature Pattern on Crop Production

Table 8. Cross tabulation of point of effect of changes in temperature on crop

			Point of effect				Total
			land preparation	germination and growth	fruit development	Maturity	
Change in temperature affect Output	Yes	Count	15	26	61	44	146
		% of Total	9.7%	16.9%	39.6%	28.6%	94.8%
	No	Count	0	2	5	1	8
		% of Total	0.0%	1.3%	3.2%	0.6%	5.2%
Total		Count	15	28	66	45	154
		% of Total	9.7%	18.2%	42.9%	29.2%	100.0%
Pearson chi square			P – value (0.457)				

Source: Author's field data (2015).

Majority of farmers (94.8%) indicated that change in temperature affects output with 39.6% indicating its effect on fruit development stage (Table 8). There was no significant difference among the responses regarding the point of effect of change in temperature ($p > 0.05$). This implies that farmers were able to acknowledge that change in temperature affected land preparation, germination and growth, fruit development and maturity. Majority of the farmers indicated that changes in temperature affect crop yield especially during the fruit development stage. Farmers also acknowledged the impact of changes in temperature on land preparation, germination and maturation stages of crop production. Emphases from the FGD has it that except for mulching (an adaptation measure) that shields the tubers of cassava from the high intensity of the incoming solar radiation (high temperatures), in most cases the tubers become heated up in the soil and get rotten. A doubling effect is observed in the rate of photosynthesis when temperature changes by 10^0C help to increase crop output, however excessive temperature as in the case observed by farmers inhibits enzyme activities thereby reducing productivity.

Another observation made by most of the farmers over the years which was raised during the FGD was that the high temperatures lead to extinction of most native plants and weeds and lead to proliferation of strange weeds (Figure.2) that seem to colonize the land and affect the thriving of the crops. The two most troublesome strange weeds that were identified are called "*Ananse Tumi* and *Onyame Nwui a Menwui*" in the local parlance, which means by translation "*the power of the spider* and *I live as long as God lives or until God dies I will never die*" respectively. These weeds are both creeping plants (see Figure 2) and attack both the bare land and coil around the maize, cassava and plantain plants to climb in order to pull them down. Their proliferation is such that once they emerge, they will continue to flourish whether rainy season or dry season and they don't die even after they are cleared. When this happens, the weeds usually take over the farms since farmers find it difficult to control and leads to deficiencies like stunted growth of crops and poor yield in terms of quality and quantity.

This is directly consistent with the findings of the OLS (regression) model in chapter four, since the output of all the crops (maize, cassava and plantain) were negatively impacted by the monotonic increasing temperature trend. A consistency in the sense that, the results of the Sen's slope of the trend analysis of rainfall and temperature revealed a highly significant monotonic increasing trend. The impact of such increasingly high temperatures also showed a significant negative impact on maize output. Farmers have also observed a decrease in output of most crops due to extreme events like excessively high temperatures and dry spells. This has negative implication on food security if appropriate measures are not put in place to adapt.

Figure 2. Strange creeping plants induced by extremely high temperatures. Source: Author's field work

4. Conclusions and Recommendatuons

The study revealed that, output of maize, cassava and plantain have all proved to be negatively impacted by changes in rainfall and temperature patterns with a more significant impact observed from maize responses to temperature. Changes in climatic variables such as rainfall, temperature, windstorm and humidity invariably affect the output of crops negatively. The study also indicated that the impact of climate change may affect the crops at any stage of the production process right from the land preparation to maturity stage of crops but more profound effect is observed at fruit development and maturation stages. The study indicated that changes in temperature affect crop yield especially during the fruit/seed development stage. Some farmers also acknowledged the impact of changes in rainfall on fruit development stage, germination and maturation stages of crop production. The study revealed that majority of farmers, (about 92.2%) have observed climate change in the study area and indicated events like unpredictable rainfall pattern, excessively high temperatures and strong winds. More so, to confirm their observations that indeed the climate has changed, they linked CC to specific events like sounds of some animals such as frogs and crickets which for a long time have been aligned to the onset of rains but which have changed completely. It is recommended that capacity building and awareness creation should be enhanced GMA and MoFA through the media to ensure that communication about climate change and food security is meaningful. This means that education on diversification of farming methods has not been enough if there is any at all in the area. Awareness creation therefore allows people to make informed and responsible decisions towards sustainable farming practices which will lead to food security and also environmental sustainability.

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