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FARMERS' PERCEPTION ON CLIMATE CHANGE ITS MANIFESTATIONS IN SMALLHOLDER COCOA SYSTEMS AND SHIFTS IN CROPPING PATTERN IN THE FOREST-SAVANNAH TRANSITIONAL ZONE OF GHANA

BY

EDWARD YAW KYERE

JUNE, 2016

FARMERS’ PERCEPTION ON CLIMATE CHANGE; ITS MANIFESTATIONS IN SMALLHOLDER COCOA SYSTEMS AND SHIFTS IN CROPPING PATTERN IN THE FOREST-SAVANNAH TRANSITIONAL ZONE OF GHANA

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN SUSTAINABLE AND INTEGRATED RURAL DEVELOPMENT

BY

EDWARD YAW KYERE

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DECLARATION

I, **Edward Yaw Kyere**, author of this thesis do hereby declare that except for specific references which have been duly acknowledge, this project is the result of my own research and it has not been submitted either in part or whole for any other degree elsewhere.

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ABSTRACT

The current and projected climatic conditions show a rise in temperature and decrease in mean annual rainfall in all the agro-ecological zones of Ghana, including cocoa growing areas in the forest-savanna transitional zone. Cocoa systems are therefore expected to be impacted on negatively, with its resultant effect on rural livelihood. However, there are indications that farmers in the study areas are massively converting croplands to cocoa farming in spite of the climatic effects on cocoa. The study therefore explored farmers' perception on changes in climatic parameters (rainfall and temperature) and the effects of farmers' perceived manifestations and impacts of climate changes on shifts in smallholder cocoa farming systems in the forest-savannah transitional ecological zone of Ghana. The study was situated in three epochs (pre-fire, post fire and the current epoch) to give respondents a better reference to the relativity of climate change and its impacts on cocoa over a forty year period. Also, in order to have a better understanding of the historical perspective of climate impacts on cocoa, farmers aged 45 years and above formed the sample population for the study. A multistage sampling technique was employed in selecting a sample size of 270 cocoa farmers from nine communities in the Berekum, Wenchi and Techiman Municipalities of Brong Ahafo Region. Results show that farmers have perceived changes in rainfall and temperature over the forty year period, which contributed to the prolonged dryness hence the seasonal bushfire destroying cocoa farms. It was also perceived that the changes in climate and its impacts contributed to shifts in cropping systems from cocoa to annual crops (maize dominant), which became the major livelihood of farmers in the post-fire economy. The study brought to the fore evidences that show that although climate change is impacting negatively on crop production, there are indications of massive shifts to cocoa production, with farmers indicating that current value chain challenges with cereal production makes cocoa cultivation a better livelihood option. Thus, in the face of perceived climate impacts on cocoa, farmers are increasingly converting annual crops (mostly cereals) into cocoa systems by adopting some on-farm measures such as planting more plantain suckers at least inches away from cocoa seedlings as shade for the young cocoa. Also the adoption by farmers irregular planting of seedlings for the purposes of insurance and creating good micro environment. The use of shade trees is also becoming a common practice by farmers and other on-farm practices to protect their farms against bushfires. It can be concluded that farmers have shifted their sources of livelihood from cocoa in the pre-fire epoch to cereals in the post-fire epoch and are now increasingly converting annuals croplands to cocoa systems, in spite of current and projected impacts of climate on cocoa. The study holds implications for the sustenance of farmer livelihood in the forest-savanna transitional zone within the context of perceived climate impacts.

DEDICATION

This work is dedicated to God Almighty for the gift of life, for hearing my daily prayers and the many blessings and mercies given my family and myself. Thank you (Mother Mary) for interceding on behave of me whenever I pray to your son our Lord and savior Jesus Christ. Also to my Mum and Dad (Elizabeth and Paul) and my siblings (Eugenia, Bernard, Collins and Benedicta) for the support and prayers

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LIST OF ACRONYMS

ACPC	African Climate Policy Centre
ARCC	African And Latin American Resilience To Climate Change
AIPM	Agricultural Investment Portfolio Model
CYRT	Crop Yield Response Theory
CGIAR	Consultative Group On International Agricultural Research
COP	Conference Of Parties
CRIG	Cocoa Research Institute Of Ghana
COCOBOD	Ghana Cocoa Board
CSD	Cocoa Service Division
CDM	Clean Development Mechanism
CII	Country Implementing Institution
ENSO	El Nino Southern Oscillation
ENRAC	Environment And Natural Resources Advisory Council
EPA	Environmental Protection Agency
FAO	Food And Agricultural Organization
FSD	Forest Service Division
FOB	Free On Board
GAIP	Ghana Agricultural Insurance Programme
GCM	Global Circulation Model
GDP	Gross Domestic Product
GHG	Green House Gases
GMET	Ghana Meteorological Agency
GSGDA	Ghana Shared Growth And Development Agenda
GSNC	Ghana’s Second National Communication
ICCO	International Cocoa Organization
IIPACC	Innovative Insurance Products For The Adaptation To Climate Change
IPCC	Intergovernmental Panel On Climate Change
IFPRI	International Food Policy And Research Institute
LAI	Leaf Area Index
LSP	Light Saturation Point
MSD	Meteorological Services Department
MOFA	Ministry Of Food And Agriculture

MTM	Metaeconomic Theoretical Model
NAMA	Nationally Appropriate Mitigation Actions
NEPAD	New Partnership For Africa's Development
NCCSAP2	Netherlands Climate Change Studies Assistance Programme Phase 2
NCCAS	National Climate Change Adaptation Strategy
NCCC	National Committee On Climate Change
NDPC	National Development Planning Commission
NREG	Natural Resources And Environmental Governance
PACJA	Pan African Climate Justice Alliance
RM	Ricardian Theory
SCM	Simple Climate Model
SRID	Statistical Research And Information Department
USAID	United States Agency For International Development
UNFCCC	United Nations Framework Convention On Climate Change
VNM	Von Neumann-Morgenstern Theory
WCF	World Cocoa Foundation

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

This research focuses on farmers' view on changes in climatic parameters on smallholder cocoa (*Thebroma cacao*) production and shifts in cropping pattern in the forest – savanna transitional zone of Ghana. Cocoa produce from the agricultural sector serves as an important cash crop around the world especially for developing nations and a vital import for processing and consuming countries. A regular demand from worldwide consumers draws numerous global efforts and funds committed to supporting and improving cocoa farm sustainability (WCF, 2012). Cocoa is known to be one of the significant land uses in the West African Sub-region which is the largest producer. It is known to occupy about 5 and 6 million hectares of the moist tropical forest of the producing countries like Cote D'Ivoire, Ghana, Nigeria and Cameroon (Gockowski *et al,* 2004).

According to a report by World Cocoa Foundation (2012), Africa is known to be and is projected to remain the principal cocoa producer with its 73% share in 2011 market; with Cote d'Ivoire alone producing 40% of the global percentage. Ghana is the third largest world producer (Gockowski *et al.* 2004) and the second largest exporter of cocoa beans after Cote D'Ivoire (Gain, 2012). Cocoa is by far Ghana's most important cash crop dominating the agricultural sector. It is a major source of income for approximately 800,000 smallholder farm and families and others engaged in trade, transportation and processing of cocoa (Anim-Kwapong and Frimpong, 2008). For Ghanaian cocoa farmers, cocoa contributes 70%-100% to their annual household income (Ntiamoah and Afrane, 2008). Over the last 20 years, the poverty rate of cocoa farmers in Ghana declined from 60.1 % in 1991/92 to 23.9 %, or 112,000 households, in 2005/06 (Coulombe and Wodon, 2007). Cocoa occupies 2.4 million hectares in Cote D'Ivoire and 1.5 million hectares in Ghana which is more than in any country in the world (Franzen and Borgerhoff, 2007). These make the cocoa sector very important to the countries and Africa in general in terms of its socioeconomic development.

Evidence shows that about 60 percent of Africans depend on agriculture directly for their livelihood (FAO, 2003). That notwithstanding, the continent is known to be vulnerable to the impacts of climate change. This is because natural resources on which they depend are being lost through environmental degradation thus enhancing the impacts of climate change felt by millions of Africans (PACJA, 2009).

Major driving factors of cocoa production internationally have been the Economic, Ecological and Technological factors over the last three decades. In the late 1970s when there was almost a collapse of Ghana's cocoa sector, Cote D'Ivoire took the chance and became the world largest producer (Ruf, 2007). Production in Ghana slowly rose during the 1990s and after a boom production in 2000, returned to the high levels of the 1960s (ibid) it has been estimated that in 2010/2011 Ghana's export of cocoa reached 1,004,000 MT (Gain, 2012). In terms of world cocoa exports, Ghana has maintained its position as second largest exporter (by quantity) of cocoa beans for the period of 2005-2011. According to 2016 Statistics compiled by Statista on Global cocoa bean production from 2012/2013 to 2014/2015, by country (in metric tons) show that currently the three major producing countries are Côte d'Ivoire, Ghana and Indonesia. Surprisingly all the three major producing countries are predominantly smallholder enterprises showing the efficiency of smallholder cocoa system as compared to estates (Statista, 2016). However cocoa production increases for centuries have been achieved through massive migration and extensification at the expense of tropical rain forest (Ruf, 2004).

Despite the gains of increased production of the producing countries there have been series of events which in one way or the other inhibited the cocoa sectors' progress. Evidences show the cocoa sector had in the past suffered some major setbacks, renowned is the period 1982-83 that saw a major twist in the cocoa industry in Ghana. Literature shows a massive drop in levels of production considerably from over 450,000 tons in the 1960s to as low as 159,000 tons in 1985 (Berry, 1994). This massive decline was attributed to several factors including pests and diseases, aging trees, lower producer price, climate variability and change, changes in environmental conditions and the 1983 bushfires that ravaged the whole nation (Adjei-Nsiah and Kermah, 2012). Forest cover loss was high as a result of wildfires and there was decline in agricultural crop production after the 1983 wildfires ravaged the semi-deciduous forest zone (Hawthorne, 1994; Nsiah-Gyabaah, 1994). An estimated 60,000 hectares of cocoa farms in the entire country were destroyed by the 1983 bushfires. Cocoa sector in Ghana has showed a remarkable salvage in recent years. A record Production height of nearly 1 million metric tons has been reached. Currently, Farmers comparatively receive a large share of the Free on Board (FOB) price; Bean quality is prominent worldwide and regularly exceeding the most rigorous international standards.

Agriculture is known to contribute about 50% of total export worth of Africa and about 21% of its total GDP (Mendlesohn *et al.,* 2000). The developmental impacts of changes in climatic parameters on Africa suggests that food security and smallholders' incomes are severely threatened as growing seasons shorten and percentage of arable lands decline (Adjei-Nsiah and Kermah, 2012). Ghana is experiencing a progressive increase in temperature with a corresponding decline in rainfall across all ecological zones (EPA, 2007). The Ghana Meteorological Agency's (GMet) scenarios of climate change established based on forty year data predicts a continuous rise in temperature with average increase of about 0.6°C, 2.0°C and 3.9°C by the year 2020, 2050 and 2080 respectively whiles rainfall is also predicted to reduce on average by 2.8%, 10.9% and 18.6% by 2020, 2050 and 2080 respectively in all agro-ecological zones in Ghana (EPA, 2007, Minia *et al*. 2004 cited in NCCAS, 2010). Patterns of agriculture production in Ghana have been impacted by these predicted changes especially in the regions where the agro-ecological systems are in transition. Those known to be more vulnerable to the manifestations of climate change are the various smallholder farmers in Ghana who are known for the bulk production of food and cash crops (Adjei-Nsiah and Kermah, 2012). According to Agyeman Bonsu *et al*., (2008) cereals and cocoa are crops that are particularly important and would be adversely affected.

The rainfall epoch normally affects the year to year variations in yield of cocoa more than by any other climatic variable (ICCO, 2009). Cocoa production is heavily influenced by the pattern of rainfall, thus distribution of monthly rainfall averagely during the course of the year is more important than the annual total rain (Marcella, 2008). Also dry conditions where rainfall is less than 100 mm per month should not go more than three months since marked dry periods may result in reduction in Leaf Area Index (LAI) known to be the key causes of the lower annual cocoa yields (Zuidema *et al.*, 2005). A regression analysis by Zuidema *et al*. (2005) suggested that quantity of rainfall during the driest months of the year is more important than the total annual rainfall in determining the yield of cocoa. Though cocoa yield is correlated with total annual rainfall, it shows strong correlation with the total annual rainfall during the driest month of the year. It is known that annual rainfall in excess of 2,500 mm is likely to lead to a higher incidence of fungal diseases, the most common being Phytophtorn pod rot, the main cause of the black pod disease, and the cocoa swollen shoot virus (Wood and Lass, 1985; ICCO, 2000).

Prolonged dry season and seasonal bushfires make the production of cash crops such as cocoa extremely difficult (Adjei-Nsiah and Kermah, 2012). According to studies by Amanor (1993) and Adjei-Nsiah *et al*. (2007), cocoa remained an important cash crop in Wenchi and for that matter Brong Ahafo until the 1983 bushfires which ravaged the whole country. Any attempt at replanting cocoa in these areas after the fire epoch failed partly due to increasing climatic variation, environmental changes, deforestation and the persistent dry season bushfires (Amanor, 1993) resulting in a shift in the cropping patterns.

Plate 1 - 1: A matured cocoa tree bearing fruits

To the farmer in developing countries like Ghana, Nigeria and Cote d'Ivoire, a matured cocoa tree (Plate 1-1) is a life line to his/her family. It is an important tropical income earning tree for the upkeep of farmers and the households. Cocoa is a prominent cash crop to the Government, its contribution to socioeconomic growth cannot be over-highlighted. Therefore Cocoa is regarded as an important crop not only to the smallholder farmers but to the economy of Ghana as a whole (Danso-Abbeam, 2012). In view of this it is important to understand the perspective of farmers on observed changes in climate, the response of farmers to these changes in the aftermath of the nationwide fire ravage, the specific strategies being adopted for a post cocoa rural economy in the Brong Ahafo Region of Ghana and the necessitating conditions resulting in farmers reverse to cocoa farming.

1.2 Problem statement

Cocoa is Ghana's most important cash crop dominating the agricultural sector and serving as a major livelihood option for more than 800,000 smallholder families; it is meaningfully contributing to the socioeconomic development of the country in varying ways. In 2009/10 financial year for instance, export and local duties Ghana Cocoa Board (COCOBOD) paid to the government treasury was GH¢153,933.25 including performing some social responsibility services for many communities around the country (COCOBOD, 2011; Asamoah *et. al.,* 2013). To the cocoa farmer, cocoa tree is a life line to his/her family. But, while the regional contribution of cocoa production has increased in other regions of Ghana, that of the Brong Ahafo Region has been on the decline (COCOBOD, 2011).

As reported by Adjei-Nsiah and Kermah, (2012), cocoa growing areas in the Brong Ahafo Region declined, with farmers abandoning or converting cocoa plantations into annual food crops (maize, yam, pepper, Okra) and other perennial crops (cashew, orange, mango and teak). While cocoa production decreased in the entire Brong Ahafo Region, available data indicated that cocoa production was at the same time increasing in the Western Region, another major cocoa producing area in Ghana which lagged behind Brong Ahafo in cocoa production in the 1970s. This suggests that factors responsible for the decline in cocoa production in Brong Ahafo were specific to the local conditions (Adjei-Nsiah and Kermah, 2012). The causes of the decline in cocoa production in most areas have been attributed to a combination of factors, which include; seasonal bushfires, deforestation, poor farm maintenance, poor environmental conditions, and all these factors are exacerbated by variability and changes in climatic parameters (Ibid). While most of these factors can be addressed through law enforcement, forest governance and the provision of extension support, the aspect relating to climate is challenging (ibid). Changes in rainfall and temperature are affecting cocoa in various stages (Codjoe *et al.,* 2013) and there is no information on the manifestations of climate impacts in cocoa systems which will inform appropriate extension support for farmers.

Among other things, Ghana's historical data from 1961 to 2000 show clearly an upward movement in temperature and downward trend in mean annual rainfall across all the agro-ecological zones with annual temperature increase of 1°C in the last 30 years (Minia *et al*., 2004; NCCAS, 2010). Notwithstanding the changes in the prevailing climatic parameters and environmental factors in the Brong Ahafo Region, as well as indications from research findings alluding to the fact that future shifts from annual crops to cocoa based cropping is unlikely since the uncertainty in climate impact are making evaluation of potential impacts on cocoa production difficult (Läderach *et al.*, 2011;2013), a reconnaissance survey at the study area showed that farmers are actively reverting to cocoa farming, with most cereal farms being converted to cocoa. Furthermore, there is no documentation of the factors informing farmer decision to revert to cocoa systems in most parts of the forest-savanna transition zone, given that recent scientific findings and climate data have showed that the forest-savanna transition zone will have climatic parameters that will be unsuitable for cocoa cultivation (Anim-Kwapong and Frimpong, 2008; Läderach *et al*., 2013).

The forest-savanna transitional zone was dominated by cocoa, which declined and farmers converted to cultivating annual crops. Farmers are now reversing most annual/cereal farms into cocoa. Surprisingly current and projected climatic variables in the forest-savanna transitional zone are predicting the zone to be unsuitable for cocoa production. It is therefore paramount to recognize the contribution of climate related issues, environmental factors and their impacts on cocoa production in transitional zone, the response of farmers to these changes, the specific strategies adopted by farmers in a post cocoa rural economy in the study areas and the necessitating conditions resulting in farmers' decision to revert to cocoa farming in despite predictions are otherwise.

1.3 Justification

Cocoa has long played significantly in the country's development and continues to be vital source of rural employment livelihood (SCRA, 2011) but the apprehensions over low productivity and environmental impacts have long fired insecurity over the sector's long-term sustainability (Gockowski, 2007; Vigneri, 2007). According to WCF (2012) Africa has been and is projected to remain the principal cocoa producer but the issue of climate change is a big concern. With various studies predicting the agriculture being impacted on by climate change including cocoa which is the main livelihood option for most rural Africans especially in Ghana; the Pan African

Climate Justice Alliance (2009) reports that Africa is particularly susceptible to climate change because natural resources on which they depend are being lost through environmental degradation.

Ghana's cocoa production internationally has increased, but that of Brong Ahafo has reduced according to COCOBOD (2011). This Adjei-Nsiah *et al.*, (2010) attributes to numerous factors, which could be specific to the local conditions of Brong Ahafo Region given that other regions are increasing in production. With the evidence that most areas in Brong Ahafo have shifted back to cocoa production, it is relevant to study the cycle the region has undergone by documenting farmers' perception of climate change; the pre-fire, post-fire and current agricultural land uses (cropping pattern); manifestations of changes in climate on cocoa; environmental changes and livelihood shifts; and the reasons why farmers are shifting back to cocoa production. It is also necessary to learn about the practices (innovations) farmers are adapting in the current cocoa farming in this era of changing climatic conditions.

1.4 Research question

How has climate variability and its impacts contributed to the shifts in smallholder cocoa systems within Brong Ahafo Region, and what are the responses to these impacts?

1.4.1 **Specific Questions**

1. How has climatic parameters affected the cocoa farming systems in the pre-fire, post-fire and current epochs in the forest-savannah transitional zone?
2. What cropping activities have characterized the forest-savannah landscape and what reasons informed farmers' decision for the changes in cropping systems?

3. How are farmers responding to the impacts and manifestations of the climatic parameters on cocoa?

1.5 Aim

The aim of this study was to document farmers' perception on how climatic parameters and its impacts contributed to shifts in cropping patterns in smallholder cocoa systems in the forest-savanna transitional zone and the responses farmers made in terms of on-farm practices, land use and livelihood options.

1.5.1 Specific Objectives

1. To explore farmer perception on changes in climatic parameters and its impact on smallholder cocoa systems in the forest savannah transitional zone.
2. To document shifts in cropping systems that characterized the landscape from the pre-fire to the current epoch and the reasons informing farmer decision for these changes.
3. To determine the response of farmers to the impacts of climate change in cocoa in terms of on-farm practices and land use following the fire epoch in the cocoa producing areas.

1.6 Organization of the study

This study is structured into six chapters. Chapter one opens with background information of the study followed with problem statement and research questions relevant to the study. Chapter one also contains the objectives of the study followed by the need for undertaking the study. The scope as well as the organization of the study can also be found here.

In chapter two, relevant literature based on critical review and evaluation of the empirical and theoretical propositions and generalization on the subject matter are the main focus. This is important in understanding the work of others and gaps that could be filled in already completed works in order to add more to knowledge.

The third chapter contains the methodology employed in this study. Here, the choice of the study area and sampling procedure as well as the data collection method are elicited and includes some basic concept definition as used in this work. Chapter four deals with results analysis and presentation pertaining to the data collected, and discussion of the outcome in chapter five. The study then concludes with chapter six, which summarizes the major results of the study and the main recommendations.

CHAPTER TWO

THEORETICAL FRAMEWORK, THEORETICAL UNDERPINNING AND LITERATURE REVIEW

2.1 Theoretical framework

The study areas in the Brong Ahafo region were known to be major cocoa growing areas in the Pre-fire epoch (1960's and 1980's). The climatic variations, environmental conditions, soil fertility were all in a relatively good condition supporting the establishment of various smallholder cocoa farms in these areas. Historically, Ghana has experienced some instances of national disasters related to rainfall deficits. This is said to be partially swayed by the *El Nino Southern Oscillation* (ENSO), where changes in temperature and air surface pressure in the tropical western Pacific have led to below average rainfall in such years (Stutley, 2010).

Within the past 50 years, the worst El Niño year occurred in 1983 which led to a National response to receive food aid. Several efforts to prepare for such emergency situations are orchestrated to reduce and likewise to respond to Ghana's increased risk and risk exposure. Researchers established the nationwide fire ravage as the spark of worsening situation in the cocoa growing areas (Sakyi-Dawson *et al*., 2006; Adjei-Nsiah *et al*., 2010, Adjei-Nsiah and Kermah, 2012).

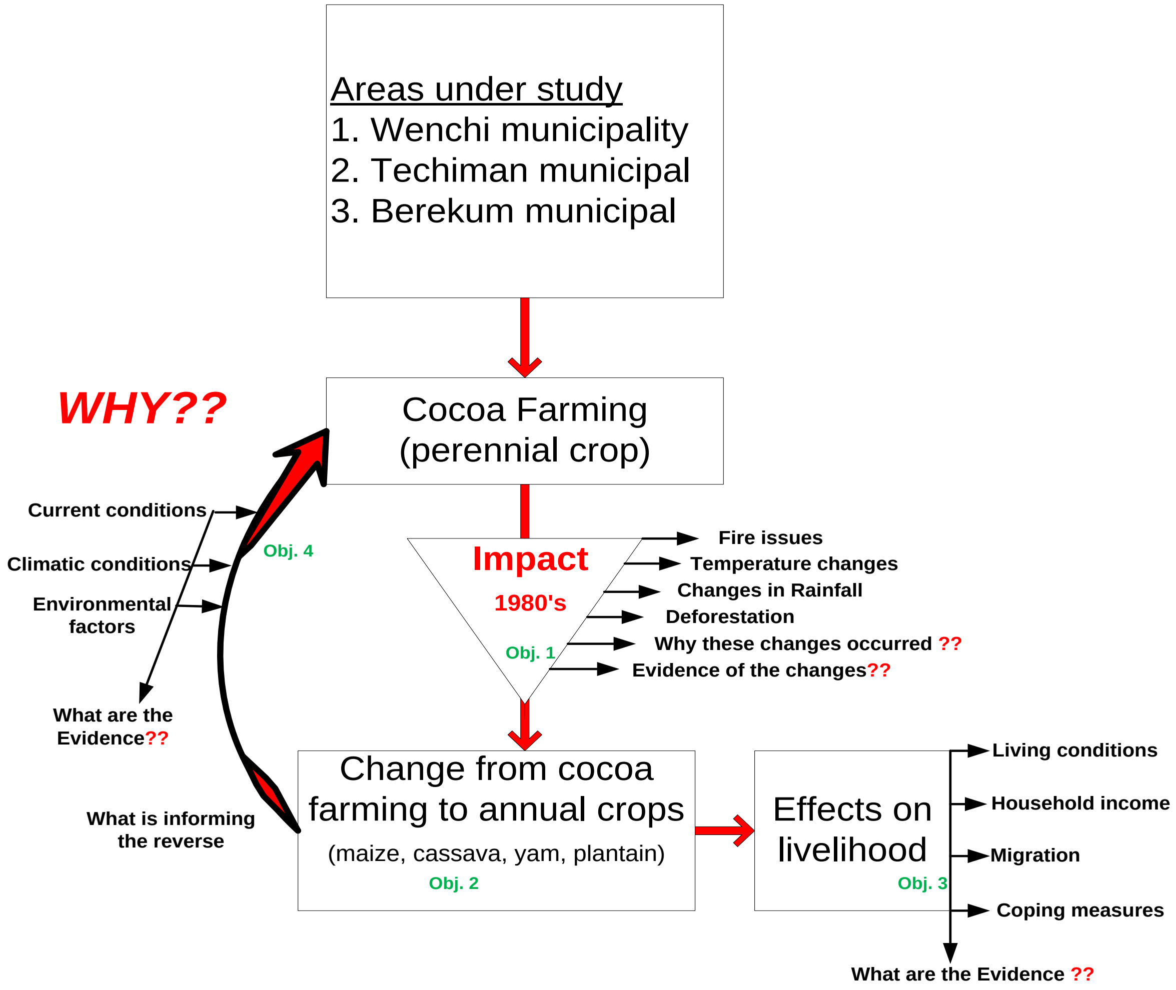

Figure 2 - 1: Illustration of the logical framework

Environmental factors like deforestation which opened up the forest areas and massive harvesting of timber also played a major part in the overall negative impacts on cocoa growing areas. The work of Adjei-Nsiah and Kermah (2012), conducted in the Wenchi municipality outlined clearly the impact of climate change and the resulting shift in cropping from cocoa to maize.

The 1983 bushfire and the prolonged dry season that followed made the production of cocoa extremely difficult for smallholder cocoa farmers. According to Amanor (1993) and Adjei-Nsiah et al. (2007), cocoa remained an important cash crop until the 1982-83 bushfires which ravaged the whole country. All attempts cocoa farmers made to bounce back failed partly due to increasing deforestation and the seasonal bushfires

(Amanor, 1993) resulting in a shift in the cropping patterns from cocoa to annual food crops (maize, yam, plantain, cassava). The study by Adjei-Nsiah and Kermah, (2012) for instance concluded that the prevailing climatic conditions and the deforestation activities in Wenchi suggested future shift from maize to cocoa based cropping is unlikely. They added though, that adaptation needs of farmers in the area suggest the need to redesign research and extension support systems. This may include both technical (new technologies and technical practices) and institutional dimensions (e.g. adapted land tenure arrangement and contract, the reorganization of input supply and marketing arrangement for the new crops) in order to improve collective adaptive capacity of the rural communities.

Feasibility studies of the areas under study have shown a massive reverse of farmers to the cocoa cropping on large-scale re-establishment. This study therefore sorts to investigate the reasons informing the reversal to the current cocoa cropping by farmers. The issues of changes in climatic parameters, worsening environmental conditions are still of great concern at the global level and its impacts are felt in everyday life activities of various stakeholders. Therefore finding out what has changed on the environmental front, climatic conditions, soil fertility and the social parameters (livelihood of the people) and finally the evidence of the changes in current conditions necessitating the reverse to cocoa cropping in the study areas are key components of this study.

2.2 Theoretical underpinnings

Underpinning climate change and crop productions are these theories: the Ricardian Theory (RM), Crop Yield Response Theory (CYRT), Agricultural Investment Portfolio Model (AIPM) and Metaeconomic Theoretical Model (MTM).

At the micro level, one approach of finding the impact of climate change on crop revenue in general is the Ricardian Method (RM) which regresses climatic variable such as temperature and precipitation on farm yields. A cross-sectional technique that measures the determinants of farm revenue based on Ricardo's original observation that the value of land reflects its productivity (Asafu-Adjaye, 2008).

As cited in Seo, *et al*., (2005), the RM accounts for the direct impact of climate on yields of different crops and an indirect replacement of different inputs; introduction of different activities and other potential adaptation activities. The greatest strength of the model however is its ability to incorporate the changes that farmers would make to fit their operations to climate change (Mendelsohn et al., 1999 cited by Ofori-Boateng and Insah Baba, 2011).

The RM has some flaws including the fact that crops are not subject to controlled experiments across farms, RM does not account for future change in technology, policies and institutions. It also assumes constant prices which is really not the case with agricultural commodities since other factors determine prices and fails to account for the effect of factors that do not vary across space such as CO_2 concentrations that can be beneficial to crops (Kaiser *et al.* 1993). This method has been extensively used in most studies in Africa to measure the impact of climate change on crop production (Molua and Cornelius, 2007; Kabubo-Mariara and Karanja 2007; Kurukulasuriya and Mendelsohn, 2007 and De, 2009).

The Crop Yield Response Theory (CYRT) allows for weather influence upon crops in agricultural production analysis. It is based on the works of Koppen (1918), Lang (1920), Martonne (1926), Angstrom (1936) and Thornthwaite (1948). The method combines precipitation and temperature into composite "aridity" indexes. Though the CYRT conceives that output is generally through a production function of land, labor and capital, the direct application of such a general function to agriculture neglects the existence of weather as an important exogenous factor. As a result the theory considers rainfall, temperature and sun radiation as well as many other weather factors as "noncost" inputs into the production process especially when they are taken as deviations from average.

The Agricultural Investment Portfolio Model (AIPM) on the other hand reflects farmer risk aversion of weather and leans on the Von Neumann-Morgenstern (VNM) theory. The model assumes that farmers cannot insure against any risk ex-ante and cannot perform any consumption smoothing ex-post (Just and Pope, 1978; Antle *et al*, 1987 & 1989). The basis of the theory is that farmer utility depends on farm income so that farmer consumption variability is isomorphic with farm profit variability. It therefore visualizes weather variables as risk to the farmer due to the nature of the uncertainties involved. The underlying precept of the metaeconomic theoretical model is on how much influence weather information forecasts have on decisions of farmers?

2.3 Vulnerability of Ghana to climate change

A valuation of Ghana's susceptibility to climate change (EPA, 2000) concentrated on the way climate change possibly will affect the important sectors of the country including water, coastal resources and agricultural production. This valuation involved basically an analysis of the scope and severity of potential effects of rise in temperature and reduction in rainfall. Anticipated scenarios of climate change indicate reduction in the flows between 15-20% and 30-40% for the years 2020 and 2050 respectively in all basins. Similar reductions in ground water recharges between 5% and 22% by the year 2020, and 30 and 40% were projected for 2050.

This would result in serious constraints for water for irrigation; hydropower generation; ancillary impact on health and nutrition and on energy-based activities (EPA, 2000). The Ghana National Initial Communication to the UNFCCC concludes that by the year 2020 and 2050, all river basins will be marginally vulnerable and the country will face water management problems. Food production is also projected to decline.

2.4 Impacts of climate change and manifestations on agriculture in Africa

Pan African Climate Justice Alliance (2009) report that the continent of Africa is vulnerable to climate change since it includes some of the marginalized nations of the world and these nations' population are surging quickly. They strongly depend on natural resources which are being lost through deforestation and degradation and therefore their vulnerability. It is seriously impacting enormously on economic and human development losses, a real disadvantage towards meeting the MDGs.

Climate change is widely agreed to be already a great concern; its manifestations and negative impacts are overlaid on the already fragile poor communities. It is expected that access to drinking water, arable land are increasing and continuously posing a real danger to Africa, Asia and Latin America especially (Pradeep *et al.*, 2003, IPCC 2007).

The world is already facing an inevitable increase in average temperatures by 0.5°C to 1°C until approximately 2035, with expected acceleration and approaching a 2°C increase by 2050 according to IPCC (2001) reports. It is also expected that natural variability which occurs regardless of human activity may act to amplify these projected changes. The impacts (expected) of these changes and the resulting biophysical, socio-economic and environmental changes are varied and dependent on the type, frequency, intensity, duration and distribution of climate-induced hazards even under relatively modest scenarios of climate change. As such different physical environments will respond in different ways even if they are exposed to the same manifestation of climate change, be it hazard or perturbation (UNDP, 2010). This explains perfectly why the African continent is described by researchers to be the hardest hit by climate variability and the less resilient to climate change effects.

Adjer *et al*. (2007) explain that vulnerability in the context of climate change is the consequent fall in wellbeing attributed to the change simply because people are unable to cope and adapt positively without adverse effects. They discussed two sides of vulnerability: the extent to which an area is susceptible to unfavorable climate impact changes and the adaptive capacity of local population and described the vulnerability of a society as influenced by its development path, physical exposures, the distribution of resources, prior stresses and social and government institutions.

In Ghana the largest employer being the agricultural sector suffers the most impact of climate change (NCCAS, 2010). Vulnerability (a function of exposure to climate hazards and perturbations, sensitivity to that hazard or perturbation and the adaptive capacity of the subnational territory (UNDP, 2010) of the Ghanaian agricultural sector, likewise most countries especially in the sub-region, stems from rainfall distribution since the landscape is dominated by small-holder rain-fed farming activities.

The vulnerability of agricultural sector to climatic impacts is acknowledged in literature. Generally, temperature and precipitation changes are expected to result in land and water regimes expectedly affecting agricultural production mostly in the tropical regions as research shows (Pradeep *et al*., 2003).

Changes in land and water regimes in agricultural sector are projected to be direct manifestations from impacts of climate variability and change. Fragile areas are expected to experience low production in agriculture (Rosenzweig *et al.,* 2002). The negative tone of deforestation and loss of soil nutrients as well as the increasing use of marginal lands for agriculture (especially among small-holder farms) is anticipated as the availability and productivity potential of land begin to decline. Ultimately social fallout of variability would be on the increase within societies. The fact being that individuals demand for additional land for cultivation would be high, changing the land tenure systems and collapse in social relation, increased migration and subsequent urban vulnerability as emphasized in NCCAS.

In another event, according to Mendelsohn *et al*., 1999 climate change is again expected to yield some beneficial effects most importantly in the temperate regions. The positive effects of enhanced photosynthesis (from doubling CO_2) would be more than offset by temperature increases 2°C (Matthews, *et al*., 1995). Increase in crop yield in areas in mid and high latitudes (Lou *et al.,* 1999). The lengthening of growing seasons, carbon fertilization effects, and improved conditions for crop growth are forecast to stimulate gains in agricultural productivity in high-latitude regions, such as in northern China and many parts of northern America and Europe.

Generally on world agriculture, economic impacts of climate change were said to be Minor; thus decreasing food production in some areas balanced by gains in others

(Kane *et al*., 1991; Tobey *et al*., 1992; Rosenzweig and Parry, 1993) but the recent climate scenarios greatly doubt this since positive gains are becoming less globally. For instance in Ghana, Climate change scenarios developed based on the forty-year data, predicted a continuous rise in temperature whiles rainfall is also predicted to decline on average in all agro-ecological zones in Ghana (EPA, 2007). It is evident climate change conditions have accelerated vulnerability of the rural population thus increasing the rate of land and forest degradation. The cycle of income poverty exacerbates the potential negative impacts of climate change (Marger, 2008b), yet natural resources upon which they depend are themselves being modified by climate change. And very seriously impacted by direct human activities on a daily basis, especially in impoverished areas where people have no option but to degrade their lands, use the trees, hunt wild life, pollute rivers and exploit sea life (START, 2011).

2.5 Cocoa and the Ghanaian economy

Cocoa plays a pivotal role in the socio-economic development of Ghana relatively from a socio-economic and a socio-ecological standpoint. For smallholder cocoa farmers, cocoa contributes about 70-100% of their annual household incomes (Anim-Kwapong and Frimpong, 2004). With over 800,000 smallholder families in addition to other stakeholders such as researchers, agro-chemical companies, input dealers, licensed buying companies, export agencies depending largely on cocoa production, the sector is undoubtedly a great source of employment and income. According to Anim-Kwapong and Frimpong (2004), in 2002, foreign exchange earnings of cocoa was 463 million US$ representing 22.4% of Ghana's total foreign exchange earning within the period. Also, foreign exchange earnings that were accrued from cocoa made up 63% of the export earnings from the agricultural sector, compared to 25% and 12% contributed by timber and the non-traditional export crops respectively

(ISSER, 2003 in Anim-Kwapong and Frimpong, 2004). Cocoa is thus ranked as number one cash crop in Ghana in terms of its socio-economic importance (Table 2-1).

Table 2- 1: Ranking and importance of cocoa for selected African Countries.

Cocoa Data	Cameroon	Cote D'Ivoire	Ghana	Nigeria
Agriculture income earner	1	1	1	-
Source of employment	1	1	1	1
Production (2005)	180 000	1,400,000	630,000	190,000
People living on cocoa	1,400,000	7,000,000	6,300,000	1,400,000
% People living on cocoa	12%	44%	29%	1%
Foreign exchange earnings (US$)	270, 000	2,100,000	945,000	285,000
% Foreign exchange earnings	15%	35%	30%	0.40%

Adapted from Grinsven, (2007).

The percentage of smallholder farmers living on cocoa is highly significant. The Ghanaian economy in general depends highly on the foreign earnings from the sale of cocoa beans to the international market.

2.6 Climate change cocoa production and the agricultural sector

Cocoa's high sensitivity to changes in climatic conditions is well established; temperature and rainfall, soil conditions as a result of water deficit. These are known to alter the stages of development of the cocoa tree and its ability to resist pest and pathogens

The most likely concerns are shifts in the geographical distribution of host and pathogen/pests, altered crop yields and crop loses which, will impact socio-economic variables such as farm income, livelihood and farm-level decision making. Hence the need for an understanding of climate change impacts on cocoa production and the potential for adaptation to climate change. Cocoa can only be profitably grown under temperatures varying between 30-32^{o}C mean maximum and 18-21^{o}C mean minimum and absolute minimum of 10°C.

Temperature has been related to light use efficiency with temperatures 24^{o}C having a decreasing effect on the light saturated photosynthesis rate (Wood and Lass, 1985 cited in Danso-Abbeam, 2010). There is increased pod failure in recent times, and this current occurrence according to farmers is highly insignificant during seasons when rainfall patterns are better and dry periods relatively short. The effects are manifested in most cocoa trees aborting their flowers prematurely and not leading to the formation of pods whiles some pods also ripen prematurely (GSNC-UNFCC, 2011).

Strengthening agricultural production systems is a fundamental means of improving incomes and food security for the largest group of food insecure in the world (World Bank 2007; Ravallion *et al.,* 2007). As outlined in an assessment report by ITDS-TASRP (2000), since the oil boom in the 1960s, the agricultural sector as a whole has been depressed though income from cocoa in the 1950s and 1960s enabled the schooling of many young people giving them access to the University. Now many farms have been abandoned and the proportion of aging farmers is on the increase. In many cases cocoa has been abandoned for short duration and more profitable crops. Most farmers attribute the abandonment to difficulties in farming due to the unpredictable nature of the climate and costs of production.

Cocoa is known to serve as an important crop around the world especially for developing countries and a key import for processing and consuming countries. Cultivation of cocoa at the farm level is a delicate process as crops are susceptible to various conditions including weather patterns, diseases, and insects. A steady demand from worldwide consumers draws numerous global efforts and funds committed to support and improve cocoa farm sustainability (WCF, 2012).

Small-holder/family-run cocoa farming: WCF, (2012) describes the complex production process of cocoa to involve numerous parties including, farmers, buyers, shipping organizations, processors, chocolatiers, and distributers. Unlike larger, industrialized agribusinesses, the vast majority of cocoa still comes from smallholder, family-run farms, who often confront outdated farming practices and limited organizational leverage. Small cocoa farms provide more than 90% of world cocoa production. In Africa and Asia, a typical farm covers 2 to 5 hectares (4.9 -12.3 acres) 5-6 million cocoa farmers exist worldwide and 40-50 million people depend on cocoa for their livelihood (ibid).

The prospects of an increase in cocoa cultivation in African countries are slim due to unavailability of land and labor competition from other economic agricultural activities. West African cocoa’s erstwhile growth was essentially due to the occupation of accessible forest areas favorable to its cultivation.

Without speaking of sedentarization as such, farmers’ migration to regions where forest resources are still available are now quite limited (ECOWAS-SWAC/OECD, 2007). As revealed by the work of Adjei-Nsiah and Kermah (2012), farmers were compelled by persistent bushfire caused by long term dryness, land tenure, loss of soil fertility and other factors to move to the new frontier in the Western Region of Ghana in search of fertile land for cocoa cultivation. Now improving production merely by increasing the cultivation area will be harder to accomplish according to ECOWAS-SWAC/OECD, (2007).

Smallholder farmers have a wide range of challenges confronting them in the cocoa sector including limited access to resources and organized markets, low yields attributed to pests, aging trees, and diseases that attack the trees, difficulty obtaining farming supplies, unfamiliarity with modern farming techniques and limited access to credit and insurance (Houston *et al.*,2012). Worsening the challenges of agricultural development is the issue of climate variability, environmental factors and competing land uses (IPCC, 2007). Also, in many rural areas of sub-Saharan Africa, cocoa-growing communities face a multitude of social issues, such as low levels of adult literacy, health risks including malaria and HIV/AIDS, and lack of access to quality education for children. These and other difficult factors mean that the cocoa sector's long-term viability and production is seriously threatened (Houston *et al*., 2012).

2.7 Adaptation to climate change

Adaptation to climate change is one of the critical issues in climate studies because from all indications, climate change is real and living with it requires planned activities that will reduce its effects and make life possible (Gyampoh, 2009).

The great need for adaptation is given attention in Article 4.1.b of the United Nations Framework Convention on Climate Change (UNFCCC) which provides that all countries must formulate and implement national or regional programs containing measures to facilitate adequate adaptation to climate change (Art. 4.1. b).

Adaptation to climate stimuli includes adaptive responses to extremes, variability from year to year, and to changes in long-term mean conditions, both independently and as they relate to each other (Smit *et al.,* 2000).

Adaptation to climate change has been given several definitions and at different times, has meant differently from author to author and this, according to Smit *et al.*, (2000), requires a need for users of the term to specify adaptation in what, and to what. There are several definitions of Adaptation to climate change (e.g. Burton, 1992; Smith, 1993; Stakhiv, 1993; Smit *et al.*, 1996; Watson *et al.*, 1996) but they all refer to adjustments in a system in response to climatic change, or/and variability.

The IPCC defines Adaptation to Climate Change ‘as a process by which strategies to moderate, cope with and take advantage of the consequences of climate events are developed and implemented’ (IPCC, 2001b).

According to Easterling (1996) adaptation can be either autonomous (reaction of individuals to changing climate) or planned (conscious policy options or response strategies) Similarly, Smith (2000) groups adaptations into passive, reactive or anticipatory; and spontaneous or planned.

Stakhiv (1993) groups adaptive strategies according to the time frame of the stimulus: long range, tactical, contingency, and/or analytical, and Smithers and Smit (1997) differentiate adaptations on the basis of intent or purposefulness, the role of government, the spatial and social scale, duration, form and effect.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

This section describes some basic terms as used in this research; it describes the study areas; describes the approaches adopted for the study; sample and sampling techniques; data sources, data collection and analysis tools as well as how field data was useful for analysis and presentation.

3.2 Basic definition of concepts

The following terms have been adopted and used as working definitions for the study:

i. Pre-fire epoch

The years preceding the occurrence of the 1983 bushfires in Ghana, thus from the 1960 to 1982

ii. Post-fire epoch

The years from which the fire started and those periods where bushfire had become seasonal, thus from 1983 to 2000.

iii. Current epoch

This period represents the years from 2000 to the current day.

3.3 Study areas

The study took place in three municipalities; Techiman Municipality (7.35^{o} N, 1.56°W), Wenchi Municipality (7.75^{o} N, 2.1^{o} W) and Berekum Municipality (7.45^{o} N, 2.59^{o} W), all in the transitional zone (Figure 3-1) of Brong-Ahafo Region. The transitional zone covers over 6.5 million hectares (Owusu and Waylan, 2013).

Studies show that what is now known as the transitional zone has been derived so due to land uses and degradation creating this savannah forest mosaic (Kalame et al., 2011, Egyir *et al*., 2014). However, it must be emphasized that even though the Transition Zone is highly degraded by human activities, the mixture of woodland and Savannah in this zone is naturally occurring (Fianu *et al*. 2001).

Figure 3 - 1: Ghana ecological map showing the transitional ecological zone

The zone which was originally forested thus favoring cocoa production, lost most of its forest cover and is now a derived savannah suitable for the production of grains, cereals and tubers, and is the leading producer of these food stuffs in Ghana. Until recently where cocoa production is picking up in these areas, commercial tree crops such as cashew, mango, orange and teak were more popular. Though variations in climatic and vegetative conditions have rendered the transitional zone and the southern part of Ghana difficult for farmers, it is still favorable for farming compared to the north. The transitional zone experiences double maximum rainfall regime, occurring from May to August and from September to October, with a mean annual rainfall of 1430 mm (GMet, 2011).

Techiman Municipality shares boundary with Wenchi municipality to the North and Western part whiles Berekum Municipality is to the Southeast of Wenchi Municipality. Wenchi is 29 km away from Techiman the municipal capital of Techiman municipality and 56 km to Sunyani the Regional capital of Brong Ahafo.

Techiman municipal and Berekum municipal belong to the semi-equatorial climatic zone but Techiman also possesses features of the tropical convention or the savannah climatic zone (GSS, 2013). Whiles Wenchi belongs to the moist semi-deciduous and the guinea-savannah vegetation zone. Techiman municipality encompasses three vegetation zones namely; Guinea savannah woodland found at the North and West part of the municipality, Semi-deciduous forest vegetation found at the south and the Transitional zone which stretches from the southeast to the west up to the north. Berekum municipality is predominantly semi-deciduous occupying 80% of the area with isolated patches of wooded savanna in the northern-most and eastern corner of the municipality. Figure 3-2 is a map of Brong Ahafo showing the study communities.

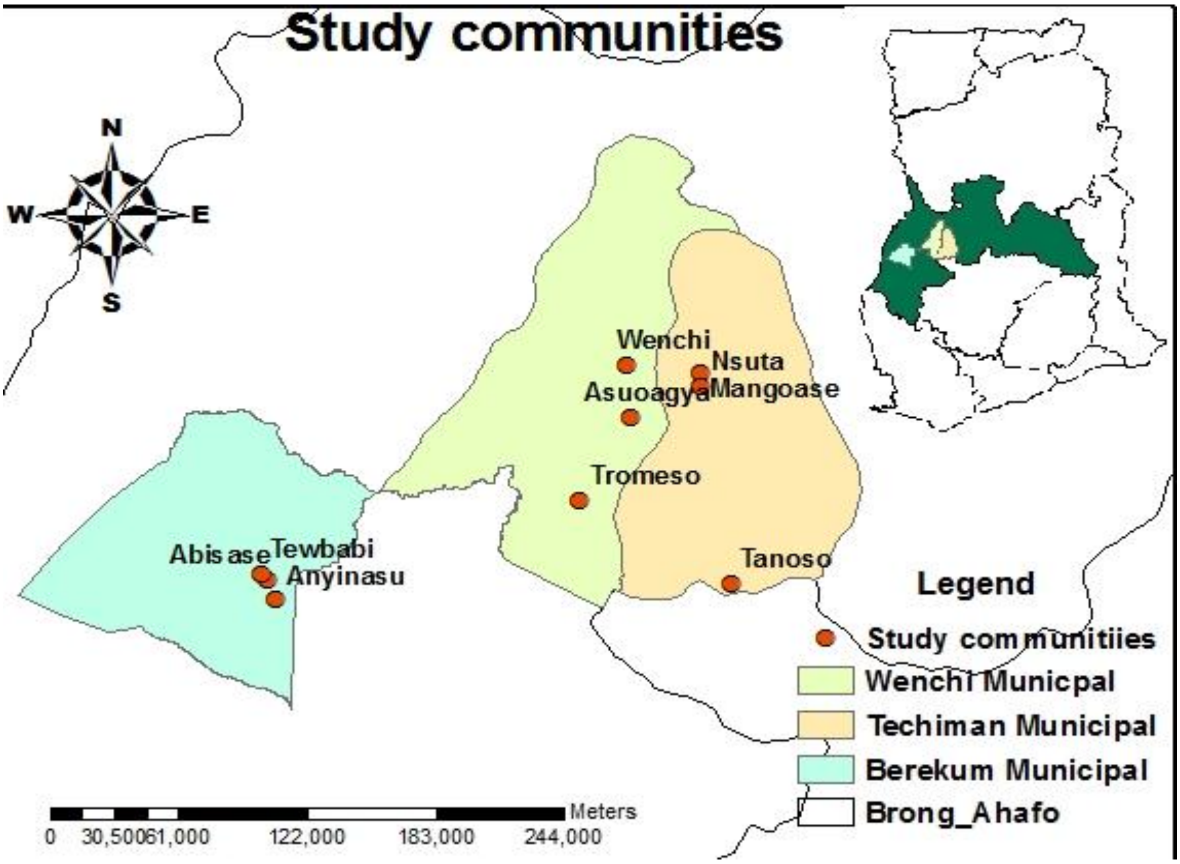

Figure 3 - 2: A map showing the study communities

Techiman Municipality: In Techiman the major rains start from April to July and the minor from September to October, then the only dry season which is highly pronounced in the savanna zone starts in November and lasts until March. It has annual average temperature of 28^0C and a relative humidity of 75-80% in the rainy season and 70-72% for the rest of the year. There are three major soil associations in the Techiman Municipality, namely: The Damango-Murugu-Tanoso Association, Bediesi-Bejua Association and The Kumasi-Offin Association.

Wenchi Municipality: The rainy season in Wenchi occurs between April and October with a short dry spell in August. The average annual rainfall is about 1,140 – 1,270mm. The dry season (hamattan) occurs between November and February. This long period of dryness makes the Municipality very vulnerable and susceptible to bushfires. Bushfire is therefore very rampant during the dry seasons. A greater proportion of the soils in Wenchi Municipality fall under the savannah Ochrosol with some Lithosols. The land is generally low lying and most of the soils are sandy loam and in the valleys, loamy soils exist.

Berekum Municipality: The rainfall in Berekum is the double maxima type with mean annual rainfall ranging between 1,275 mm-1,544 mm. Between May and June, the first rainy season with the heaviest rainfall is recorded. This is followed by a second rainfall season between September and October. A four month dry season start from December to March. Soils of Berekum municipality are mostly forest Ochrosols; well-drained soils in the weathering products of intermediate or moderately acidic rocks. Decades of continuous cropping, incessant logging and widespread bushfires have led to deterioration in soil fertility leading to reduced average farmer productivity (MoFA, 1998).

The study was conducted in nine (9) communities, thus three cocoa farming communities each in the three municipalities as shown in Table 3-1;

Table 3 - 1: Municipalities and communities involved in the study

Techiman Municipality	Wenchi Municipality	Berekum Municipality
1. Nsuta,	4. Asuoagya area	7. Abisase,
2. Tanoso	5. Tromeso	8. Anyinasu,
3. Mangoase	6. Wenchi	9. Tewbabi

However the Asuoagya area in Wenchi municipality consisted of Koase, Droboso, Nkonsia, Yoyoano communities.

The selection of the communities was based on the fact that they have experienced all the characteristics of the three epochs. Also the vegetation zones in which these communities fall give them unique location and characteristics therefore data collected from these communities were representative and as comprehensive as possible.

3.4 Methods

3.4.1 Research design

The research methodology was designed to meet the research objectives as outlined and incorporates both qualitative and quantitative approaches to research and a combination of research techniques. The research adopted the major criteria for survey design which are a representative sample size, low cost, and areas with concentration of the targeted population in this case small-holder cocoa farmers aged 45 years and above. A cross-sectional data was used in this research to obtain farmers perception on changes in climatic parameters in a trend from specified periods, perceived/observed impacts of climate change on cocoa, causes of the shift from cocoa farming and the livelihood options that characterized the landscape, reasons informing farmers decision to revert to cocoa production and the adaptation measures by farmers in the new cocoa farming in this era of climate change.

The research drew on non-empirical (comprehensive literature review) and empirical (data collection, formal and informal interviews) research approaches. It employed mainly the following methods and tools: desktop studies (literature review), interviews, questionnaires, observations, and key informant discussion and field assessments. And to aid in triangulation, focus group discussions were conducted in the various communities.

3.4.2 Sampling Techniques

This denotes all the stages and the processes involved in selecting the respondents. According to Twumasi (1986), the first step in the selection of a sample is to consider sampling technique. In sampling design, characteristics of the population to be studied must be clearly indicated. The sampling technique used in this study was a multistage technique. The transitional zone of Brong Ahafo was purposively selected because of the nature of the development path the cocoa sector has undergone from the beginning of cocoa farming to the present epoch likewise the three municipalities selected for the study. Within the three municipalities, three communities each were randomly selected from a crosschecked list of cocoa cultivation communities provided jointly by CSD and PBC regional offices at Sunyani. From there, contacts were established with the leaders of the various cocoa farmers' groups in the communities selected.

To ensure the right farmers were contacted, a list of cocoa farmers were obtained and with the help of the leaders of the cocoa farmer's groups, the list was stratified to isolate farmers aged 45 years and above. This was done to get older farmers to respond to the questions pertaining to the pre-fire, post-fire and current epoch to help established a good trend analysis of the situation. Also the technique was used in separating male from female. The sex/gender-based stratum is justified on the grounds that women tended not to be heads of households, have small size farms, and engage in retail marketing during the periodic market days. If women were not purposefully targeted, their numbers would have been small and their opinions and interpretations not be given proper attention.

Gender sensitivity and social exclusion was a central theme, hence the study was designed to ensure participation of all sexes men and women farmers, very old farmers, and minority groups (migrants, non-Christians, non-Akans, wage earners, and tenants). Egyir *et al*., (2014) also used this approach in their work "Climate change and agricultural adaptation measures in the transition zone of mid-Ghana". After the list of farmers aged 45 years and above was generated, farmers were randomly selected to form the sample size for the study. Snowball technique was employed in some instances to fast-track the questionnaire administration. Cocoa extension officers within each zone, the Technical Director-Sunyani and Municipal directors of Cocoa Service Division (CSD), Ministry of Food and Agriculture (MOFA), Produce Buying Company (PBC), Forestry Commission-Forest Service Division (FSD), and Municipal chief Cocoa farmers and some older folks in the communities formed the key informants purposefully selected for the work.

3.4.3 Sample Size

Two hundred and seventy cocoa farmers were chosen to be interviewed. Focus Group Discussion (FGD) was conducted for each community as and when the timing was perfect for the farmers. In selecting the sample size, Israel's equation (3) criterion was used (Israel, 1992).

$n = \frac{N}{1+N(e)^2}$ Where ***n*** = sample size, ***N*** = population, ***e*** =level of precision.

In Tanoso community, the total cocoa farmers' population was below 200, therefore the whole cocoa farmers population was used as was stated by Israel (1992). The researcher kept in mind the cost and time constraints in administering questionnaires therefore a total of 30 respondents from each community was used to give a fair representation. Table 3-2 shows the municipalities, communities and the sample size for questionnaire administration and focus group discussion and the proportion of women to men in each community.

Table 3 - 2: Sample size of various communities

Municipality	Community	Sample size for survey			Sample size for FGD		
		Male	Female	Total	Male	Female	Total
Techiman	Tanoso	19	11	**30**	9	6	**15**
	Nsuta	22	8	**30**	15	10	**25**
	Mangoase	23	7	**30**	10	5	**15**
Wenchi	Asuoagya	22	8	**30**	8	4	**12**
	Wenchi	23	7	**30**	16	7	**23**
	Tromeso	23	7	**30**	12	10	**22**
Berekum	Abisase	24	6	**30**	15	6	**21**
	Anyinasu	22	8	**30**	15	7	**22**
	Tewbabi	22	8	**30**	11	5	**16**
Sub-total				**270**			**150**
Grand total							**420**

Note: M=male, F=female. Source: authors' compilation 2015

3.4.4 Data Type and Sources of Data

The research made use of both primary and secondary data. In answering the research questions on farmer perception on changes in climate and the manifestations and impact on cocoa production primary data was sourced from the sampled smallholder cocoa farmers and other relevant stakeholders as stipulated in Table 3-2. The secondary data provided background information on the study areas as well as contextual background information of the research. Secondary data such as baseline information of the selected Districts, program/project documents and existing reports from Ministry Of Food And Agriculture, Cocoa Service Division, GMet, EPA, and FC-FSD among others were used. The other relevant secondary data was obtained from research articles, journals, books, news items and the internet. Whilst the secondary data was useful, the key aspects of the study were based on the primary data collected through field exercise.

3.5 Data collection instruments, procedure and pre-testing

A questionnaire in both opened and closed forms was administered to the stakeholders; cocoa farmers, Ministry of food and agriculture (MoFA), Forestry Commission-forest service division (FSD), Ghana COCOBOD (cocoa service division) PBC (accredited Cocoa purchasing company) to collate data.

Qualitatively, a checklist of issues relating to the study was prepared to guide the researcher in conducting the Key informant interview and focus group discussions (Plate 3-2). Focus group discussion brought out a lot of revelation because farmers and especially women were bold to discuss issues bothering their minds and what they term as unfair treatment by cocoa sector workers.

Plate 3 - 1: (a) A key informant interview (b) A one-on-one interview (c) FGD at Wenchi and (d) An interview with the municipal chief cocoa farmer of Berekum

In the use of questionnaire it is important to specify precisely the measurement indicators in conducting a research to guide the researcher. The preparation of the questionnaire took into consideration factors that have been found to minimize non-sampling errors, namely, clarity of expression, potential for respondent recall, cultural specific conceptions, sensitive questions and the time required to complete an interview as expressed by Nicholas, (1991). Pre-testing was done with 15 respondents in the Berekum Municipality; this was to test the clarity of questions and respondents' understanding of questions based on which modification was carried out before administering to the stakeholders. Field observation formed one of the key means through which most of the manifestation indicated by farmers were verified (Plate 2-1). Data collection and analysis took the approach illustrated in the figure 3-3.

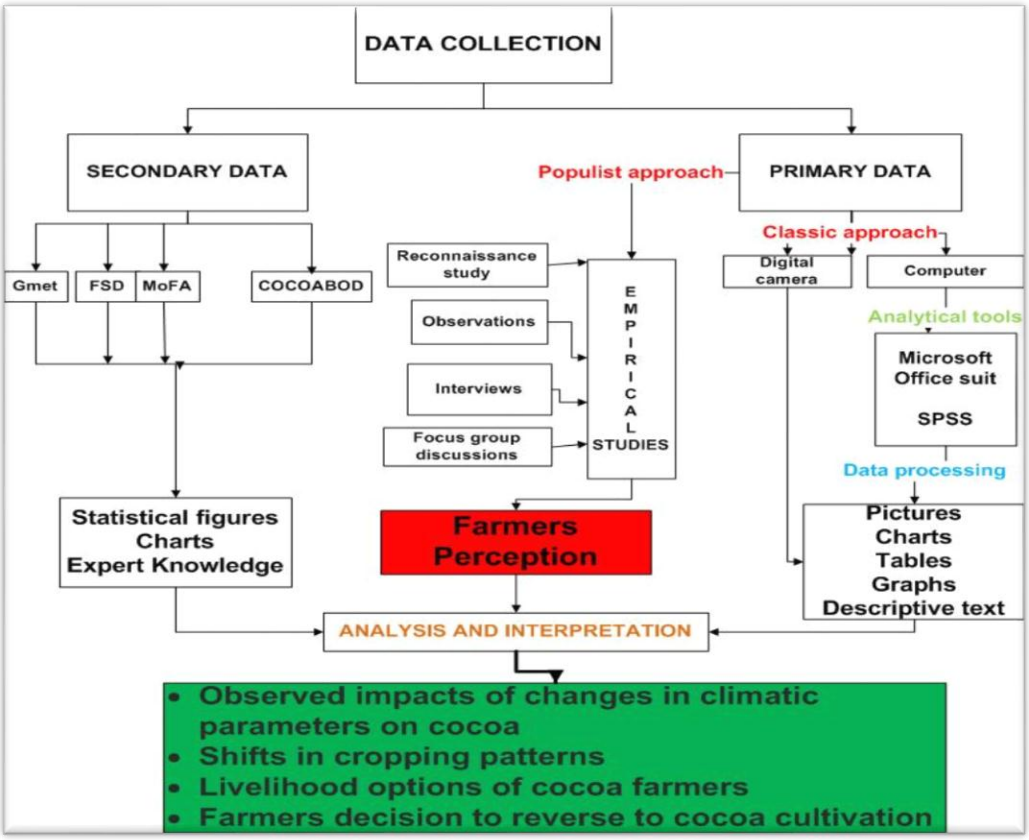

Figure 3 - 3: Approaches to data collection and analysis (adopted from K. McCall and Minang, 2005)

3.5.1 Data processing and analysis

Analysis of data is a process of editing, cleaning, transforming and modeling data with the goal of highlighting useful information, suggestion, conclusions, and supporting decision making (Adèr, 2008). The Inductive Approach to analyzing qualitative data was employed in this work due to the fact that the researcher had little or no predetermined structure. Burnard *et al.*, (2008) emphasize this approach as helpful in analyzing and presenting qualitative data with little or no predetermined theory, structure or framework and use the actual data itself to derive the structure of analysis.

The approach however is comprehensive and time-consuming but it is the most common approach used to analyze qualitative data and the suitable approach for this analysis.

There are various approaches to analyzing qualitative data but Thematic Content Analysis (TCA) was employed in this research. It is a descriptive presentation of qualitative data and is, perhaps, the most common method of data analysis used in qualitative work which in conducting the researcher's epistemological stance is objective or objectivistic (Rosemarie, 2007). Indeed, the process of TCA is often very similar in all types of qualitative research, in that the process involves analyzing transcripts, identifying themes within those data and gathering together examples of those themes from the text (Spencer *et al*, 2004). Data from the field were edited and coded appropriately to make meaning out of them. Editing was done to correct errors, check for non-responses, accuracy and right answers. Coding was done to facilitate data entering and a comprehensive analysis. Descriptive statistics was the medium used for analysis.

The data collected was analyzed using Statistical Package for Social Science-SPSS V-20.0 and Microsoft excel, and synthesized to facilitate the achievement of the outputs. Descriptive statistics analysis factors like frequency tables, percentages, pie charts, bar graphs were generated and their interpretations thoroughly explained with real world examples. Analysis was carried out concurrently with report writing. Some quotations to support the arguments were also provided. However these quotations are emblematic of wider data and the selection is based on their general representation.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents some demographic characteristics of the respondents of the survey. It also presents farmers' perceptions regarding changes in climatic parameters i.e. changes in rainfall and changes in temperature and the observed manifestation impacts of the perceived changes in climate on cocoa production. The results are presented in figures, tables and Plates below. Perceptions on observed changes in rainfall and temperature were taken into the three epochs (pre-fire, post-fire and current epoch). The results indicate that most farmers perceive temperature is increasing. On the other hand, the overall rainfall in the region is reducing thus the areas are getting drier and that there are pronounced changes in the onset of rains therefore impacting negatively on cocoa production.

4.2 Demographic characteristics

The study targeted old cocoa farmers aged 45 years and above. After careful and conscious efforts were made to achieve the set target group, it was found that majority (41.5% and 26.7%) of the farmers were within the age group of 51-60 and 61-70 respectively as shown in Table 4-1. The mean age however of the respondent is 58 years.

Table 4 - 1: Percentage of respondents' age groups within municipalities

Municipality		**Age Groups**				
		45-50	**51-60**	**61-70**	**71-80**	**81+**
Municipality	Techiman	22.2	42.2	26.7	6.7	2.2
	Wenchi	25.6	36.7	30	6.7	1.1
	Berekum	20	45.6	23.3	10	1.1
Total		**22.6%**	**41.5%**	**26.7%**	**7.8%**	**1.5%**

Source: author's compilation 2015

Males formed the majority (74.1%) of the cocoa farmers interviewed with the females being the minority (25.9%) as in Table 4-2. Techiman municipality recorded the highest percentage (37.1%) of female cocoa farmers. The community that recorded the most males was Abiasae whiles Tanoso recorded the highest percentage (36.7%) of females.

Table 4 - 2: Sex distribution within communities

Municipality	Communi		Sex		Total
			Male	**Female**	
Berekum	Abisase	Count	24	6	30
		% within Community	80.0%	20.0%	100.0%
	Tewbabi	Count	22	8	30
		% within Community	73.3%	26.7%	100.0%
	Anyinasu	Count	22	8	30
		% within Community	73.3%	26.7%	100.0%
Wenchi	Tromeso	Count	23	7	30
		% within Community	76.7%	23.3%	100.0%
	Wenchi	Count	23	7	30
		% within Community	76.7%	23.3%	100.0%
	Asuoagya	Count	22	8	30
		% within Community	73.3%	26.7%	100.0%
Techiman	Tanoso	Count	19	11	30
		% within Community	63.3%	36.7%	100.0%
	Nsuta	Count	22	8	30
		% within Community	73.3%	26.7%	100.0%
	Mangoase	Count	23	7	30
		% within Community	76.7%	23.3%	100.0%
Total		**Count**	**200**	**70**	**270**
		% within Community	**74.1%**	**25.9%**	**100.0%**

Source: author's compilation 2015

As presented in Table 4-3, majority of farmers (88.5.9%) were natives of the various communities whiles the remaining 11.5% were migrants from other places in the country especially from the three Northern Regions of Ghana. These migrants were mostly children and relatives of those who came to farm maize during the post-fire epoch. The greater percentage (64.9%) of farmers with experience/many years of cocoa farming were largely the natives and the returnees from other areas mostly the Western Region after their migration in the post-fire epoch. Most of the cocoa farmers were found to be between the age ranges of 51-70 as in Table 4-1 accounting for their huge experience in cocoa farming. Also some (35.1%) of the native cocoa farmers who had little experience in the cocoa business were those who are on retirement from the civil service and have resettled into the cocoa farming business. The same business according to them their parents did to support them in their education.

Table 4 - 3: Origin of respondents and years of cocoa farming

		Cocoa farming experience			
Origin of farmers		**Old farmer**	**New farmer**	**Count**	**Total**
Native	Count	155	84	239	88.5%
		64.9%	35.1%		100.0%
	Count	10	21	31	11.5%
Migrant		32.3%	67.7%		100.0%
Total	**Count**	**165**	**105**	**270**	
		61.1%	**38.9%**		**100.0%**

Source: author's compilation 2015

4.3 Effects of climate change on cocoa farming in the forest-savanna transitional zone.

4.3.1 Perceived changes in climatic parameters

Farmers believe that there have been changes in climatic parameters in the study areas. Farmers placed emphases on rainfall and temperature as the climate variables which have visible changes and which also affect their farming activities. Figure 4-1 shows the proportion of farmers and their perceptions of the extent of changes in the quantity of rainfall. These changes have negatively affected the yield of cocoa, and influenced the subsequent change from cocoa to maize dominated cropping in these areas in the aftermath of the 1983 bushfires.

The Figure 4-1 presents the changes in rainfall within the three epochs (pre-fire epoch, post-fire epoch, current epoch) as observed by farmers which affected the yield of cocoa.

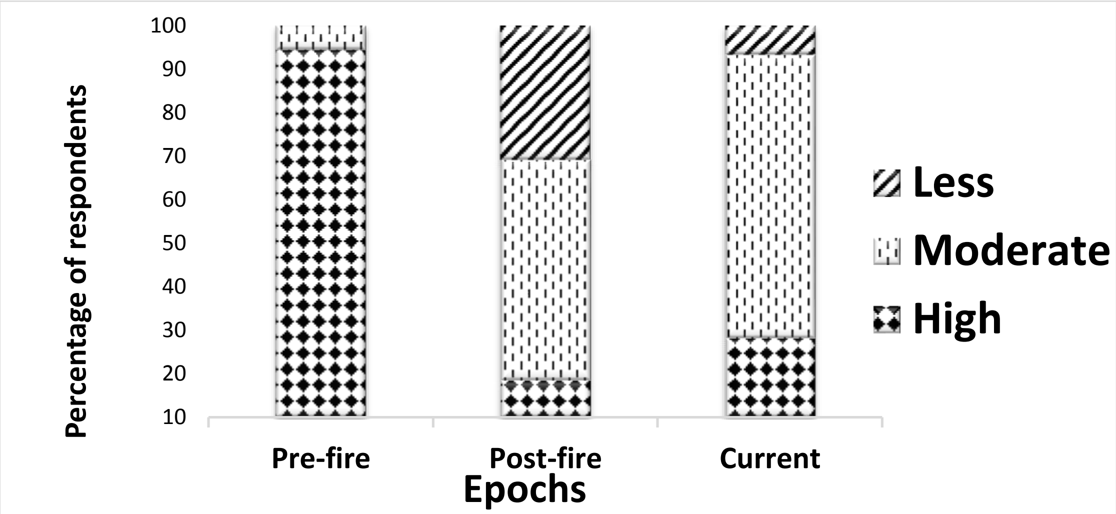

Figure 4 - 1: Respondents on perceived extent of changes in the quantity of rainfall in the three epochs

Above 94% of the respondents indicated that rainfall was higher in the pre-fire compared to the post-fire and current epochs. The post-fire epoch according to farmers (30.7% respondents) experienced the worse rainfall in terms of quantity. The farmers also indicated that currently the quantity of rainfall received annually is quite good though it cannot be compared with the pre-fire epoch. About 93.3% of the respondents agreed that in the current epoch the quantity of rainfall is between high and moderate and considerably higher rainfall is recorded than the post-fire epoch.

The intensity of the rain over the specified periods (Figure 4-2) as observed by farmers show that the pre-fire epoch received high intensity of rainfall (95.2%) as compared to the post-fire epoch (46.3%) and the current epoch (50.7%).

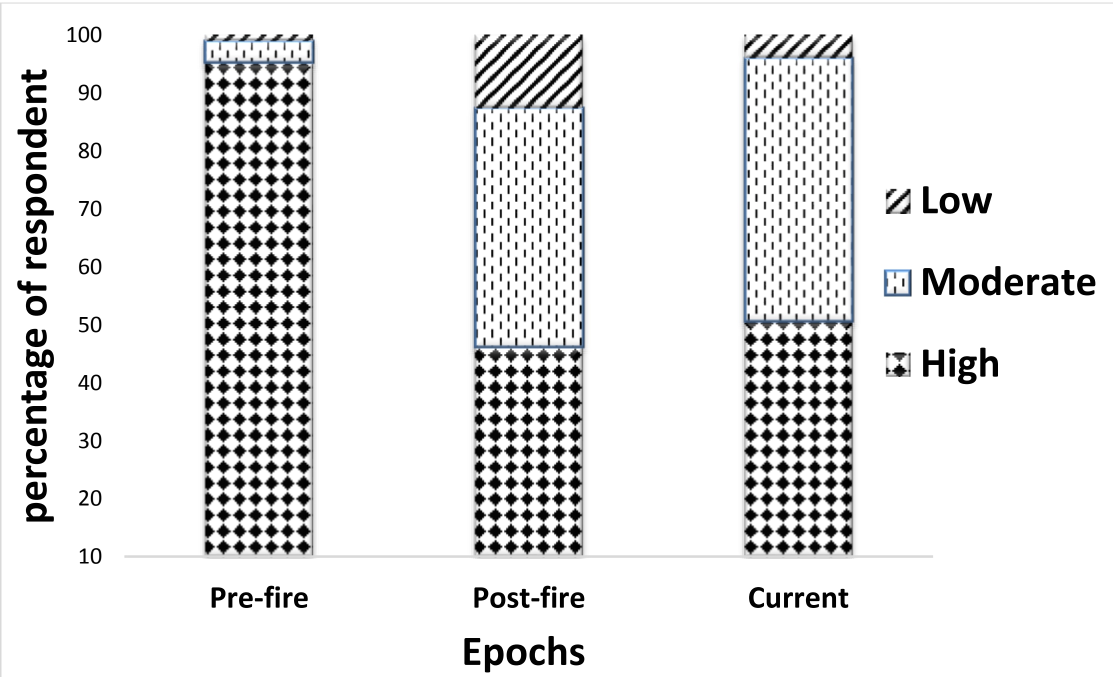

Figure 4 - 2: Respondents on perceived changes in rainfall intensity in the three epochs

According to the farmers the rainy season has become shorter and erratic. This is indicated by the unpredictable onset of rains, the decrease in the number of days/times it rains during the major raining periods and the amount of rainfall received during the major and the minor season in the three epochs. According to farmers (95.2%) the pre-fire epoch experienced high rainfall intensity and this is reflected in the number of days it rained within that period as indicated to be more by the respondents (92.2%) in the figure 4-3. Comparably the post-fire and the current epochs recorded moderately low number of rainy days (57.8% and 42.2% of respondents respectively) which farmers attributed to the erratic nature of the rain.

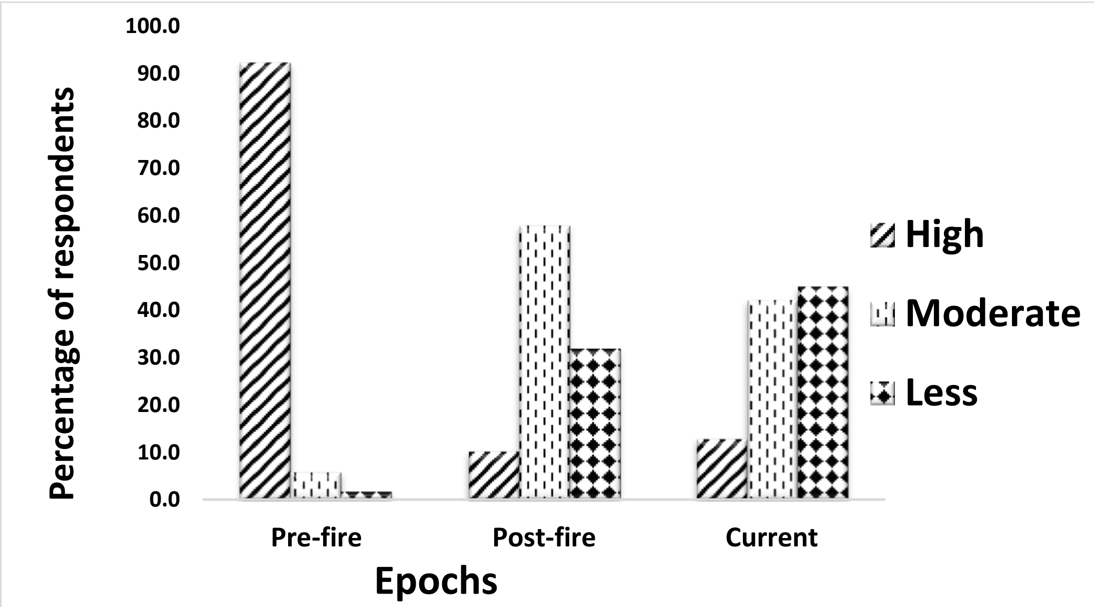

Figure 4 - 3: Respondents' perceived changes in number of rainy days in the three epochs

The onset of the rain has changed over the specified periods. The rainy season used to start expectedly according to famers in the pre-fire epoch as the results show, about 95.6% indicating the onset of the rain at the expected time in the pre fire epoch. But over the period (post-fire and current epoch) this has changed, it no longer starts expectedly according to famers as indicated in Figure 4-4. In the focus group discussion, farmers were unanimous in their observation that there have been delays in the onset of rainfall. Even though it may be difficult tracing the delays in the onset of rainfall from the available climate data, farmers lamented that, they are no more benefiting from the indicators used by their fathers to predict the behavior of the climate which guided their farming activities.

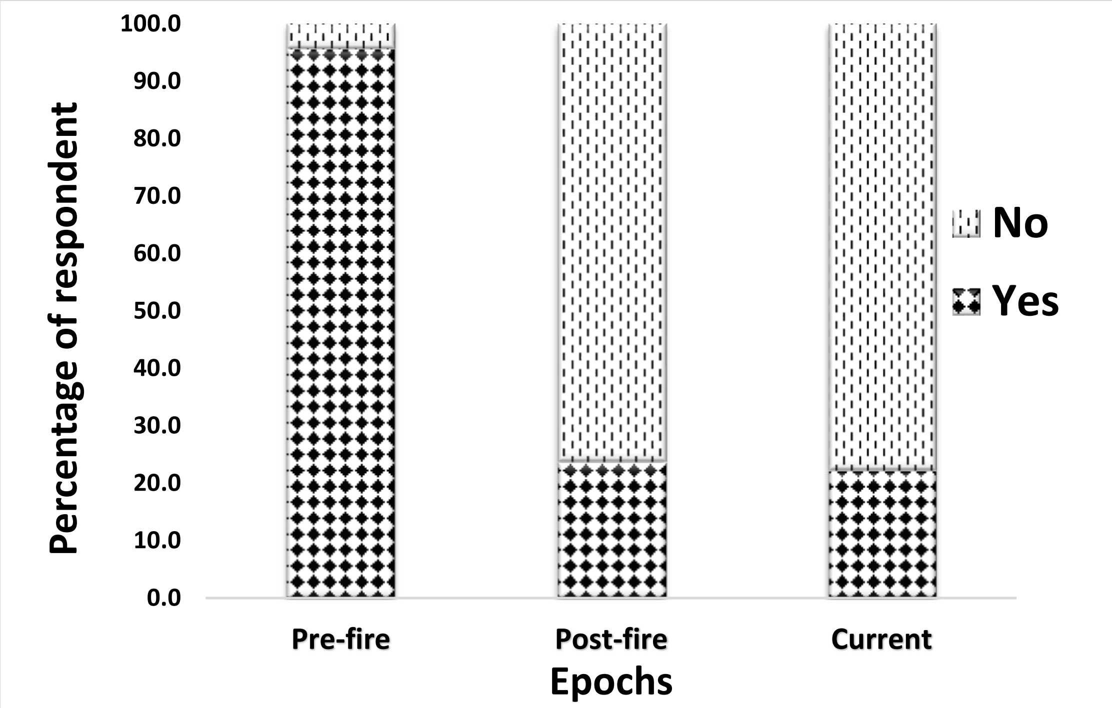

Figure 4 - 4: Respondents' perceived changes in onset of rain at the right time in the three epochs

Farmers confirmed that cocoa cropping had started declining with other issues before reaching the lowest production in 1983, rainfall also played a major factor as the dry climatic conditions favored the occurrence of the bushfires.

With temperature, the farmers reported an observed increase in the intensity over the three epochs as indicated in Figure 4-5. According to farmers, the pre fire epoch experienced considerably lower temperatures since the number of rainy days was more and intensity of rainfall was high. The few (10.7%) of farmers who stated high temperature in the pre fire epoch were quick to add that in the instances where temperatures were high the presence of thick forest cover shielded the landscape and crops from the high intensity of the temperature.

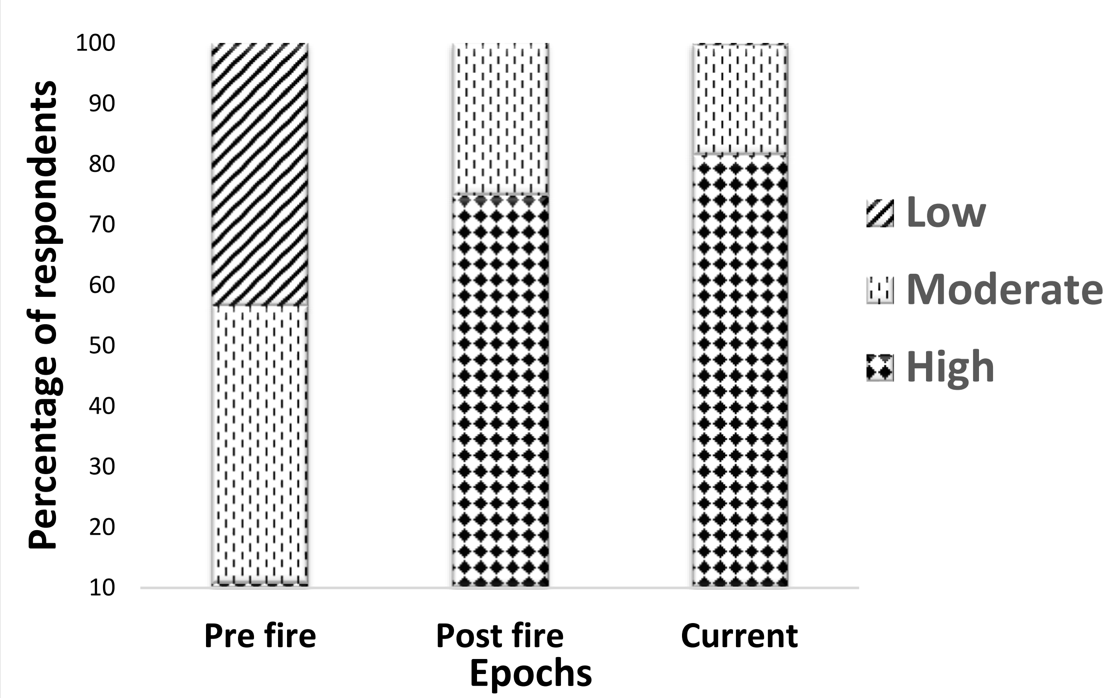

Figure 4 - 5: Respondents' perceived extent of changes in temperature over the three epochs

Currently, temperatures are higher according to the responses given by farmers; thus 81.5% of respondents as compared to 74.8% in the post fire epoch said it was high in the current. Farmers attributed this to the massive deforestation and destruction of the forest rendering the landscape highly susceptible to impacts of the elements of climate.

4.3.2 Farmers' perception on indicators of changes in climatic parameters

Farmers live closely and interact with the environment and as such have indicators showing how the environment has changed over the years due to the changes in climate. Over the years these elements indicated in table 4-4 as mentioned by farmers have changed in how they occur or are experienced according to farmers. These are the indicators farmers gave as evidences to their claim of having observed changes in climatic parameters.

Table 4 - 4: Farmer's perceived indicators of changes in climatic parameters

Conditions	Pre-fire epoch	Post-fire epoch	Current epoch
Climate events	Predictable climate	Unpredictable climate	Extremely unpredictable climate
Seasons (rain/dry)	Long rain season & Short dry spells	Shorten rainfall season & Long dry spells	Less number of rain days/ Shortened rainy season & Extreme occurrences of climatic elements
Temperature	Low temperature	High temperature	Extremely High temperature
River bodies	Flowing water bodies throughout the year	Drying up of water bodies	Loss of river bodies
Crop yield	Good/high crops yield	High crop failure	Poor crop yield
Pest and diseases	Minimal pest and disease infestation	High incidence of pest and diseases	Extremely high incidence of pest and diseases **high dependence on agrochemicals
Bush fire	occasional bushfires	High incidence of bushfires	Minimal occurrence of bushfire
Forest products	Availability of NTFPs	Destruction of NTFPs	Loss of most NTFPs

Source: author's compilation 2015

Farmers living in the environment from the pre-fire to the current epoch mentioned some of the indicators used to either predict the onset of the rains or the dry season and also, the conditions that have changed over the years as the climate changes.

Post-fire epoch

River bodies and streams: Farmers recalled that river bodies and streams were more in the communities. These rivers and streams flowed throughout the year because they received a lot of rains during the long rainy season. The flow of river/stream indicated the intensity and amount of rainfall in the previous season. Due to the extreme climatic conditions farmers indicate the current epoch is experiencing low rainfall as such rivers/streams do not flow throughout the season.

***Tree species*:** Some tree species were used in predicting the onset or otherwise of the rain in any particular season. Tree species like *Ceiba pentandra* and *Terminalia ivorensis* according to farmers do not shed their leaves often in the year and as they begin to shed their old leaves and sprout new ones then the rainy season is about to start. And as soon as the tree’s leaves begin to drop, it is an indication that the rainy season will start soon. *Terminalia superba* also sheds its leaves from January and by March the tree will be very bare, devoid of any leaves. When the leaves of the trees begin to sprout then the rain season is near. When the time for the leaves to sprout is due and the leaves do not appear then it is an indication of bad rainfall.

Ants and Birds: The movement of ants up lands signifies the onset of the rains. When the ants are seen carrying their eggs from one point to the other then it signifies that rainfall is near.

During the rainy season whenever one hears of the whistling of a certain bird all farming activities must stop for one to rush to the house. These were aided by the thick forest and green vegetation that existed during that time.

Number of rainy days: The number of days it rained was more; sometimes for whole week you cannot even go to farm or school.

"I remember we used to have two (2) weeks break from school during the minor season because it could rain for a whole week without resting" a cocoa farmer from *Tewbabi*.

The intensity of the rain was high it sometimes rain with ice pebbles falling. All these helped farmers predict the weather, plant accordingly and enjoy good yield.

Current epoch

According to farmers, the post-fire and current epochs are exhibiting different occurrences of indicators. The forest has been destroyed through timber harvesting, small-scale agriculture, and various land conversions. There have been extreme occurrences of climatic and environmental events; floods, drought, bushfires, erratic rainfall, loss of vegetation, biodiversity and loss of river bodies, increased desertification/land degradation, high incidence of pest and diseases, poor crop yield and increased in the use of chemical fertilizers for farming.

"The weather has become highly unpredictable for farmers now; there are no trees left and if you manage to observe some of the indicators used earlier and you don't wait for the rains to come and you go on to plant your crops thinking that the rain is coming, my friend your crops would all die" as reported by a cocoa farmer from *Nsuta*.

4.3.4 Perceived manifestations of climatic impacts on smallholder cocoa system

Farmers indicated observed changes in the climatic parameters over the years and went on to show the impacts manifested on cocoa by these changes. The climate impacts on cocoa were manifested in the following ways;

i. **Differentiated impacts on different maturity stages of cocoa:**

It was observed that young cocoa in the establishment phase (less than 3 years) were the most vulnerable, as high temperatures and reduced rainfall resulted in high desiccation leading to high mortality of the cocoa seedlings (Plate 4-1).

Plate 4 - 1: Impacts of prolonged dry periods nad high temperatures on cocoa

ii. Impacts on leaves:

Farmers perceived that due to prolonged dry periods and high temperatures, the cocoa leaves curl while attached to the branches and drop off in their green state as in Plate 4-2. This is different from the natural deciduousness of the leaves because unlike the natural process, the cocoa leaves do not turn yellow before turning brown and falling down but curl and drop off in their green state.

Plate 4 - 2: Climate change impacts on cocoa leaves

iii. Impacts on fruits (cocoa pods):

Farmers reported that cherelle wilt (dropping of young cherelles) a physiological trimming mechanism to prevent over-bearing of pods has increased due to extreme climatic conditions. Pod failure is very high currently; its occurrence according to farmers is highly insignificant during seasons when rainfall patterns are better and dry periods relatively shorter. It is observed however that most trees abort their flowers and cherelles prematurely and do not lead to the formation of pods. On the other side 'fortunate' pods also ripen prematurely as shown in the Plate 4-3.

Plate 4 - 3: Perceived climate change impacts on cocoa cherelles and pods

iv. High Incidence of Pests and diseases

Increasingly, farmers are observing high incidence of insects/pests attack on the cocoa trees and pods as shown by Plate 4-4. Notable are Black pod, Mirids/Capsid (akate), *Bathycoelia thalassina* (Atee), Stem borers, Termites, Rodents and other vertebrates attack on cocoa pods and trees. These incidence according to farmers, are observed to be high during periods of prolonged dryness. At minimal occurrences farmers also experience plant pest or parasite.

Plate 4 - 4: Various incidences of pests and diseases as a result of changes in climate

v. Differentiated impacts on shaded and full sun cocoa:

Plate 4-5 shows observed differences in extent of leaf desiccation of portions of the cocoa farm under shade and other portions that are full sun by farmers. Farmers noted that while cocoa trees under shade trees have their leaves green and well attached to the tree, those under full sun portions had shed their leaves and appear like "skeletons". Also too much shade suppresses the growth of the young cocoa as shown in the Plate 4-5.

Plate 4 - 5: Differentiated climatic impacts on shaded and full sun and cocoa

vi. Impact on cocoa varieties:

Farmers in the transitional zone observed that the "Tetteh Quarshie" which they used to cultivate was able to withstand the drought and high temperatures of the early 1980s, except that fire ravaged most of the plantations. However, the current hybrid varieties are not able to tolerate comparable levels of climatic conditions.

4.4 On-farm practices and land-use change following the fire epoch

4.4.1 Response of farmers in terms of land use following the fire epoch in the cocoa-producing areas

Farmers recalled that cocoa production had started declining in these areas due to other social and economic factors before the climatic conditions got worse in the 1980s' and the eventual savaging of cocoa by bushfires. In the era of these impacts of worsening climatic parameters i.e. low rainfall and extremely high temperature which aided the seasonal occurrence of bushfires, smallholder cocoa farmers lost the confidence in predicting the weather and therefore could not continue cocoa farming. Consequently, farmers employed the following coping strategies and general responses;

i. Shift from cocoa cropping pattern to short rotation crops.

Almost all cocoa farms were destroyed by the 1983 bushfire. The few cocoa fields that were not destroyed by the fire could not be maintained after the 1983 bushfire as bushfire had become an annual ritual. Farmers therefore resorted to the cultivation of annual crops. Maize therefore dominated the landscape in addition to other staple crops and vegetables like yam, cassava, plantain pepper, tomato among others. These crops according to farmers have short gestation period and before the dry season starts they have already harvested the crops. According to farmers, maize is a biannual crop which can be planted with the late rains in the event that the early rains delay. Also, considering the time and efforts put into cocoa, a permanent crop, that could be destroyed by bushfire to that of maize, farmers were able to cope with the climatic effects on maize than cocoa.

Plate 4 - 6: Plate 4- 6: (a) Dr. K. A. Busia in a maize farm at Wenchi after the 1983 bushfire (b) a maize farm (source: farmer at Tromeso)

ii. Constant shifts in cropping patterns

Farmers explained economic hardships over the years in terms of low crop yield and some postharvest losses. It has therefore become a common practice according to farmers to resort to cultivating different crop every season either in succession on the same piece of land or on different land. According to farmers, the land has lost its fertility due to the extreme weather conditions making its ability to support crops very low, therefore the need to rotate crops cultivated so as to utilize the little soil nutrients.

4.5 shifts in cropping that have characterized the landscape and farmers reasons for these changes.

The landscape was covered with cocoa and almost all farmers were one way or the other involved in cocoa farming. Thus cocoa was the major crop cultivated by farmers in the pre-fire epoch. Annual crops like yam, cassava, plantain vegetables were also cultivated by farmers. This epoch was basically a cocoa economy. The figure 4-6 shows the cropping patterns from the pre fire, post fire to the current epoch. And how the people have moved from a cocoa economy to annual crops (maize dominated) economy and now reverting back to cocoa based economy.

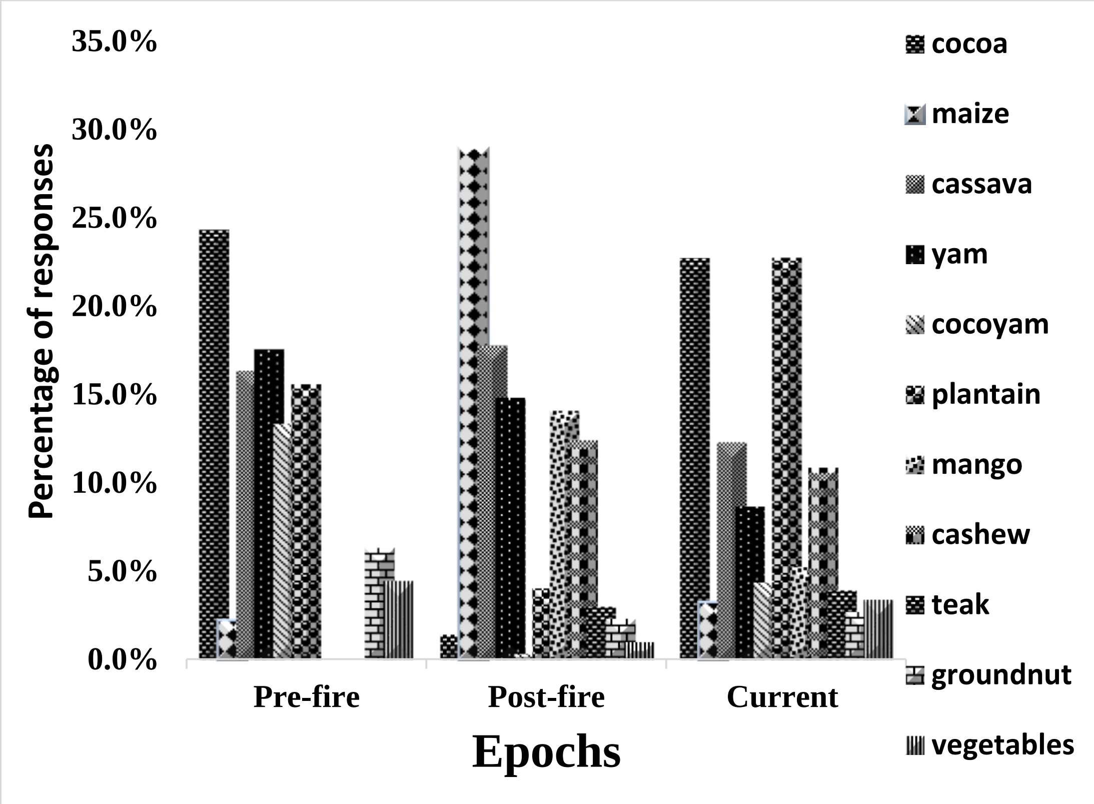

Figure 4 - 6: Respondents percentage of past and present cropping patterns in the three epochs

Farmers have moved in a cycle from cocoa economy to an annual crop based economy and now reverting back to cocoa economy as shown in plate 4-7. Cocoa production was not as productive as it used to be in the pre-fire epoch for farmers during the post-fire epoch especially since the bushfire continued to scare farmers seasonally. The few farms that were not destroyed by the 1983 bushfire could not withstand the harsh climatic conditions that were prevailing, making it difficult for farmers in terms of farm rehabilitation and the difficult task of cocoa cultivation.

Migrating to other communities because of the insecurity associated with the livelihoods became another option for farmers who in one way or the other were pushed or pulled out of the community. According to farmers, although people had started moving to new frontiers which affected cocoa production, it was not until the period of the bushfires of 1983 which saw massive movement of both the young and the old to other regions, mostly the Western Region where the weather was still ideal for cocoa production and bushfire was not prevalent.

Cocoa farms and forest lands were left bare by the bushfires, a perfect condition which favored annual crops farming therefore the takes over the landscape by annual crops farming. Maize farming dominated the landscape and it became intense with the influx of migrant farmers largely from the Northern Regions of Ghana who are noted for cereals cultivation. According to farmers, maize farming was the most lucrative farming activity which helped in their survival after the bushfire.

The economy became a food crop based economy with concentration on maize, yam and cassava. Some factors associated with the cultivation of annual crops like post-harvest losses, lack of storage facilities, instabilities in pricing, unstable markets and the fact that one needs to cultivate every other season and also the climate change impacts. These factors led to the quest for tree crops which farmers to withstand the climatic changes more than the annual crops. This is described as the transit period where farmers became interested in planting mango, oranges, teak and cashew (Plate 4-7). The establishment of cashew became popular especially in the Wenchi and Techiman areas after it was introduced by ADRA-Ghana as women Livelihood project in the early1990s.

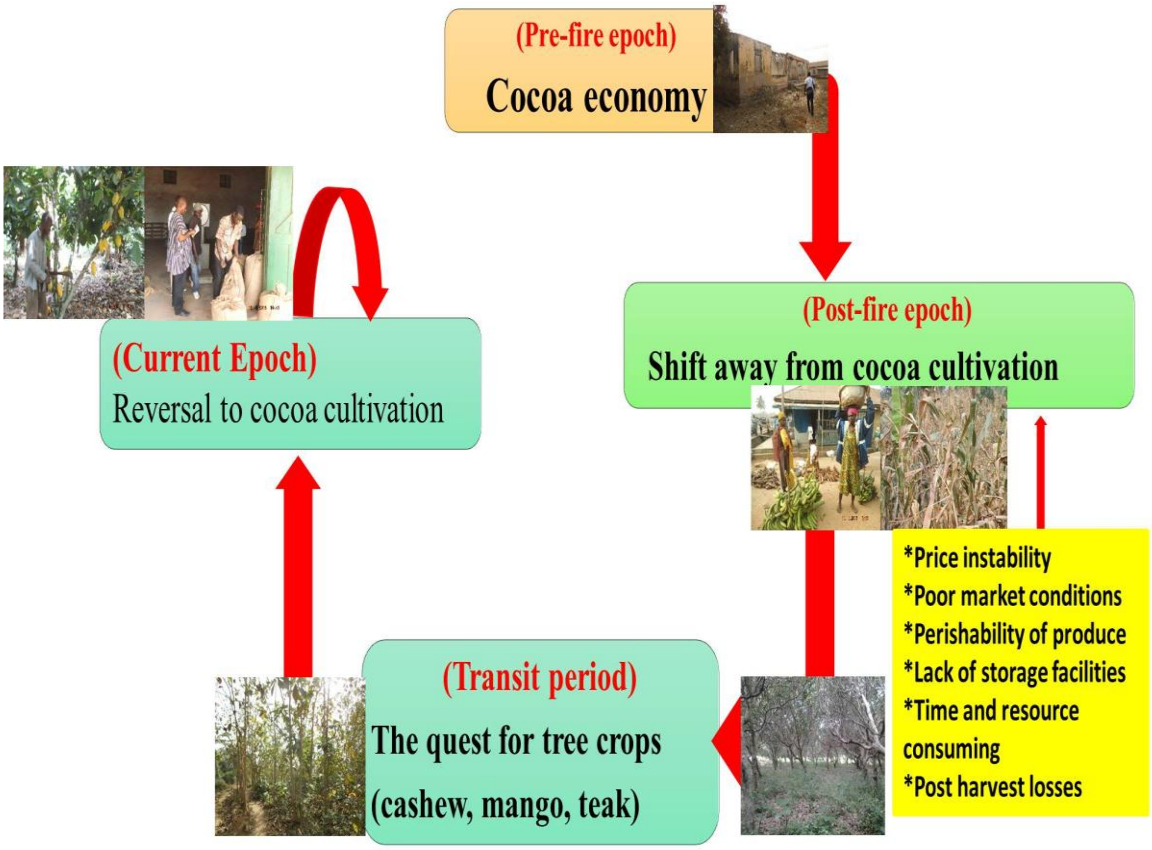

Plate 4 - 7: Livelihood shift from pre-fire to current epoch

4.6 Reasons informing farmer decision to revert to cocoa cultivation and on-farm climate change adaptation practices.

4.6.1 Reasons Informing Farmer Decision to Revert to Cocoa Cultivation

Figure 4-7 shows the reasons farmers gave for their reverting to cocoa cultivation. It is evident that changes in climatic parameters and changes in environmental conditions were the least factors linked with the shift in the cropping patterns.

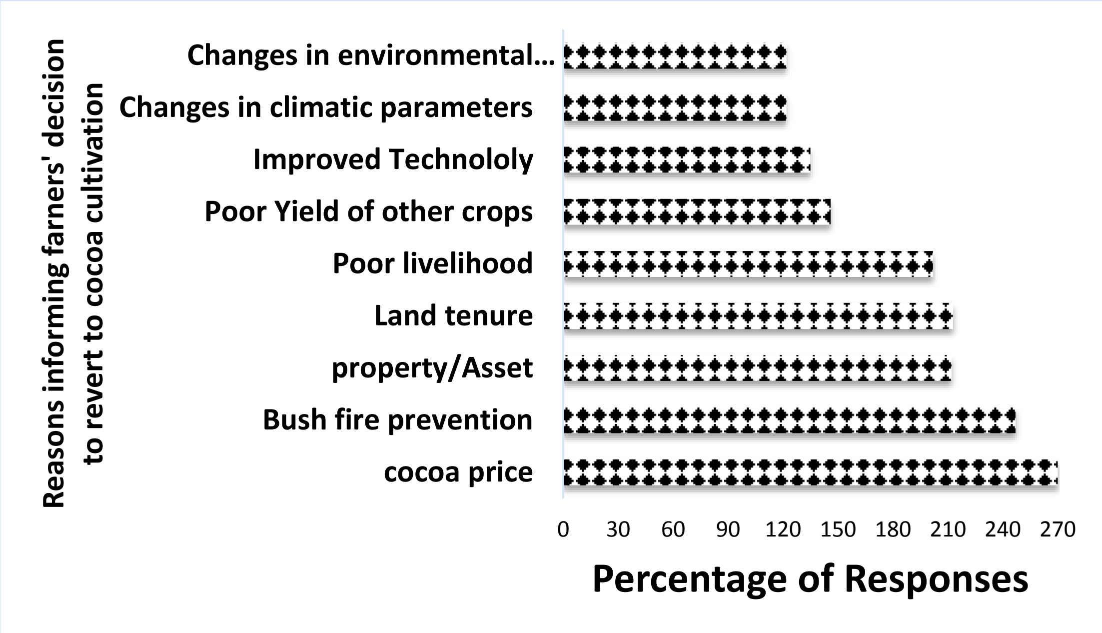

Figure 4 - 7: Respondents' reasons informing the decision to revert to cocoa cultivation

Cocoa farmers, like any other sector workers, are generally motivated by the economic returns from cocoa farming. Therefore the renewed interest is driven largely by the pricing policy of the state in cocoa sector. The sector enjoys equal pricing of cocoa which stands at GH¢ 350.00 per bag including annual bonus (2014/2015 cocoa season) across the nation, something different in annual crops. Farmers regard this condition as the best and a perfect motivation. The anxiety of farmers due to the annual occurrences of bushfire has reduced to the barest minimum or insignificant in some areas. This, according to farmers, has brought back the confidence which they lost in planting cocoa. This had been made possible by the strong community fire volunteerism. Among other issues contributing to farmers reverting to cocoa cultivation is the quest for property acquisition by farmers which according to them could not be found in the annual crops they were forced to rely on for many years. According to farmers half an acre of cocoa is now worth more than three acres of maize farm. Also, cocoa can last for more than thirty years; this can provide for them now and for their children in future.

Until the 1983 bushfire that savaged the cocoa landscape, one factor that was contributing to the decline in cocoa was the issue of scarcity of land. This factor was seen to have pushed people from the study communities to the other areas, with Western region being the major destination. Over the years, family lands, stool lands and that of individuals put under the cultivation of maize and other annual crops are being released and converted to cocoa farms. This is perceived by farmers as one of the reasons people are moving back into cocoa farming. Although it can be said the rate of conversion is a threat to food security as most food crop lands are being converted to cocoa farms, there is extensification of cocoa therefore the call for more intensification measures in these areas.

Other factors such as poor livelihood, poor yields of other crops, improved technology, changes in climatic parameters, and changes in environmental conditions were also indicated as some of the factors that may have contributed to the shift back to cocoa cropping as is shown in Figure 4-7. The changes in climatic parameters, farmers claimed was not a major factor influencing their return to cocoa cultivation because it is seen to affect every other crop.

4.6.2 Farmers adaptive strategies in the new cocoa farming system

i. Abandonment of the recommended line-and-pegging of cocoa seedlings to the old irregular planting:

Planting of seedlings irregular, ‘atogwe’, (Plate 4-8) on an acre of land is an old system of cocoa farming. Here, more seedlings are used to fill the land than in the line-and-pegging system. However, most farmers have observed some difficulties associated with the recommended line-and-pegging. They claim that the long dry spells negatively affect their seedlings and young cocoa. And so even though the line-and-peg method is more economical, the ‘atogwe’ method affords them some sort of security when some of the seedlings get destroyed. Farmers are aware of the impacts the long dry spell has on their farms especially the seedlings and young cocoa (below 3 years), for which reasons they resort to practicing the irregular (atogwe) planting if they are unable to buy more plantain suckers to protect their seedlings.

Plate 4 - 8: Irregular (atogwe) planting practiced by farmers

First and foremost, this practice is to provide an insurance since some seedlings may not survive the harsh climatic conditions. Again, it is to reduce the on-farm work load if the young cocoa does not survive after being spaced to the recommended line-and-pegging system of 10 feet interval between seedlings; which creates parks in the farm therefore increasing the workload of weeding and replanting.

ii. Planting more plantain suckers as protective cover for seedlings

Deforestation has made the landscape bare. Farmers realizing the impacts of changes in climatic parameters (reduced rainfall and increased temperature) on their crops have adopted the practice of planting more plantain suckers purposely in their cocoa farms to shield the seedlings from the high temperatures.

Plate 4 - 9: Planting of plantain suckers with seedlings

Planting of the cocoa seedlings inches away from plantain suckers (Plate 4-9) allow the seedlings to benefit from the succulent nature of the plantain. This provides moisture for the seedlings especially in the long dry season where these seedling need moisture for survival. This is an innovation by farmers that is helping to cut down the mortality rate of seedlings but at a cost to farmers.

iii. Strong community based fire volunteer system that is highly responsive to fighting fire:

In areas where bushfire is still a challenge, community members volunteer to form gangs to provide fire preventive services and fight against those activities that cause bushfires. The gangs have their head office at the Ghana National Fire service within their districts. They get training from the Ghana National Fire service. The volunteer gang supervises farms that need to be burnt after weeding at a fee; mobilize through blowing of whistle as signals to provide quick firefighting response when such occur. Occasionally, the gang patrol areas they consider as potential source of fire and areas known to be fire prone. Offenders of the rules of the gangs in any way are charged an amount to pay or sometimes prosecuted. Farmers put barrels on their farms which they hire people to fill up with water; this water is used to irrigate the seedlings and serve as fire hydrant should fire occur.

iv. Creating fire belts around their farms:

Individual farmers put in place some on-farm measures to prevent fire either spreading to or from their farms by creating fire belts (Plate 4-10) around their farms. Portions of land left around the farm are sometimes cleared of all weeds and dried leaves or left green by planting some trees like *Senna siamea*, cashew which are considered to be fire resistant.

Plate 4 - 10: Fire belt created around cocoa farm; on-farm practice against bushfire

v. Increased awareness of the role of shade trees in mitigating the impacts of changes in climatic parameters:

Farmers have observed changes in climate (rainfall and temperature particularly) and the impacts it is having on crops. Therefore farmers are increasingly adopting measures to help protect their crops from the impacts of changing climate. This farmers' strategy may be aimed at forest creation that may induce frequent rainfall. This includes the establishment of tree plantations and leaving some trees standing on their farm during land clearing when establishing new farms (Plate 4-11a). Some farmers occasionally cut down some trees from their farms as shown in Plate 4-11b. The reasons for this being that, some of the trees harbor pest which eventually destroy their cocoa trees. Also some farmers indicate the trees overshadow the cocoa tree so the need to remove it.

Plate 4 - 11: (a) Trees left standing in a new cocoa establishment (b) tree cut down in a cocoa farm

Though farmers revealed their willingness to plant more shade crops, their challenge is having access to tree seedlings and the appropriate species that would help their farms as farmers have knowledge of some tree species serving as host to pests.

4.6.3 Cocoa farmers perception on difficulties in current cocoa farming compared with cocoa farming in pre-fire epoch

i. Preparation of land for cocoa cultivation

Preparing the land for cocoa farming in pre-fire epoch involved; clearing the land, leaving the debris to rot on the land and planting the cocoa seedlings. The rotten debris added organic matter to the soil helping the cocoa to grow well. The use of chemical fertilizers was limited to the aged cocoa trees, a practice which was also good in carbon sequestration. Comparably, the current epoch involves the practice of slash and burn and usage of weedicides and chemical fertilizers even on young plants

ii. Differences in time spent and efforts on cocoa farming

The time spent and efforts on farming in the pre-fire epoch were considerably less and not difficult according to farmers (Figure 4-8). Same cannot be said for the current epoch since the approach to farming is different. This according to farmers is as a result of poor climatic conditions and changes in the physical environment.

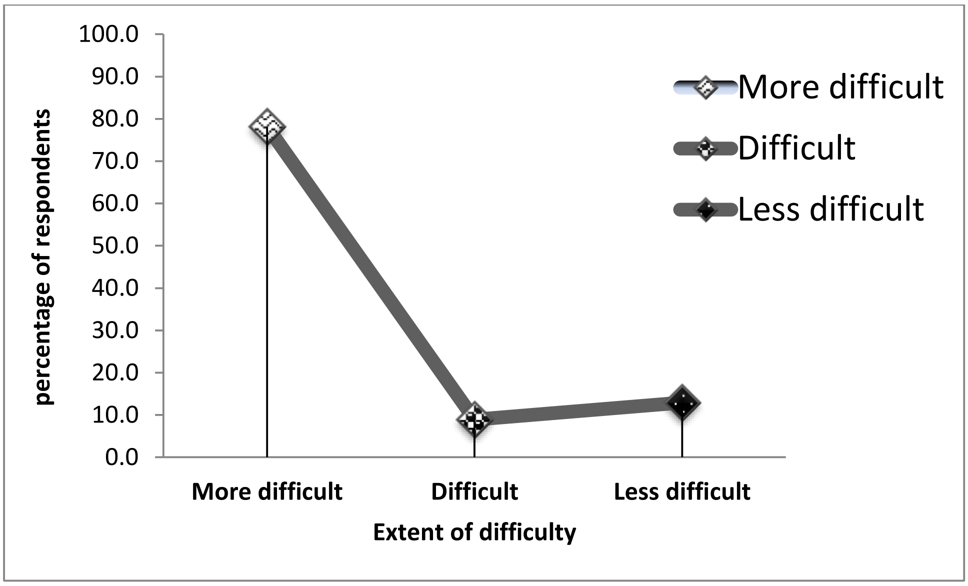

Figure 4 - 8: Perception of farmers on cocoa farming dificulties in the current epoch compared to the pre-fire epoch

78.1% and 8.9% respondents indicated that cocoa farming today is more difficult and difficult respectively than the pre-fire epoch. They explained that extreme pressures were exerted on the land in the post-fire epoch when land was put under extensive maize cultivation. It involved clearing the land constantly and the use of chemical fertilizers and weedicides and this led to the land fertility issues thus the land becoming more difficult working on. Currently, farmers are forced to use chemical fertilizers on farms even and sometimes at the young and maturing stage, a situation which increases the financial hardship on farmers. Weeding has also become frequent (2-3 times) in a season which was only once in the pre-fire epoch. The few (13%) who considered the current farming is less difficult accounted for the fact that labor is available now and chemicals are available which limit time and energy. This they acknowledged increases the cost of farming. Farmers added to the problems they are facing in the current epoch the, issue of free inputs supply by the Government.

Though a good idea but for the deep politicization, nepotism and corruption that have bedeviled the system, the once efficient policy has lost its direction. They complained bitterly about the system and therefore wish Government abandoned the project and make available the inputs for sale. It was mind baffling seeing four farmers sharing one bottle of ‘confidor’ chemical while some individuals could have more than four. A product indicated not for sale but people go on to sell it.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter provides detailed discussion of the results obtained from the studies. It further explains the results, its implications and relates it to other studies to explain the observed changes in climatic parameters by farmers, the reasons for the shifts from cocoa to annual crop (maize dominated) and back to cocoa cropping, and the adaptation mechanisms of farmers in this current epoch of climate change.

5.2 Perceived changes in climatic parameters

Perception of farmers of changes in rainfall is reinforced by studies at Akim Tafo indicating annual rainfall (1938-1986) following a two year cycle with a weaker cycle of five years. This is to say years of relatively low or high rainfall might occur every ten to twelve years when two cycles reinforce each other (Brew, 1991). Historically, Ghana has experienced some instances of National disasters related to rainfall deficits. This is said to be partially influenced by the *El Nino Southern Oscillation* (ENSO), where changes in temperature and air surface pressure in the tropical Western Pacific have led to below average rainfall in such years (Stutley, 2010). Within the past 50 years, the worst El Niño year occurred in 1983 which led to a National response to receive food aid. Several efforts to prepare for such emergency situations are orchestrated to reduce and likewise to respond to Ghana’s increased risk and risk exposure.

A report by Enete and Amusa (2010) admits that climate change is one of the most serious environmental threats mankind is facing globally. Farmers also share this knowledge that changing climatic elements and weather patterns are to have severe negative impacts on food production, food security and natural resources in the immediate and coming years.

Rainfall data for the four driest months November, December January and February (Figure 5-1) shows that rainfall sharply dropped from about 170 mm in 1980 to below 50 mm per month between the years 1981 and 1983. These periods also recorded high temperatures with 1983 being the year where devastating bushfires occurred destroying a lot of cocoa farms. Cocoa production reached the lowest level for the first time between 1981 and 1983 (Figure 5-1).

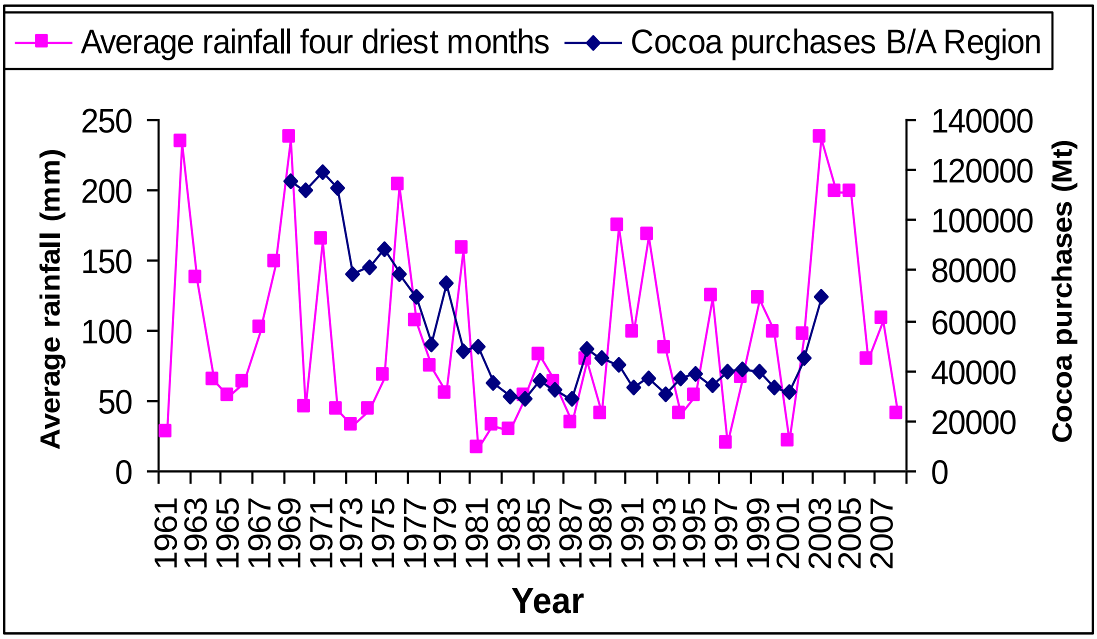

Figure 5 - 1: Average rainfall for the period of January, February, November and December 1961 – 2008 plotted against cocoa purchases 1969/70–2003/04. Sources: Rainfall-Ghana Meteorological Agency and cocoa purchases – COCOBOD in Anim-Kwapong and Frimpong (2008)

It is evident from the results that rainfall and temperature have over the years changed and it is affecting crop yield. Cocoa production like any other agricultural activity is highly sensitive to changes from length and intensity of sunshine, to rainfall and water application, soil condition and temperature due to evapo-transpiration effects. In the pre-fire epoch temperature, rainfall, humidity, and altitude were the major components that interacted to produce the local climate which was ideal for the cultivation of cocoa (Opeke, 2005). This somehow is confirmed by the perception of farmers in terms of rainfall intensity, the number of raining days, the onset of rain expectedly and temperature intensity (Figures 4-2, 4-3, 4-4, 4-5) for the pre-fire, post-fire and the current epoch. It can be put forth that the rain falls heavily during the raining season for some few days, which may result in runoff and soil erosion. It is therefore possible that, in spite of the heavy rains, water deficit could still persist in the soil which can result in decreased cocoa yield. Also, it shows that there was not an even distribution of rainfall within the post-fire epoch. However according Naturland (2000) and ICCO (2009), adequate distribution of rainfall throughout the year is required for better cocoa growth and yield. It can be observed cocoa production has been affected as indicated by the cocoa purchases within the periods as shown in Figure 5-2.

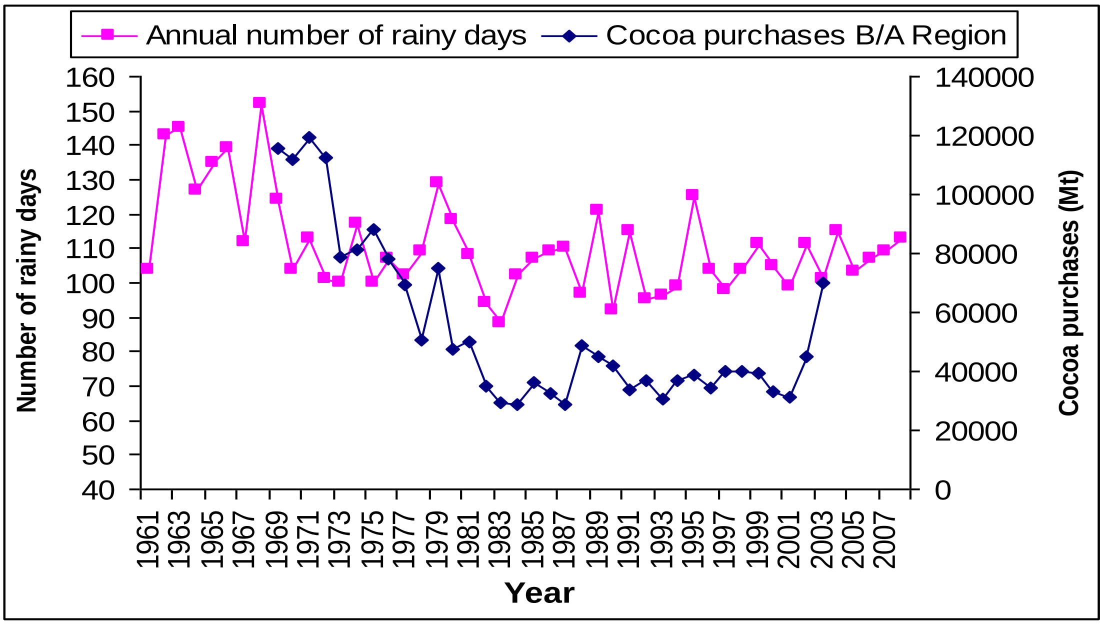

Figure 5 - 2: Annual number of rainy days, 1961 – 2008 plotted against cocoa purchases. Sources: Rainfall data - Ghana Meteorological Agency and cocoa purchases – COCOBOD in Anim-Kwapong and Frimpong (2008).

Other factors like soil fertility, farming practices could be said to have contributed to the low cocoa yield. From farmers' account, the presence of forest played a part in the distribution of the climatic elements in the pre-fire epoch, but the destruction of forest (deforestation) in the post-fire and current epoch negatively affect the distribution of weather elements. Land cover changes in Africa have occurred within two main biomes – the tropical rainforest and acacia savannah. Theoretical and empirical evidence that contemporary tropical rainforest destruction significantly reduces regional scale rainfall remains inconclusive for Africa. Although there is no doubt that moist micro-climate ideally suited to cocoa is lost when forest areas are opened up by felling of trees and bushfire (Codjoe *et. al.*, 2013).

The post-fire epoch saw a massive drop in rainfall for the four driest months, November, December January and February. Figure 5-1 shows rainfall sharply dropped from about 170 mm in 1980 to below 50 mm per month between the years

1981 and 1983 (Anim-Kwapong and Frimpong, 2004). These periods also recorded high temperatures with 1983 being the year where devastating bushfires destroyed lots of cocoa farms. Cocoa production reached the lowest level for the first time between 1981 and 1983 (Figure 5-2) though farmers confirmed that cocoa had started declining with other issues before reaching the lowest production in 1983. They also do acknowledge erratic rainfall, poor soil conditions played major factor. The long dry climatic conditions favored the occurrence of the bushfires which later became the major reason for abandoning cocoa farming in the transitional ecological zone of the country.

In Ghana, temperatures are generally high and meteorological evidence projects increase in temperature over the coming years. The mean annual temperature generally ranges between 24^{o}C and 30^{o}C. Extreme temperature conditions are experienced in some areas, for instance, temperatures ranging between 18^{o}C and 40^{o}C or more are common in the Southern and Northern parts of Ghana respectively (EPA, 2011). This explains the study areas in the transitional zone experiencing high dynamics in the temperature intensity.

These marked differences in climatic conditions manifest in various forms and reveal symptoms of climate change and climate variability. Based on observed rainfall recordings between 1961 and 2000, the annual mean rainfall levels are likely to reduce between 1.1% and 3.1% across all agro-ecological zones by 2020 and expected to be as high as 13% and 21% in 2080 based on the observed baseline values according to Ghana’s Second National Communication to the UNFCCC (2011). From the study in the transitional zone of Ghana, cocoa farmers expressing fear with the trend of changes in rainfall and temperature perhaps is a great concern.

Available evidences show that climate change is global, likewise its manifestations/impacts, but the most adverse effect will be felt mainly by developing countries, especially those in Africa due to the low level of coping mechanisms of these countries (Odjugo, 2010). As the planet warms, rainfall patterns shift and extreme climate events such as droughts, floods and forest fires become more frequent (Zoellick, 2009). These result in poor and unpredictable yields, making farmers more vulnerable, particularly in Africa (UNFCCC, 2007). Perhaps a step in the right direction as NEPAD initiative recognizes global warming and desertification as priority intervention and emphasizes monitoring and regulating the impacts of climate change and integrating fire management projects (GSNC-UNFCCC, 2011).

5.3 Perceived manifestations of climatic impacts on small holder cocoa system.

Climate is very important in agriculture; it sets the limit for the agricultural activities in any area or ecological zone of the world. Changes in climatic parameters for instance are known to alter the development of cocoa pods, insect pests and pathogens which translate into lower crop yields and impact farm income *(*Agbongiarhouyi *et. al., 2013)*. The result presented in Figure 4.3 indicates farmers are fully aware of the changes in climatic parameters and the manifestations on their cropping patterns. This sits well with the comment of CGIAR (2002) 'no one understands better than farmers how the weather, especially when it takes a turn for the worse, can affect people and their land'. Notwithstanding farmers as well as other stakeholders are unable to do much about the observed changes in climate and its impacts on production.

Young cocoa in the establishment phase (less than 3 years) are the most vulnerable (Plate 4-1), since high temperature and reduced rainfall result in high desiccation. This is pronounced during prolong droughts where soil water deficit is high, a situation that increases mortality of the cocoa seedlings (GNSC-UNFCC, 2011). This poses huge challenge to farmers' efforts perhaps a reason for farmers' reluctance in rehabilitating and rejuvenating old and unproductive cocoa farms. As a result, farmers prefer to keep their old cocoa, since there is high uncertainty about the survival of young cocoa. However, though matured and old cocoa are also impacted on by poor climatic conditions through loss of leaves and smaller branches and effects on cherrels/pods, they are able to bounce back when the climatic conditions become favorable for production becomes low.

Farmers are aware of the benefits derived when planting is done according to the recommended line-and-pegging (10 ft. intervals) method introduced by the Cocoa Service Division (CSD) but considering the high mortality rate of seedlings farmers prefer planting in the old random method. This is an insurance against the high rate of desiccation in this era of climate change. Farmers indicated that due to prolonged dry periods and high temperatures, the cocoa leaves curl while attached to the branches and drop off in their green state. This is different from the natural deciduousness of the leaves because unlike the natural process, the cocoa leaves do not turn yellow before turning brown and falling down.

There is increased pod failure in recent times compared to the pre-fire epoch, and this current occurrence according to farmers is highly insignificant during seasons when rainfall patterns are better and dry periods relatively short. It is observed that most cocoa trees abort their flowers prematurely and do not lead to the formation of pods whiles some pods also ripen prematurely as shown in the Plate 4.3. Also, during the short dry season, pod filling can affect bean size if it is sufficiently severe (GSNC-UNFCC, 2011).

The crop (cocoa) is highly susceptible to drought and the pattern of cropping of cocoa is related to rainfall distribution. A reason why cocoa is not usually grown in the savannah is mostly because it is drier not because it is hotter than the rainforest zone; the rainforest zone of Malaysia, which is about 2°C hotter than that of West Africa, is very suitable for growing cocoa (Wood and Lass, 2001). The impacts of climate change on the supply of dry cocoa beans was estimated by Anim-Kwapong and Frimpong (2008), in which they determined the effect of changes in total annual rainfall, total rainfall in the two driest months and sunshine duration. They used multiple regression analysis to show that over 60 percent of variation in dry cocoa beans could be explained by the combination of the preceding total annual rainfall, total rainfall in the two driest months and the total sunshine duration. Oyekale *et al*., (2009) also showed that about 82% of cocoa farmers in Nigeria depend heavily on rainfall and could be more in the rest of West African countries. They estimated the impact of climate change on the production of cocoa and it was stated that, the main climate element was rainfall and has a very significant impact on cocoa growth. Rainfall failure therefore has the ability to increase the cost of controlling diseases and pest and reduce the quality of the cocoa beans. Excess cost and reduce quality were significant at 1% and 5% respectively (Danso-Abbeam, 2010).

The annual total rainfall in the cocoa growing regions of Ghana is less than 2000 mm. The rainfall distribution pattern is bi-modal from April to July and September to November. There is a short dry period from July to August during which the relative humidity is still high with over cast weather conditions. There is a main dry season from November to February-March. The four to six months of dry weather results in soil water deficit and since irrigation is not part of the cocoa farming system, cocoa seedling mortality is high. In bearing plants, the existence of the short dry season during main crop increases pod filling which can affect bean size if it is sufficiently severe (Anim-Kwapong and Frimpong, 2000).

In adult plants, water deficit results in lower yields and an increase in pest and disease infestation notably Mirids/Capsid (akate), Black pod, *Bathycoelia thalassina* (Atee), Stem borers and Termites. Mirids/Capsids are sucking insects that feed on the cocoa and make them difficult to establish and the damage can cause tree death. They are usually active and destructive from September to March when moisture deficit is severe and light intensity and humidity in the cocoa micro-environment is high. Black pod is the most destructive which attacks the developing or ripening cocoa pod. Closely related to weather and climate, it is more prevalent and destructive in damp situations and in years when the short dry period from July to August is very wet.

Climate change also alters stages and rates of development of cocoa pests and pathogens, modify host resistance and result in changes in the physiology of host pathogen/pests interaction. The most likely consequences of the impacts of climate change on cocoa are the shifts in geographical distribution of host and pathogen/pest, altered crop (cocoa) yields and crop losses which will impact socio-economic variables such as farm income, livelihood and farm-level decision-making (Ajewole and Iyanda, 2010).

5.4 Response of farmers in terms of land use and livelihood shifts after the fire epoch in the cocoa producing areas.

The IPCC (2001) defines adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. According to Farmers the climatic conditions got worse in the 1980s' and eventual destruction of cocoa farms by bushfire in 1983. In the era of impacts of worsening climatic parameters (Low rainfall and extremely high temperature) which aided the seasonal occurrence of bushfires, smallholder cocoa farmers lost the confidence in the weather as the pattern of rain and dry seasons changed, and so could not continue cocoa farming. Therefore the only option was to diversify and hence a massive shift to annual crops which was dominated by maize farming. The fear of seasonal bushfires and other socio-economic factors caused nearly the collapse of cocoa farming in most parts of the transitional zone of Brong Ahafo.

Migrating to other farming areas and already chocked urban cities became another option for farmers. This is due to the livelihood insecurities that were being experienced. The natural resources on which farmers depended for their livelihoods were under serious stress. Therefore this situation pushed some farmers to migrate and in some instances resorted to illegal activities for income. One of the reasons for the declining cocoa production in these areas in the late 1970s' was the issue of land scarcity. Based on this, people started moving to other areas (Western, Eastern and Ashanti Region) to look for new/virgin lands to farm cocoa.

According to farmers, as people moved in search of new lands others who lost confidence in farming and could not secure any meaningful livelihood also moved to the urban cities in search of jobs and other professions other than farming. The fear of seasonal bushfires and other socio-economic factors continued to scare farmers and nearly caused the collapse of cocoa farming in most parts of Brong Ahafo. For instance Produce Buying Company (PBC) had to combine Techiman and Wenchi cocoa buying centers to that of Sunyani since these centers where basically inactive.

Farmers after some periods of being aware of the benefits of tree crops started looking around for alternative tree crops to replace cocoa but this time the one that could withstand bushfires. This led to the massive establishment of cashew, teak, mango and orange plantations in areas of Wenchi, Techiman and Berekum. Largely farmer's diversification was from a perennial cocoa crop to annual crops (maize dominated), the best way of adapting to the changing climate according to farmers.

Agricultural adaptations are known to involve two types of modification in production systems. The first is increased diversification that involves engaging in production activities that are resistant to temperature stress as well as activities that make efficient use and take full advantages of prevailing water and temperature conditions. Among other factors this is known to provide insurance against rainfall variability, as different crops are affected differently by climate events (Orindi and Eriksen 2005; Adger *et. al.*, 2003).

The second strategy focuses on crop management practices geared towards ensuring that critical crop growth stages do not coincide with very harsh climate condition such as mid-season droughts. Crop management practices that can be used include modifying the length of growing period and changing planting and harvesting dates (Orindi and Eriksen 2005). The issue is that cocoa farmers could not undergo these diversification and management practices. Therefore, in the face of extreme climatic conditions which were not favoring their cocoa farming after the 1983 bushfire which had later become an annual ritual, farmers resorted to cropping annual crops replacing cocoa with maize as their cash crop.

> A cocoa farmer from Abisasi; *“The fire had become seasonal, group hunters were taking advantage of the prolonged dry seasons to set fires into the fallow lands in order to get bush meat. We had no option than to cultivate maize which helped us to survive the difficulties and hunger that came after the 1983 bushfire had destroyed all our crops”*

Maize became the dominant annual crop in the landscape in addition to other food crops like yam, cassava, plantain and vegetable (in waterlogged areas). Maize in particular was selected based on its short gestation period and the fact that it could be harvested before the dry season starts. According to farmers, maize is a biannual crop which could be planted with the late rains in an event the early rains delay and considering the time and efforts put into cocoa to that of maize, farmers were able to cope with the climatic effects on maize than cocoa.

Cocoa production was not a suitable job for farmers after the 1983 bushfire coupled with the fact that most land owners and cocoa farmers were old folks as at then, and therefore could not go through all the many years of farming before the cocoa matures,

> A cocoa farmer from Tromeso; *“My father was nearly 60 years when our cocoa farm of about 15 acres was burnt by the fire, he couldn’t stand the idea of having to start cocoa farming which would take about 10 years to develop, and therefore he gave the land out for maize farming on share cropping so we could survive. All his toiling for so many years was gone nothing could make him go back to cocoa farming*”

The few farms that were not destroyed by the fire could not stand the harsh climatic conditions that were prevailing, making it difficult for farmers especially having to continue the seasonal rehabilitation of farms. Cocoa farms and forest lands were opened up by the fire which favored maize farming all over the landscape. This situation attracted migrant farmers largely from the Northern Regions of Ghana. These migrant farmers from the savanna zone were well noted for cereals cultivation, and they therefore cultivated the land immensely and continuously. A reason given was that they (migrant farmers) had the aim of returning to their native land with their returns. Their farming practices aggravated the already worsening situation since it involved clearing all trees from the land.

5.5 Reasons informing farmer decision to revert to cocoa cultivation.

Cocoa farmers as any other sector workers are generally motivated by the economic returns from cocoa farming. Therefore the renewed interest is largely driven by the pricing policy of the state in recent times. Cocoa sector across all cocoa growing areas have the same pricing, something different in other annual crops. For instance maize, tomatoes and yam pricing is determined to a large extent by buyers (mostly marketers) in most cases to the detriment of the poor farmers.

> A cocoa farmer from Abisase; *"The cocoa price is better now compared to that of maize and it's the government that determines how much cocoa is bought, unlike maize which the buyers come and give the price they want. You would have to take it like that because if you don't your family is going to starve. Also a cocoa farm that does not yield is even better than a high yield maize farm".*

In Ghana, the price of cocoa is annually fixed; cocoa farmers cannot negotiate for higher prices, but on the other hand they are certain to get the threshold price irrespective of world market price fluctuations. For instance, the annual producer price increased from 56% of the FoB in 1998/99 up to 70% in 2004/05 and 76% in 2011/12 (MoFA, 1999), a growth path the cocoa sector has followed for ages, an incentive for increasing cocoa production though usually delayed. Besides the pricing system provides farmers with a stable income, allowing farmers business planning. There is evidence that farmers' respond to price by changing the intensity with which they tend their farm (for example when prices fall they stop with maintenance and with new planting activities). Conversely, if prices cover or exceed variable costs farmers will intensify farm management (for example by investing in harvesting, weeding and the use of inputs) (Anim-Kwapong and Frimpong, 2008; Laven, 2010).

Also Farmers doing their own analysis based on community development, housing and education of wards, have realized the pre-fire epoch was much better in terms of living conditions and community development.

A cocoa farmer from Tewbabi;"*When you look around the community, all the big houses you see around and at Berekum Township were built with cocoa money and also the educated fellows in our communities are children of cocoa farmers. When we started maize farming we couldn't build some of all these houses, all we could do is to repair them, anyone living in a modern house is either a government worker who was educated with cocoa money, so why must we waste our energy on maize farming again, besides the land now has become difficult to farm maize"*.

A woman from koase; *"My father used to travel to Kumasi every Christmas and would come with a lot of items for his three (3) wives, my siblings and myself and other family members who were living with us. We were two (2) girls out of nine children so we got a lot of things from our parents. My brothers were virtually the kings in the community because their father was a rich cocoa farmer. All these came to an end when the 1983 bushfire destroyed my fathers' cocoa farm and only two of my brothers could make it secondary school and are now government workers. I have realized that it is the best cash crop one could get".*

From the general perception of farmers, economic benefit of cocoa is the major factor driving the current movement to cocoa farming. Farmers regard the reduction in the occurrence of bushfire as another major factor driving the interest in cocoa farming.

The fire that crippled farmers' efforts after the 1983 bushfire and its subsequent annual re-occurrences has reduced due to the strong community fire volunteerism. Communities through the fire gang (fire volunteers) have enacted rules and regulations which prevented certain activities to be undertaken by community members when the dry season is approaching. Bushfire is the only incidence which would lead farmers to loss hope in cocoa farming, according to the farmers themselves. As such, the reduction in the occurrence of bushfire is a major factor driving the interest in cocoa farming. Fire management became very important as bushfire continuously waste farmers' efforts. Community members are not permitted to send naked fire to the farm and only under highly extreme circumstances is a farmer allowed thus if a farmer is to pass the night at the farm. According to farmers they either cook their food in the house before going to the farm or buy from food venders so they would not light fire at the farm. This achievement in bringing down occurrences of bushfire is made possible with the help of chiefs and the Ghana National Fire Service. GNFS gives training to the volunteers on how to manage and put out fire. With all efforts the sector has its own challenges which do not make it more efficient. Nevertheless the little efforts have yielded good results.

Cocoa is a tree crop which could last for 30 years and above, for this reason farmers are assured of a property/asset at their old age and for future generations when farms are well managed.

Cocoa farmer from Wenchi; "If my father had re-established his farm after all these time, we wouldn't have suffered as we did but I know it wasn't his fault. I don't want the same for my children and wife if I am no more. I want to get property for them and even at my old age when I cannot go to farm again I can send someone to go for the proceeds from the cocoa farm so I get something to live on. When you are into maize farming and you get old, you can't farm anymore but when you have cocoa farm and you are old you can even give it out for share cropping". This is my reason why I'm farming cocoa now instead of the usual maize farming.

According to farmers, concentrating on annual crops could not help them, especially in an even they are not able to cultivate a particular year, but with cocoa farm the story would be different Most of the families who migrated to the Western region when conditions were poor are now back because according to them, the soil has now lost its fertility, diseases are affecting their farms and most importantly farms are old and thus yields have reduced. They have realized the land they left behind now has good fertility and conditions have improved. Some would say it was the returnees who started planting cocoa on large scale before people realized the land is still fertile for cocoa cultivation.

Ownership of land has taken new shape. Lands are being given to individual family members. This is so because most of the older generations are fading away and hence siblings are getting their fair share of the property left behind. Family lands, stool lands and that of individuals put under the cultivation of maize and other annual crops are now being released and converted to cocoa farms. This is perceived by farmers as one of the main reasons young people are moving into cocoa farming.

Though the rate of conversion to cocoa farming is encouraging considering the importance of coca to the individual farmers and the country at large, this trend of conversion is a threat to food security and would become a serious issue. Farmers are converting all possible lands to cocoa farm and would possibly enter into forest reserves. This extensification calls for more pragmatic policy measures toward intensification of the cocoa sector. There are several factors such as poor livelihood, poor yield of annual crops, improved technology, changes in climatic parameters, and changes in environmental conditions mentioned by farmers as being factors that are all working to contribute to the shift to cocoa cultivation.

5.6 Farmers' adaptive strategies in the new cocoa farming system

Climate change adaptation is the ability to respond and adjust to actual or potential impacts of changing climatic conditions in ways that cause moderate harm or take advantage of any positive opportunities that the climate may afford (IUCN *et. al*., 2004). It includes policies and measures to reduce exposure to climate variability and extremes, and the strengthening of adaptive capacity. Adaptation can be anticipatory, where systems adjust before the initial impacts take place, or it can be reactive, where change is introduced in response to the onset of impacts (ibid). Adaptive strategies should therefore include local actions taken by the poor people themselves in response to changing market or environmental conditions. The process of adaptation includes learning about risks, evaluating response options, creating the conditions that enable adaptation, mobilizing resources, implementing adaptations, and revising choices with new learning (ibid).

Adaptation activities can be of different types; from the purely technological (e.g. sea defence construction), through behavioral (such as shifts in choice of food or recreation), managerial (e.g. changes in farming methods) and policy (e.g. planning regulations). This has happened because people's taste and preferences have changed due to globalization (EPA *et al.,* adopted from Codjoe, 2013). From the climate change report by GAIP (2014), International climate change models project changes in rainfall variability and dry spells for West Africa. Ghana’s farmers will have to develop adaptation strategies to respond to this threat in order to sustain their livelihoods.

From the findings of this work it is clear that farmers are already taking proactive measures for coping with challenges of climate change impacts on cocoa. The high adaptation could be attributed to farmers’ cocoa farming experience, the importance farmers are placing on cocoa production now and perhaps the educational level since cocoa farming now is not left to the illiterate but educated and professionals including youth are involved in cocoa farming now.

Deforestation is known to be a major environmental problem Ghana is battling with. The forest trees give shade to protect cocoa; shade trees have an important function in the cocoa farm. The more shade the more humidity, if there is not enough shade, the farm gets too dry in the dry season, but if there is too much shade the farm gets too humid in the rainy season. Shade suppresses the level of capsid attack but increases the incidence of black pod disease. It is therefore very important to balance the level of shade. In this time and day where getting forest trees to shade crops is practically impossible, farmers have adopted planting more plantain suckers as protectors especially for seedling until they become trees that could stand the dry spells.

Land preparation for the cultivation of cocoa is done the same way as for food crops. The forest vegetation is first cleared, but with some of the trees left standing. The litter is burnt during the height of the dry season. Traditionally, food crops like cocoyam and plantain are first planted at the start of the rain in March, and the cocoa seedlings are planted among them to shelter under their broad leaves. This traditionally has been practiced by farmers but because of the extreme climatic conditions, farmers have resorted to planting of the cocoa seedlings one-to-one and inches away from plantain suckers. This allows the seedlings to benefit from the succulent nature of the plantain which provide moisture for the seedlings especially in the long dry season where these seedling need moisture for survival. This is a new way by farmers that is helping lower rate of seedlings mortality; this new way of farming is only to aid in the survival of seedlings. Farmers' worry now is the additional cost of getting plantain suckers.

Also planting of more seedlings randomly than required on an acre of land was practiced in the pre-fire epoch where the land was fertile and could support almost anything. Farmers' observation of the difficulties associated with the recommended line-and-pegging (10 ft. interval) which though farmers would wish sticking to its practice, but for the high mortality of seedlings in the long dry spells; farmers fear it would increase the already difficult conditions of farming. The strategy now is to start planting with the random practice which will aid in the survival of more seedlings. When cocoa trees are about two years and above, farmers' start to trim the farm by removing some of the cocoa trees to attain the recommended line-and-pegging or something similar to provide good aeration and avoid competition for nutrients.

These strategies may not be comprehensive and exhaustive in nature but they are helpful in adapting to changes in climate in local or regional levels. It could be observed that most adaptation strategies seem very difficult and unfavorable for the sustainability of cocoa production. For instance, farmers have observed a delay in onset of rainfall and so they adapt by changing the planting dates of their food crops (e.g. minor season maize) to coincide with the rains to ensure good yield. This cannot be done with cocoa which is a perennial crop. Furthermore, controlled land clearing where selected trees are left on the farm to provide a good micro-climate is more suitable with food crops which are grown on seasonal basis than cocoa that is a perennial crop and requires one time establishment.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

It is well accepted now both scientifically and politically that climate change is occurring (Ladislaw *et. al.*, 2008) and studies (Kates 2000; Mendelsohn *et al.* 2007; Thomas and Twyman, 2006) point to the fact that poor, natural resource-dependent rural households will be the worst hit by adverse climate impacts.

Visible changes in climate have occurred in the study areas and transitional zone in general within the last three to four decades. These changes have impacted on agricultural production patterns. Historical analysis of past and current cropping patterns in the areas indicate some major shifts in the cropping patterns; *from cocoa cultivation economy to annual crops maize dominated economy and back to cocoa cultivation economy*. The number of people involved, land conversion rate and the gradual increase in total production levels all point to the fact that cocoa is gaining its rightful popularity in these areas and has replaced maize as the most important cash crop cultivated by the people.

The shift to maize dominated was based on declining cocoa yields influenced to some extent by some social and economic factors, and largely by decreased rainfall and increased temperature which favored seasonal bushfires. The catastrophic bushfires that occurred in 1983 was the beginning of the end of cocoa cultivation and eventually the shift from cocoa to maize dominated.

A number of factors that include, bushfire prevention, quest for property/asset, land tenure system, poor livelihood, poor yield of annual crops, improved technology, improved on-farm practices may have a hand in the current conversion to cocoa farming. But the pricing policy has been one single factor according to farmers to be responsible for the current shift from maize dominated to cocoa based cropping.

Currently, there is an observed increased dryness in the system and there is a projected extreme change in climatic events. It is known that the amount of rainfall during the two driest months of the year has stronger impact on cocoa yield than total annual rainfall. Therefore the mild decline in the rainfall amounts for the two driest months of the year is having negative impacts on cocoa production and overall cocoa yield. These dry months with rainfall less than 100 mm per month now span more than three months. The impacts of decreased rainfall and increased temperature on cocoa are manifesting in various ways and stages of the cocoa farming systems. Small-holder cocoa farmers realizing the importance of cocoa as the best livelihood option in the current climate change predicament are adapting strategies to manage the impact of climate change on their cocoa farming.

Considering the results presented, it could be concluded that, climate change is impacting on agriculture and that notwithstanding, there is indeed a shift from maize concentrated cropping back to cocoa cultivation in the study areas. Farmers have developed strong interest in cocoa farming, but there are issues confronting them. It has been discovered that apart from climate related issues stakeholders don't have influence on, there are certain challenges hindering farmers' efforts including; inadequate supply of fertilizers and or cocoa inputs, difficulties in accessing credit and inadequate extension services. At the end of all the discussions, a single answer, answers the questions "*Will it be a good idea trying to bring back cocoa to these areas? Will it be feasible?" and the answer was **YES** as demonstrated by farmers.*

6.2 Recommendations

With the results presented in this study, it is highly recommended that Government of Ghana, COCOBOD, Scientific community, International organizations conduct more research and formulate workable policies to ease the load and difficulties on cocoa farmers.

Though on the part of researches, they are working to better the adaptive options of farmers, e.g. demonstration of the technical advantages of fertilized, low shade or full sun hybrid cocoa. The current recommendations from CRIG is fertilizing densely planted hybrid cocoa in full sun or light shade with phosphorus, potassium and micronutrients. In practice, smallholder farmers have the knowledge but they lack resources to acquire fertilizers and hybrid cocoa seeds. For some reasons, farmers are willing and partially practicing shade cropping; only they lack the resources to acquire recommended tree species. Because the people usually most affected by climate change are the poor and marginalized, their abilities to adapt are also limited. Adaptation measures may be outlined for the local communities but the success of it depends on the implementation. This is where the Government, Scientific Community, Research Institutions, Civil Societies, NGOs, International Agencies and everybody in a position to help are needed because the effects of climate change cut across all territories.

The government needs to develop a holistic National Adaptation Programme of Action (NAPA) which would ensure effective implementation of adaptation strategies as emphasized by Gyampoh, (2009). It is therefore highly recommended among other things below;

6.2.1 Recommendations for Adaptation

The recommendations in this work are in the form of proposed adaptation strategies which when implemented can enhance the communities' adaptation strategies to the effects of climate change. The planet has already been committed to some form of change through greenhouse gas emissions and what is needed is for people to adapt to the coming changes (adaptation) whilst we find means of mitigating further high levels of GHGs emissions.

The great diversity of the people in the study areas and differences in resources available to them are generally the differences in situations encountered by various sectors and may require different adaptation strategies developed for each sector. But in the midst of all the difference, some common problems cut across upon which adaptation options could be developed for the communities.

Even before a strategy is implemented it must be noted that there must be flexibility in its application to changing situations. It is important to highlight that the relationship between a changed climate system (e.g. higher temperatures, altered precipitation epoch, etc.) and impacts on human systems are not necessarily linear. Human agencies and institutions can play a crucial role in minimizing the adverse effects and in seizing opportunities resulting from climate change.

6.2.2 Community Level Adaptation

i. Agriculture

Agriculture is the main livelihood option for most people in the rural communities and it is highly vulnerable to current and projected climate changes. The situations in the communities are aptly described by Watson *et al.,* (1997): 'in Regions where agriculture is unable to cope with existing extremes, where markets and institutions to facilitate redistribution of deficits and surpluses are not in place, and/or where adaptation resources are limited, the vulnerability of the agricultural sector to climate change should be considered high'. Community development and agricultural development Policies must be strategically planned and implemented to ensure sustainable livelihoods.

ii. Improved Varieties

The variety of cocoa being planted by the farmers can be improved or enhanced to ensure that farmers get the best out of their labor. With the help of CRIG-CSIR and other relevant stakeholders, improved seedlings that are well adapted to the changing climate could be developed. For example, drought resistant varieties which can even grow very well when planted at the end of the rainy season. Early maturing varieties of cocoa already being cultivated by the farmers is a very good entry point in helping the farmers.

iii. Community Reforestation

The communities should embark on reforestation projects. The planted trees will restore the degraded forests and help in creating an atmosphere to reduce high temperature impacts. The reforestation can be done with or without external assistance though it is very important. Tree seedlings can be harvested from the wild and planted as has been successfully done by some farmers. Also, fast growing trees seedlings can be supplied by the Forestry Commission of Ghana and planted in the communities under good supervision. The trees will also serve additional purposes as windbreaks since there are occasions of extreme weather conditions like storms. And also reforestation will contribute to mitigating the emission of GHG by enhancing carbon sequestration.

iv. On Farm Tree cultivation

The use of plantain suckers as shield for cocoa in the establishment phase being practiced by farmers present a clear picture of how intense temperature has become and the impact it is having on crops. Strategies proposed here include the incorporation of tree crops on farmlands for which farmers are ever prepared but the issue of access to tree seedlings remains crucial. When given much attention there can be both ecological and economic advantages for incorporating trees into farmlands. The trees can provide shade for the crops, as is being done by some farmers with the support of IITA‘s STCP. Apart from providing shade, the trees can also help in improving the fertility of the soil and reduce the application of chemical fertilizers, depending on the type of tree grown. Economically, the trees when harvested can also add to the income of the farmer.

v. Institutional Collaboration

There should be integrated and interdisciplinary approaches to climate change adaptation in the cocoa growing areas and other vulnerable areas. Agencies working on areas such as forest management, water resources management, land management, agricultural development and rural development should work together to develop a smart climate change adaptation strategy so that all efforts will be coordinated at one point to avoid duplication of efforts and eventual non-performance.

The Ghana Poverty Reduction Strategy lists several institutions that are expected to be involved in the implementation of strategies aimed at climate change adaptation. Some of the listed institutions are Ministry of Lands Forestry and Mines (MLFM), Ministry of Environment Science and Technology (MEST), Ministry of Local Government and Rural Development (MLGRD), Council for Scientific and Industrial Research (CSIR), District Assemblies, Forestry Commission, National Disaster Management Organization (NADMO), Ghana National Fire Service, Ghana Meteorological Agency (GMET), Environmental Protection Agency (EPA) and Environmental NGOs. Most departments working on climate related issues in different institutions do not know of what the others are doing. In reality, the institutional framework necessary for good inter-sectorial collaboration and ensuring synergy between sectors in policy planning and implementation are not in place.

There must be collaboration between and within universities on climate change studies, training and research. There are several instances where departments within the same university are all working on aspects of climate change but do not know what each other is doing. Synergy between and within the universities, which form the focus of science and technology education, will be very effective in advancing climate change adaptation strategies.

6.3 Future research directions and policy options

- Efforts must be directed towards landscape planning for more robust adaptation measures of smallholder cocoa farmers to the impacts of climate change e.g. cocoa agroforestry systems and intensification.
- Capacity building and extension support services to smallholder farmers should be readily available to increase farmers' knowledge since climate issues are woefully affecting their livelihood.
- COCOBOARD-CRIG and academic institutions should embark on extensive research to find more sustainable and efficient ways of using the plantain suckers option in order to reduce cost to farmers.
- CRIG and appropriate institutions should turn attention to developing cocoa variety that is more resistant to the long dry season like the old Tetteh Quashie which farmers prefer to grow now.
- Government policies towards inputs supply must be reviewed to remove political influences and side dealings in order to benefit the intended smallholder farmers
- Increased policies toward rehabilitating and restoring to sustainable production old cocoa farms and lands previously cultivated to cocoa as part of measures to reduce or stop the rate of deforestation to help in mitigating against the adverse effects of climate change.
- Policies to encourage farmers to adopt efficient farming practices. For instance, relatively easy acquisition of credit and farm inputs and farmer business school.
- Government making available the needed chemicals for purchase by farmers instead of supplying them freely but most farmers not benefitting from it.

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APPENDIX

Appendix A: QUESTIONNAIRE AND CHECKLIST

QUESTIONNAIRE FOR DATA COLLECTION

FARMER PERCEPTION ON CLIMATE IMPACTS ON COCOA CULTIVATION AND SHIFTS IN CROPPING PATTERN IN THE FOREST – SAVANNA TRANSITIONAL ZONE OF GHANA

INTRODUCTORY DATA

i. *Sex: 1. Male [ ] 2. Female [ ]*

ii. *Community: ……………………………………………………………*

iii. *Age of respondent: ………………………………………………………*

iv. *Years of farming cocoa experience: 1. Old farmer [ ] 2. New farmer [ ]*

v. *Native of the municipality 1. Yes [ ] 2. No [ ]*

FARMER PERCEPTION ON PAST CLIMATIC CONDITIONS AND ITS IMPACTS ON SMALLHOLDER COCOA FARMING SYSTEMS AFTER THE FIRE EPOCH

1. Comparing the pre-fire, post-fire and the current, Have you observed any changes in the climate conditions?

1. **Y**es [ ] 2. **N**o [ ] 3. **U**nchanged [ ]

2. Please choose the climate variable that has changed

1. **R**ainfall [ ] 2. **T**emperature [ ] 3. **B**oth [ ]

Please explain the trend

3.1. <u>WHAT WERE THE OBSERVED MICRO-CLIMATE CHANGES IN THE COMMUNITY DURING THE PRE-FIRE EPOCH?</u>

3.1.a. Rainfall

i. Quantity of rainfall 1. **M**ore [ ] 2. **M**oderate [ ] 3. **L**ess [ ]

What is the observed evidence (manifestation) of this change?

---

ii. Intensity of rainfall 1. **H**igh [2. **M**oderate [ ] 3. **L**ow [ ]

What is the observed evidence (manifestation) of this change?

---

iii. Number of rainy days 1. **M**ore [ ] 2. **M**oderate [ ] 3. **L**ess [ ]

What is the observed evidence (manifestation) of this change? (eg: number days in a week)

---

iv. Seasonal variation

a. More rainfall in the **m**inor season (April-July) than **m**ajor season (Sept. - Nov.). 1. **Y**es [ ] 2.**N**o [ ]

b. Onset of rainfall at the right time 1. **Y**es [ ] 2. **N**o [ ]

What is the observed evidence (manifestation) of this change?

---

v. What is the effect of the observed changes in Rainfall on your farming in the pre-fire epoch?

1. **B**ad [ ] 2. **F**air [ ] 3. **G**ood [ ]

3.1.b. Temperature

i. Intensity 1. **H**igh [ ] 2. **M**oderate [ ] 3. **L**ow [ ]

What is the observed evidence of this change?

---

ii. What is the effect of the observed changes in Temperature on your farming in the pre-fire epoch?

1. **B**ad [ ]   2. **F**air [ ]   3. **G**ood [ ]

3.2. WHAT WERE THE OBSERVED MICRO-CLIMATE CHANGES IN THE COMMUNITY DURING THE POST-FIRE EPOCH?

3.2.a. Rainfall

i. Quantity of rainfall   1. **M**ore [ ]   2. **M**oderate [ ]   3. **L**ess [ ]

What is the observed evidence (manifestation) of this change?

---

ii. Intensity of rainfall   1. **H**igh [ ]   2. **M**oderate [ ]   3. **L**ow [ ]

What is the observed evidence (manifestation) of this change?

---

iii. Number of rainy days   1. **M**ore [ ]   2. **L**ess [ ]   3. **M**oderate [ ]

What is the observed evidence (manifestation) of this change? (eg: number days in a week)

---

iv. Seasonal variation

a. More rainfall in the **minor** season (April-July) than **major** season (Sept.-Nov.)

1. **Y**es [ ]   2. **N**o [ ]

b. Onset of rainfall at the right time   1. **Y**es [ ]   2. **N**o [ ]

What is the observed evidence (manifestation) of this change?

---

v. What is the effect of the observed changes in Rainfall on your farming in the post-fire epoch?

1. **B**ad [ ] 2. **F**air [ ] 3. **G**ood [ ]

3.2.b. Temperature

i. Intensity 1. **H**igh [ ] 2. Moderate [ ] 3. **L**ow [ ]

What is the observed evidence of this change?

---

ii. What is the effect of the observed changes in Temperature on your farming in the post-fire epoch?

1. **B**ad [ ] 2. **F**air [ ] 3. **G**ood [ ]

3.3. <u>WHAT ARE THE OBSERVED MICRO-CLIMATE CHANGES IN THE COMMUNITY IN THE CURRENT EPOCH?</u>

3.3.a. Rainfall

i. Quantity of rainfall 1 **M**ore [ ] 2. **M**oderate [ ] 3. **L**ess [ ]

What is the observed evidence (manifestation) of this change?

---

ii. Intensity of rainfall 1. **H**igh [ ] 2. **M**oderate [ ] 3. **L**ow [ ]

What is the observed evidence (manifestation) of this change?

---

iii. Number of rainy days 1. **M**ore [ ] 1. **L**ess [ ] 3. **M**oderate [ ]

What is the observed evidence (manifestation) of this change? (eg: number days in a week)

---

iv. Seasonal variation

a. More rainfall in the **minor** season (April-July) than **major** season (Sept.-Nov.). 1. **Y**es [ ] 2. **N**o[ ]

b. Onset of rainfall at the right time 1. **Y**es [ ] 2. **N**o [ ]

What is the observed evidence (manifestation) of this change?

---

v. What is the effect of the observed changes in Rainfall on your farming in the current epoch?

1. **B**ad [ ] 2. **F**air [ ] 3. **G**ood [ ]

3.3.b. Temperature

i. Intensity 1. **H**igh [ ] 2. Moderate [ ] 3. **L**ow [ ]

What is the observed evidence of this change?

---

ii. What is the effect of the observed changes in Temperature on your farming in the current epoch?

1. **B**ad [ ] 2. **F**air [ ] 3. **G**ood [ ]

4. What type of farming were you involved in the 60s, 70s and early 80s before the fire?

1. [ ] Perennial crops [please state crop(s)]……………………………………….
2. [ ] Annual crops [please state crop(s)] ……………………………………….
3. [ ] Others (please state) …………………………………………………

EVIDENCE (MANIFESTATION) INDICATING THE IMPACT OF CHANGES IN CLIMATIC CONDITIONS ON COCOA

5. Does the change in the climatic conditions impact on your cocoa?

1. **Y**es [ ] 2. **N**o [ ]

6. Indicate the physical (observed) manifestation of the impact of changes in climatic parameters on cocoa.

a. **E**arly stage (Seedling)

b. **M**aturing stage

c. **O**ld stage (fruiting)

7. How do you know that the observed manifestations are due to changes in climatic parameters?

8.

i. What was the trend of cocoa yields and overall cocoa production levels in your community in the per-fire epoch?

1. **H**igh [ ] 2. **N**either high nor low [ ] 3. **L**ow [ ]

Please describe the major trends

ii. What was the trend of cocoa yields and overall cocoa production levels in your community in the post-fire epoch?

1. **H**igh [ ] 2. **N**either high nor low [ ] 3. **L**ow [ ]

Please describe the major trends

iii. What is the trend of cocoa yields and overall cocoa production levels in your community in the current epoch?

1. **H**igh [ ] 2. **N**either high nor low [ ] 3. **L**ow [ ]

Please describe the major trends

RESPONSE OF FARMERS TO THE IMPACTS OF CLIMATIC VARIABLES ON COCOA PRODUCTION.

9. How did you (farmers) respond to the impacts of changes in the climatic conditions in the post-fire epoch?

10. How did the response influence your livelihood?

REASONS ACCOUNTING FOR THE LAND-USE CHANGES AS RESPONSE BY FARMERS IN THE POST FIRE EPOCH.

11. What activities were/are you doing to earn your living (post fire and current)?

i. Post-fire epoch

ii. Current epoch

iii. Why the changes in your activity?

12. During off-farming season, what activities do you undertake? Please mention or describe them

____

13. Give your perception on the following indicators in the three epochs:

	Pre-fire epoch	**Post-fire epoch**	**Current epoch**
Family income	*1. **High** [ ]* *2. **Moderate** [ ]* *3. **Low** [ ]*	*1. **High** [ ]* *2. **Moderate** [ ]* *3. **Low** [ ]*	*1. **High** [ ]* *2. **Moderate**[ ]* *3. **Low** [ ]*
Living conditions	*1. **High** [ ]* *2. **Moderate** [ ]* *3. **Low** [ ]*	*1. **High** [ ]* *2. **Moderate** [ ]* *3. **Low** [ ]*	*1. **High** [ ]* *2. **Moderate**[ ]* *3. **Low** [ ]*
Community development	*1. **High** [ ]* *2. **Moderate** [ ]* *3. **Low** [ ]*	*1. **High** [ ]* *2. **Moderate** [ ]* *3. **Low** [ ]*	*1. **High** [ ]* *2. **Moderate**[ ]* *3. **Low** [ ]*
Migration	*1. **High** [ ]* *2. **Moderate** [ ]* *3. **Low** [ ]*	*1. **High** [ ]* *2. **Moderate** [ ]* *3. **Low** [ ]*	*1. **High** [ ]* *2. **Moderate**[ ]* *3. **Low** [ ]*

14. What are the livelihood risks associated with current livelihood activities?

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CONDITIONS NECESSITATING REVERSE BY FARMERS TO COCOA CROPPING SYSTEM.

15. What is/are really driving the renewed interest in cocoa farming?

1. Changes in Climatic parameters [ ]
2. Changes in Environmental condition [ ]
3. Improved technology [ ]
4. Poor livelihood [ ]
5. Bushfire prevention [ ]

6. Poor yield of other crops [ ]

7. Land tenure system [ ]

8. Unemployment [ ]

9. Property/assert [ ]

10. Others ……………………………………………………

NEW FARMING PRACTICES ADOPTED BY FARMERS TO COCOA FARMING (INNOVATIONS)

16. How is the current cocoa farming different from the pre-fire epoch in terms of on-farm practices?

1. **M**ore difficult [ ] 2. **D**ifficult [ ] 3. **L**ess difficult [ ]

Why?

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17. What are some of the modern technologies/methods you employ in farming cocoa?

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18. Based on your experiences and challenges with environmental issues affecting cocoa cultivation, what practices are you adopting that makes the new cocoa farming systems different?

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19. What measures are you putting up to preventing bushfires?

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20. What are the major challenges in farming cocoa now?

Appendix B: GALLERY

Recce at Wenchi

Research team with farmers drying cocoa

Discussion with 2013/2014 Berekum municipal best cocoa farmer

Discussion with some elders of Abisase

Research team enjoying fresh cocoa bean

Discussion with the chief of Tromeso

old cocoa shed at Tromeso

FGD at Mangoase in Techiman municipality