ADAPTATION TO CLIMATE CHANGE: EFFECTS OF PRODUCTIVITY IMPROVING STRATEGIES ON COCOA FARMERS' LIVELIHOODS IN THE CENTRAL REGION, GHANA

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF Ph.D. IN AGRICULTURAL ADMINISTRATION DEGREE

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DECLARATION

I, KOFI NHYIRA ASARE, author of this thesis do hereby declare that with the exception of other peoples' work, which has been duly acknowledged, the work presented in this thesis, **"ADAPTATION TO CLIMATE CHANGE: EFFECTS OF PRODUCTIVITY IMPROVING STRATEGIES ON COCOA FARMERS' LIVELIHOODS IN THE CENTRAL REGION, GHANA"**, was done entirely by me in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon. This work has never been presented in part or whole for any degree in this University or elsewhere.

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DEDICATION

This thesis is dedicated to my Godfather and guardian, Apostle Prof. Ing. Kwadwo Safo, for supporting me financially and spiritually.

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Kofi Nhyira Asare

ABSTRACT

The thesis assessed the capacity of cocoa farmers to adapt to climate change and adopt productivity-improving strategies. It also determines the effect of the adoption of productivity-improving strategies on farmer's livelihoods in the Central Region of Ghana. The key issues addressed in this thesis were: what are the key adaptation strategies; what is the level of farmers' capacity for adopting productivity-improving strategies (PIS); magnitudes in the factors influencing adoption of productivity-improving strategies and the effects of the adoption of PIS on enhancing their livelihoods. Semi-structured questionnaire was used to collect data from 443 cocoa farmers and 11 local institutions. The adaptation strategies known and employed by cocoa farmers were analyzed using relative frequencies. The level of adaptive capacity of farmers was estimated and the Logit model was used in analyzing the magnitudes in the factors of adopting PIS. Ordinary Least Square was used to analyze the effects of PIS on farmer's livelihoods. The results from the study showed that on-farm adaptation strategies known and employed by farmers included the use of improved hybrid seed varieties, changing planting dates as well as the application of chemical fertilizer. Although half (50%) of the farmers were categorized as having moderate adaptive capacity, many adopted the productivity-improving strategies (PIS). The most important factors influencing the adoption of PIS were age, gender, total on-farm income, institutional support, and adaptive capacity. Adoption of PIS had a positive effect on their livelihoods (income). The study recommends that local institutions (cocoa LBCs) should be encouraged to provide support in the form of training and education to improve the low capacity for the key crop management practices required to mitigate climate change resources to farmers to enhance their capacity. Institutions and stakeholders should provide support (credit, training, and technology transfer) to enhance their adaptive capacity (assets) and also to enhance their technology adoption.

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AC	Adaptive Capacity
ACC	Average Adaptive Capacity
CEEPA	Centre for Environmental Economics and Policy in Africa, Policy
CGIAR	Consultative Group on International Agricultural Research
DFID	Department for International Development
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organisation
FBO	Farmer Based Organisation
FC	Forestry Commission
FI	Financial Institution
GDP	Gross Domestic Product
GHG	Green House Gas
GMF	Green Microfinance
GCB	Ghana Commercial Bank
PBC	Produce Buying Company
IDS	Institute of Development Studies
ISSER	Institute of Statistical, Social and Economic Research
IPCC	Intergovernmental Panel on Climate Change
IFDC	International fertilizer development centre
IOM	International Organization for Migration
MCCIP	Marine Climate Change Impacts Partnership
MLG	Ministry of Local Government
MoFA	Ministry of Food and Agriculture
NCBL	Nyonkopa Cocoa Buying Limited
NGO	Non-Governmental Organisation
OLS	Ordinary Least Squares
PIS	Productivity Improving Strategy

SLF	Sustainable Livelihood Framework
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WHO	World Health Organisation
WRI	World Resource Institute

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Climate change threatens the livelihood of millions in developing countries, especially the very poor because it directly affects their livelihood sources (Chambwera & Stage, 2010; Aid, 2014). The livelihoods of agricultural households, particularly in Africa, are increasingly challenged by the effects of the changing climatic conditions in temperature, rainfall, CO_2 concentration in the atmosphere, humidity, etc (IPCC, 2007).

Globally rainfall pattern has changed: increased by average 11.43 mm in the 1980s, decreased by 2.54mm in the 1990s, then increased by 22.86mm in the 2000s, and in the 2010s it increased by 53.34 mm (National Academy of Science, 2018; EPA, 2018). Temperature pattern has also changed: increased by average 0.5°C in the 1980s, decreased by 0.2 °C in 1990s, then increased by 0.42 °C in 2000s, 2010s it increased by 0.6°C (National Academy of Science, 2018; EPA, 2018).

There was a further drying of the climate, leading to decreases in annual rainfall by 30% in African (Kotir, 2011; Ruf *et al*. 2015). Abu (2011), noted that reduction in rainfall amounts and changes at the start of the rainfall season was the climatic effects in the Central Region. Again, declining rainfall amounts and rising average temperatures were also affecting farmers in the Central Region (Owusu-Sekyere et al. 2011). According to the author, these effects lead to low productivity, reduced income, food insecurity, and labour emigration.

Climate changes affect agricultural production and threaten household food security globally (Ogra & Badola, 2015; Sarr *et al*. 2015). Climate changes affect crop development in diverse ways regionally:

Negatively through pest and disease invasion, poor rainfall, flooding, etc resulting in crop losses, poor outputs which eventually reduce income (Denkyirah *et al*. 2016).

Positively in enhanced CO_2 through increased in photosynthetic rate and also decrease in transpiration rate favouring some crop species; in high temperature, there is an increase in the possibility of completing two or more cropping cycles during the same season (Bosello & Zhang, 2006; Aydinalp & Cresser, 2008)

Akudugu *et al.* (2012) explained that the declining share of the agricultural sector to Ghana's GDP may be due to adverse impacts of climate change. The impact of the climate on crop development is through pest and disease invasion, resulting in serious losses, poor outputs which eventually reduce income. As per Anim-Kwapong and Frimpong (2004), climate change alters or modifies the evolution of insects, pests, and diseases of cocoa. Withering occurs in cocoa seedling when is freshly transplanted in an extended period of drought. Again, transplanting cocoa seedlings in high humidity also increases the occurrence of black pod disease. Denkyirah *et al*. (2016) also affirm that infestation of insects, pests, and diseases results in reduced cocoa yields. Lanaud et al. (2009) and ICO (2015) found that, around the world, insects, pests, and diseases reduce cocoa yield by 30–40%.

Cocoa production is influenced by climate changeability and this crop responds to climate change. Denkyirah *et al.* (2016) affirmed that environmental change in the form of decreased rainfall and increased temperatures is foreseen to unfavourably influence cocoa output and decrease the territory for cocoa cultivation in Ghana. Laux *et al.* (2010) and IPCC (2014), observed that food insecurity and low crop output are a result of the dimensional and transient changeability of rainfall. The adjustment in mean and inconsistency of climate change elements (rainfall, temperature, humidity, drought, and sunshine) over a long period, whether through natural variability or human activity defines climate change (IPCC, 2014) and it has been recognized by scientist globally since the acceptance of United Nation Framework Convention on Climate Change (UNFCCC) in 1992 and 2001 as the main threat to economic development (IPCC, 2001).

Several scientists have contributed to the knowledge and apprehension of climate change (IPCC, 2014) and its impact on economic activities and also identify vulnerable countries or communities (Fankhauser & Tol, 2005; Tol, 2009). African countries are the most affected in terms of the effect of climate change and climate vulnerability due to the over-dependence of their economies on agriculture (Kurukulasuriya & Mendelsohn, 2006; Mendelsohn, 2009). This is so because African countries have limited economic and industrial capacity to deal with climate change vulnerabilities (Kvalvik *et al.* 2011).

Individuals and societies have adjusted (adapted) to and managed climate change with shifting degrees of accomplishment (IPCC, 2014). Adaptation is the response to changes in temperature, rainfall, humidity, and wind that reduces the dangers of climate change (IPCC, 2014). Among crop farmers, there is the need to adapt to changing farming practices and technology in crop selection, crop management, and the appropriate farm-level investments in response to changes in temperature, rainfall, humidity, and wind (IPCC, 2014).

Farm technologies (hybrid seeds, fertilizer, insecticides, etc—productivity-improving technologies) exist to reduce the effect of climate change on farming (Di Falco & Veronesi 2013; Adamson et al. 2017). Farmers' adaptive capacity to climate change is enhanced by the productivity-improving strategies adopted (Egyir et al., 2015). Adaptive capacity is the ability of a farmer to adopt several of these changing farming practices and technology to reduce the adverse effects of climate change on agricultural production (Mabe et al., 2012)

The livelihoods of rural households are through agriculture, rural labour market, and self-employment in the rural non-farm economy and others through migrating to towns, cities, and other countries (Dev, 2011). Agriculture is the major source of livelihood in many African countries. Large numbers of the rural population are dependent on agriculture for their livelihoods. In Sub-Saharan Africa, more than 60% of the economically active population and their dependents rely on agriculture for their livelihoods (Dev, 2011). Farmer livelihoods impacted by climate change include income, wellbeing, food access, food availability, and utilization (Aniah et al. 2016)

Agriculture contributes immensely to the economy of Ghana. However, since 2010, its input to gross domestic product (GDP) has decreased steadily although the agriculture industry remains an essential piece of the financial system, contributing on the average about 21.1 percent (ISSER, 2017; Ghana Statistical Service, 2017). The agriculture industry takes about

56% of the total workforce of the country (MoFA, 2014). Agriculture contributed 19.1 percent to the GDP in 2016, which was the largest foreign trade earner, resulting in forty percent (40%) of Ghana's overseas income and also the key manufacturer of two-thirds of the household food require (ISSER, 2017).

The agriculture sector is divided into four subsectors, which are crops which includes cocoa (75% of Agricultural GDP), livestock (9% of Agricultural GDP), forestry and logging (10% of Agricultural GDP), and fishing (6% of Agricultural GDP) (Ministry of Economy and Industry, 2018).

Cocoa is one of the foremost contributors to the share of Ghana's GDP from agriculture. According to GSS (2017), cocoa contributed 13.3% to agribusiness's share of total national output (Gross Domestic Product) in 2016. It is the vital crop exported and the third export product after gold and timber in Ghana. It is generally the vital basis of revenue for rural farmers and over 80% of all export earnings come from the agriculture sector (Anang, 2011; Adu-Appiah et al. 2013; ISSER, 2017). According to Danso-Abbeam et al. (2012) cocoa dominates exports from agriculture. Ntiamoah and Afrane (2008), indicate that cocoa enhances smallholder farmers' annual income by 70%–100%. Furthermore, in the late 2000s, almost 350,000 farm owners were identified in Ghana and over 800,000 livelihoods of smallholder families depended on cocoa production (Anim-Kwapong & Frimpong, 2006).

Essegbey and Ofori-Gyamfi (2012), also confirmed that income from many local households comes from cocoa production which is a vital basis of employment. This means that most agricultural households' income needs depend largely on the production of cocoa. Stakeholders made up of companies that produce chemicals, suppliers of input, and licensed cocoa buying companies (LBCs) depend basically on the sector for income and employment (Anang et al. 2013). Cocoa production is intense in the forest belts where the weather is favourable, especially the forest belts with high bi-modal nature of rains. These areas include; Ashanti, Brong Ahafo, Central, Eastern, Volta, and Western regions.

In Sub-Saharan African countries, agriculture contributes up to twenty percent (20%) of their Gross Domestic Product and serves as the basis of employment for the majority of the people (Roudier et al. 2011; Waha et al. 2013). Agricultural production is dependent on rain in Sub-Saharan Africa. The climate change effect has added to worldwide agribusiness production declining by 1–5% every decade in the previous 30 years (Watchman et al. 2014).

1.2 Problem Statement

The inbuilt climate and atmospheric-sensitiveness of small-scale agribusiness employment and the persistent poverty that infest it is due to its susceptibility to climate change. The characteristics of climate inconsistency have influenced the production of cocoa over the years. For example, variation in rainfall, temperature, wind, and drought influence the development of cocoa (Ehiakpor et al. 2016).

Cocoa farming is one key livelihood activity in Ghana including the Central Region. However, the Central region is one of the regions in Ghana with a high poverty incidence (GSS, 2015), and whilst cocoa production per household are associated with a lower incidence of poverty headcount in the cocoa-growing regions, the exception is Central Region (Kolavalli &Vigneri, 2011).

Data from COCOBOD (2019), suggest low production and declining cocoa yields in Central Region (figure 1 and 2) relative to the other cocoa regions. From fig (1), output generally has increased from the 1980/81 year to the 2018/19 production season for all cocoa-producing regions, Central Region output has been the lowest (Fig 1). Most significantly, decade by decade growth rates in cocoa production in the Central Region suggests a low and declining production increases (Fig 2).

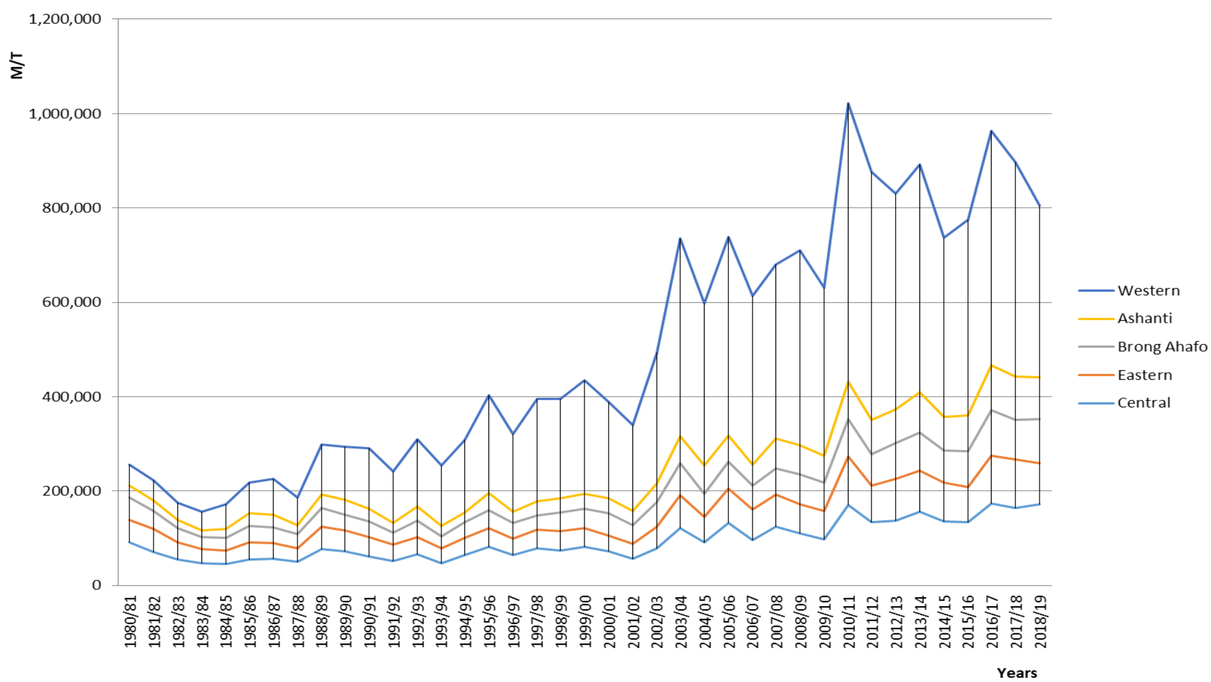


Figure: 1.1 Regional Cocoa Production
Source: COCOBOD (2019)

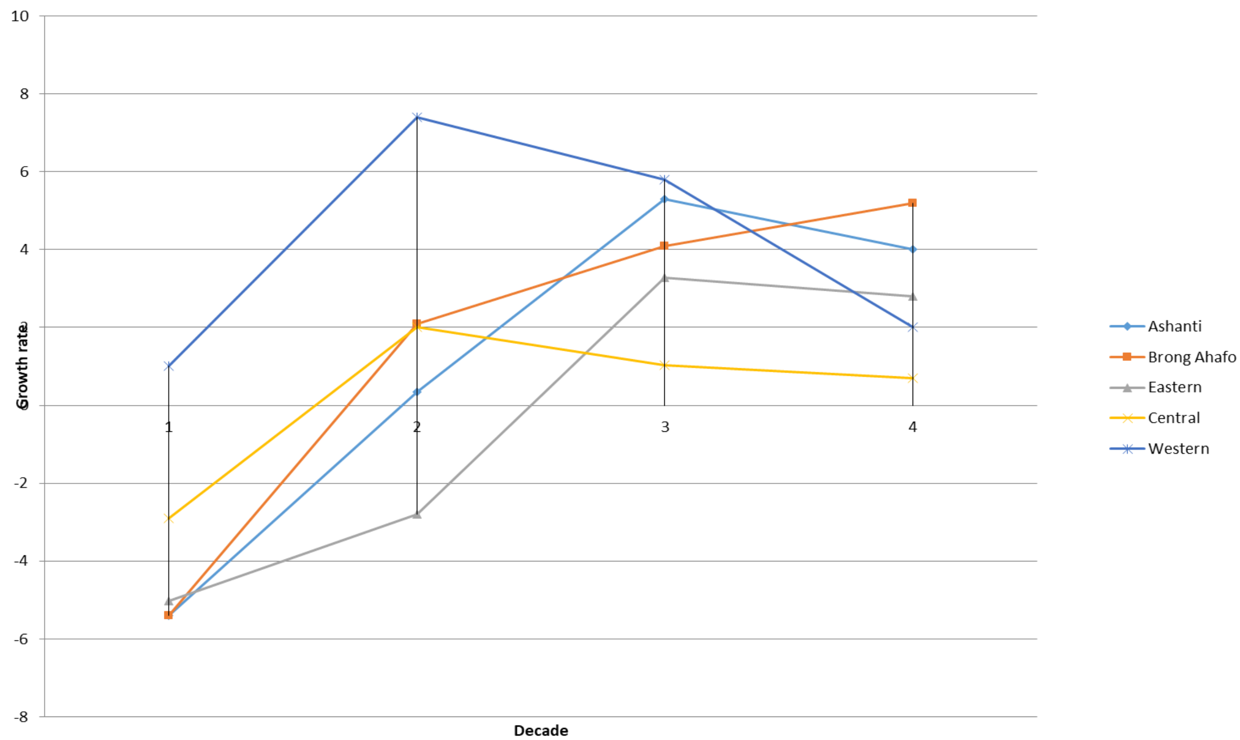


Figure: 1.2 Regional Cocoa Growth Rate
Source: COCOBOD (2019)

Over the last decade, erratic rainfall, strong wind/storm, high temperatures, drought, and flood effects in the Central Region of Ghana (Abu, 2011; Owusu-Sekyere et al. 2011; Akaba & Akuamoah, 2018) has been reported.

The low cocoa production in the Central Region is affected by factors such as over-aged trees; the variability in real domestic price; insufficiency and often complete absence of technical assistance (Läderach et al. 2013) and also speculated to largely influenced by the climate changes (Läderach et al. 2013). But the issues of over-aged trees have been addressed by cutting down of over-aged trees and replanting with new cocoa variety seedlings, increased real cocoa price by the government, and increased technical assistance by COCOBOD. This implies that cocoa production in Ghana has declined partly because of climate changes. To increase and sustain production with prevailing quality, it is important to devise effective schemes to improve the productivity of small-scale cocoa farming. Farmers need climate-smart information among others to be able to apply timely farm nutrient supplements such as fertilizer and pesticides and also to prevent insect and disease infestation.

Cocoa farming households need to escape by adopting a series of strategies especially those that depend upon agriculture for their livelihoods (Paavola, 2008). Farmers tend to migrate to the cities or adopt other growth options when they are not able to seek alternative livelihoods in the communities in which they live. Huq et al. (2004) note that the key adjustment procedure to climate change adaptation is the utilization of present-day innovation to enhance agricultural systems and dispersion of products, domesticated animals, and fisheries. These present-day innovations are productivity-improving and may be mechanical, biological or organic, chemical, or administrative. They enhance yields of crops and thereby increasing household income and reducing poverty. ADB (2008) also noted that adaptation has been accepted as a vital method to decrease climate change effects.

According to Codjoe et al. (2014) farmer's knowledge and practices that they apply are increased through the tried encounters and observations or perceptions of neighbourhood individuals and offer valuable patterns about changing weather patterns and seasons. The productivity-improving options are usually the adopted logical techniques or present-day innovations acquainted with them by various partners, such as agribusiness extension services, conservational work from forestry division, and services from environmental protection agency (Adjei-Nsiah & Kemah, 2012).

Farmers' choice of adaptation strategies has been analysed to know the adaptation strategies used by them and factors which determine those choices (Bryan et al. 2009; Gbetibouo et al. 2010). Even though there have been studies done on the constituent of adaptive capacity and farmers choice of adaptation strategies, there is little empirical work on the relationship between farmers' adaptive capacity and the type of adjustment methods employed (Nelson *et al.* 2010; Kaskitalo *et al.* 2011). Again, studies on adaptive capacity and farmers' choice of adaptation strategies by other crop farmers have been undertaken in other parts of Ghana (Nakuja et al., 2012; Asante et al., 2012; Mabe et al., 2014). There is however scanty literature on the adaptive capacity of cocoa farmers particularly in the Central Region where cocoa production can contribute to alleviating poverty for policy focus.

Adaptive capacity for climate change is the features of regions, countries, and communities which manipulate their tendency to adjust to change in climate (IPCC, 2014). According to Reidsma et al. (2010), "adaptive capacity is the ability to deal with climate change to limit the potential damage, take advantage of emerging opportunities, and deal with its consequences". It represents the set of resources available within which the farmer expresses their adaptation decision to reduce the impact of climate change. Adaptive capacity or ability determines whether a farmer can take decisions on adaptation (Grothmann & Patt, 2005) and it is not distributed equally within countries, communities and among individuals (Adger *et al.* 2007).

Adaptive capacity to climate change has benefitted from research intended at and measuring specific adaptive capacity at different levels Since the publication of IPCC third assessment report in 2001 (Engle, 2011; Defiesta & Rapera, 2014; Bryan *et al.* 2015). Studies such as Defiesta & Rapera, (2014) and Bryan *et al.* (2015) evaluated adaptive capacity at national levels to identify the most vulnerable in the Philippines and Nicaragua but the farmer or individual level is ignored. Adaptive capacity at the national level identifies factors that affect the nation's ability to react to change in climate and does not focus on the individual farmers' adaptive capacity. This is vital for the farmers' decisions on adaptation strategies. This implies that knowing how farmers' adaptive capacity evolves can give insight into how to improve their adaptation strategies to climate change (Adger *et al.*, 2007) and consequently cut down their susceptibility to change in the climate.

The government of Ghana brought two vital cocoa-based technology initiatives in 2001 to resolve some of the issues of low productivity in the sector. This technology incorporated the different innovations brought by the Cocoa Research Institute of Ghana (CRIG). Cocoa Pest and Disease Control (CODAPEC) and Cocoa High Technology (Cocoa Hi-Tech) were the initiatives. The innovations can enhance yield but not all farmers in the cocoa sector are taking advantage of the innovations (Onweremadu & Matthews-Njoku, 2007). These technologies are productivity-improving strategies that will enhance output.

Agricultural technology adoption in Sub-Saharan Africa is low. Aneani *et al.* (2012) estimated adoption rates as 10.3%, 7.5%, 3.7%, 44%, and 33% for the management of capsids, control of black pod disease, weed control, hybrid cocoa varieties, and applying fertilizer application respectively. The factors causing this low rate of adoption need to be investigated. The socioeconomic, background factors and adopters' adoption capacity (human, financial, physical, social, and natural assets) related to the cocoa farmers take part in the adoption of technologies. It has also been established that adjustment or adaptation to changes in climate is the expression of adaptive capacity and it represents the way through which it (adaptive capacity) affects the susceptibility of nations or communities (O'Brien *et al.* 2007; Engle, 2011).

Cocoa farmers in the Central Region need to adopt productivity-improving strategies to reduce the effect of climate change on farmer livelihoods. Velarde and Tomich (2006) suggest sustainable tree crop production such as cocoa sustains rural communities' livelihoods. Also, few empirical studies exist on the factors influencing the adoption of productivity-improving technologies and the effect of these on livelihoods among cocoa farmers in the Central Region. The research questions arising are:

1. What are the adaptation strategies to climate change known to and employed by cocoa farmers?
2. What is the level of cocoa farmers' adaptive capacity to climate change adaptation strategies?
3. What are the factors influencing the adoption and intensity of adoption of productivity improving strategies?
4. What are the effects of adoption of productivity-improving strategies on the livelihoods of cocoa farmers?

These are the issues that are addressed by this thesis.

1.3 Conceptual Framework of the Study

Figure 1.3 presents the conceptual framework of the thesis. It shows that farmer's adaptation to climate change is a process made up of two steps. The first step is the farming systems employed by the farmer which is affected by their socio-economic characteristics, institutional support, and non-climatic stresses. The non-climatic stresses such as declining soil fertility, water resource, insect pest epidemic, and scarcity and unavailability of agricultural input are determined by rainfall pattern, temperature, and other related changes in climate. The second step is the choice of adaptation strategies that will be applied. The adoption of technology is also determined by farmers' adaptive capacity, institutional support, and socio-economic characteristics of the farmers. The outcome of adopting adaptive innovation by the farmer are improved livelihoods.

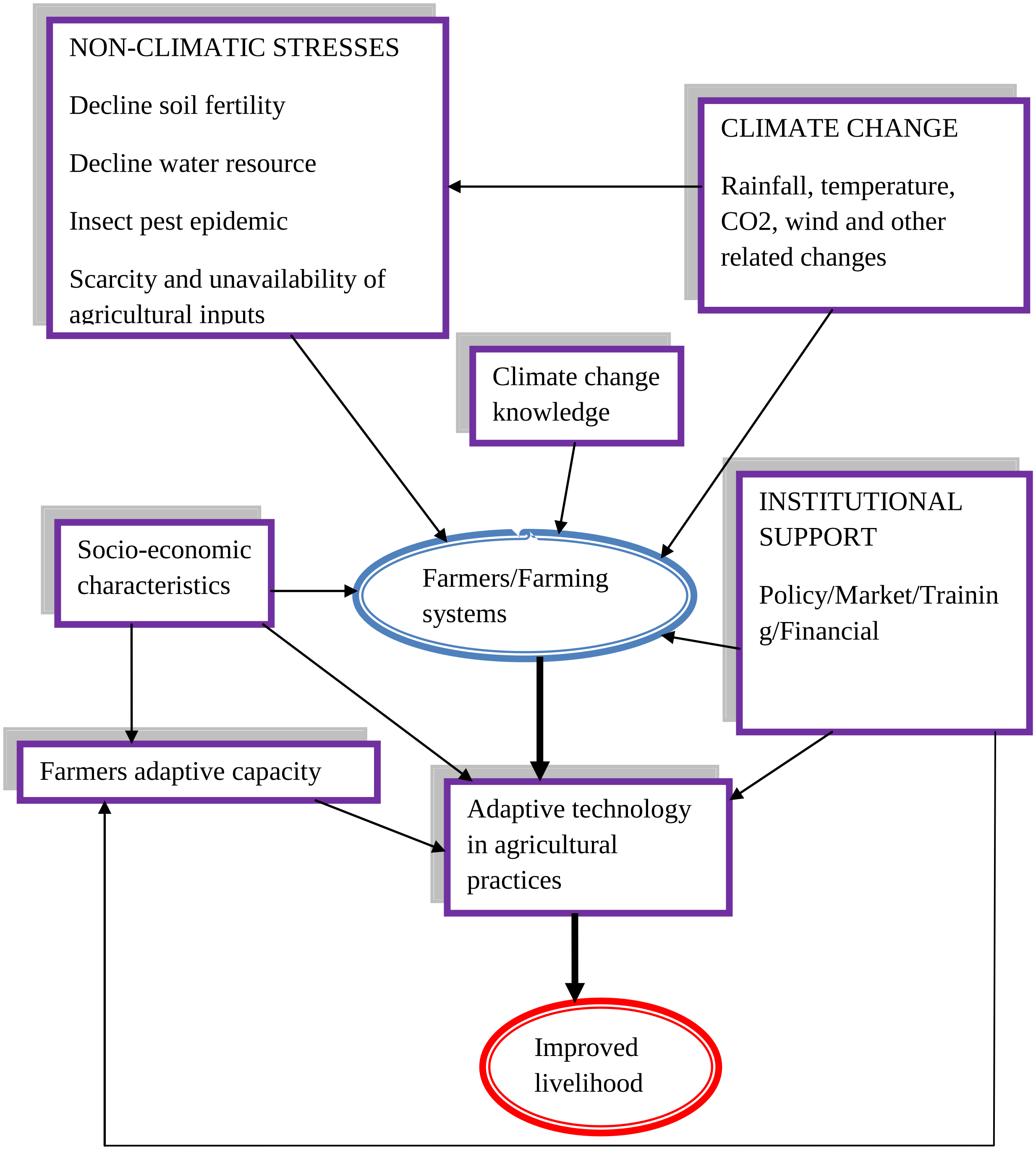


Figure: 1.3 Conceptual Framework of the Study

1.4 Main thesis

Given the important role cocoa production play in the livelihoods of farmers and the impact of climate change on cocoa output, the thesis argues that to reduce the impact of climate change on the output of cocoa and improve the livelihoods of cocoa farmers in the Central

Region, there should be enhanced adaptive capacity and the adoption of productivity-improving strategies (PIS) by farmers

Hypothesis tested

Cocoa farmer adaptation strategies influence adoption of PIS

Cocoa farmer adaptive capacity influence adoption of PIS

Institutional support influence adoption of PIS

Adoption of PIS affects the livelihood (measured as income) of cocoa farmers

1.5 Objectives of the thesis

The main objective of the thesis is to assess the effects of adaptive capacity and productivity-improving strategies on cocoa farmers' livelihoods, in the face of climate change in the Central Region, Ghana.

The specific objectives are to:

1. Describe the adaptation strategies to climate change known to and employed by the cocoa farmers
2. Determine the level of cocoa farmers' adaptive capacity to climate change adaptation strategies
3. Estimate the magnitudes in the factors influencing adoption of the Productivity-Improving Strategies and,
4. Estimate the extent to which adoption of Productivity-Improving Strategies impact the livelihoods of cocoa farmers

1.6 Relevance of the Study

This thesis has provided empirical literature on the adaptive capacity of cocoa farmers particularly in the Central Region where cocoa production can contribute to alleviating poverty for policy focus. The little empirical studies on the factors influencing adoption of productivity-improving technologies and the effect of these on livelihoods among cocoa farmers in the Central Region have been added-on. The findings on the adaptive capacity at the farmer level will be useful to stakeholders in the allocation of assets to the area. Climate change is a serious threat to global welfare (IPCC, 2014). The findings on the extent to which adoption of PIS impact the livelihood status of cocoa farmers will contribute to policy on poverty alleviation. Climate change experts always argue that smallholder farmers in developing countries are vulnerable to climate change due to the lack of adaptive capacity (Boko et al. 2011; Roudier et al. 2011) but there is scanty empirical evidence on how adaptive capacity contribute to a reduction in climate change vulnerability, or farmers with high adaptive capacity are less vulnerable to change in climate than farmers with low adaptive capacity.

1.7 Organization of the Report

This study is structured into five chapters. Chapter one has presented a brief background, explained the research problem, and described the justification of the study. Chapter two presents a review of relevant literature on the thematic areas of the study- climate change adaptation, adaptive capacity, adoption of strategies, and institutions supporting adaptation. Chapter three describes the research methodology. This includes the conceptual and theoretical frameworks, a description of the method of data analysis and data collection, including questionnaire design and characteristics of the sample. Chapter four presents the results and its discussion. Chapter five presents a summary, conclusions, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter consists of eight sub-sections, beginning with conceptual explanations and relating climate change to agriculture. The next section presents a review of adaptation strategies adopted by farmers in the face of the climate change challenge. In section three, measures and determinants of adaptive capacity have been described. The fourth section described the issues in institutional support for farm households. The fifth section is devoted to discussions on factors affecting the adoption of technology. The sixth section deals with the logistic regression model and the section is devoted to empirical studies on the use of the logistic model. The final section is on the summary of key issues reviewed.

2.2 Conceptual Explanations on Climate Change and Agriculture

2.2.1 Definition of climate change

Climate change is any change that occurs in the climate during a period of time which can range from decades to centuries (IPCC, 2007). It comprises the daily climate conditions that describe the average and changeability over 30 years (Moorhead, 2009). The elements of the weather are rainfall, solar radiation and ionization, sunshine, humidity, atmospheric pressure, wind direction and wind speed.

Climate change refers to the change in the mean climate elements which lingers on for longer duration, typically decennium or lengthy (IPCC, 2007). There is contrary view from the position of the United Nations Framework Convention on Climate Change (UNFCCC); they looked at climate change from the human perspective. They define it as the direct or indirect activities of human that affects the make-up of the climate (IPCC, 2007).

Operationally, climate change has been understood and defined from the perspective of any change in the average and or the changeability of the climatic variables for an appreciably long periods, decades onwards by statistical means

2.2.2 Causes of climate change

The two primary drivers of climate change are human actions and natural processes or disasters (Jan & Anja 2007). According to Pidwirny (2006), the notable natural causes of climate change are volcanoes, earth tilt, ocean currents, earthquakes, comets and meteorites among others. However, there is about 90 percent likelihood of human activities being the major cause of the warming of the climate system (IPCC, 2007). These activities include burning of fuels in automobiles, industrial emissions, deforestation, and land degradation through land use cover and land use change, which release Green House Gases (GHGs) into the atmosphere.

Climate changes resulting from human activities is increasing every day and this has become a worrying global issue even though there is some changes in the climate resulting from natural means. This human cause of changes in the climate can be ascribing to intentional and unintentional human factors (IPCC, 2007).

2.2.3 Evidence of Ghana's climate change

Ghana experiences changes in climatic elements. In the year 2000, Ghana completed its first national correspondent to the United Nations Framework on Climate Change (UNFCCC), which predicted the impacts of climate change. Additionally, results from Centre for Environmental Economics and Policy in Africa (CEEPA) studies carried out in 2006 discovered changes in some of the climatic elements such as rainfall, temperature and sea levels in Africa, including Ghana.

Ghana's climate change is showed through: (i) rising temperatures, (ii) declining precipitation adds up to and widen fluctuation, (iii) rising ocean degree (iv) high rate of climate extremes and disasters (Minia, 2004). They further estimated that temperature will remain increasing, whereas precipitation is likewise anticipated to reduce in all agro-biological zones of Ghana (Tables 2.1 and 2.2).

Agro-ecological zones mean yearly temperatures are expected to rise between 0.8°C and 5.4°C between the year 2020 and 2080 respectively (Table 2.2). Within the same year, mean yearly precipitation is projected to decrease by 1.1% and 20.5% (Table 2.1). The probable trends that are most likely to cause the most problem are the early cessation of rainfall which is possible to change the existing bi-modal tenure to a uni-modal one in the Transition zone.

Table 2.1: Average projected change in precipitation (%) for Ghana's ecological zones

Year	Sudan	Guinea	Transition	Deciduous Rainforest	Rainforest	Coastal Savannah
2020	-1.1	-1.9	-2.2	-2.8	-3.1	-3.1
2050	-6.7	-7.8	-8.8	-10.9	-12.1	-12.3
2080	-12.8	-12.8	-14.6	-18.6	-20.2	-20.5

Source: Minia, (2004)

Table 2.2: Average projected change in temperature (%) for Ghana's ecological zones

Year	Sudan	Guinea	Transition	Deciduous Rainforest	Rainforest	Coastal Savannah
2020	0.8	0.8	0.8	0.8	0.8	0.8
2050	2.6	2.5	2.5	2.5	2.5	2.5
2080	5.8	5.4	5.4	5.4	5.4	5.4

Source: Minia, (2004)

Owusu and Waylen (2009) indicated that change in precipitation may be the sole biggest factor of rainfall changes disturbing all of Ghana's agro-ecological zones. The short arid trance between July and August which is critical for land preparing for the second crop is more and more becoming wetter and the short rainy time of the year stopping early in the Transition zone. There is a pattern advanced toward a uni-modal system for the transitional zone with severe effects for rain-fed agriculture. According to Owusu and Waylen (2009), there is a reduction in rainfall of about 20% in the Forest zone than the 10% decrease in the Transition and Savannah to the north.

According to Daze (2007), by the year 2100, temperature in Ghana is expected to increase by 2.5^{O}C to 3.2^{O}C. This rise in temperature would however vary according to the agro-ecological zones in Ghana. Sudan savannah zone (in the Upper East region) is predicted to experience the maximum temperature of 3^{O}C by 2100, followed by the Guinea Savannah (in the Northern region) of 2.5^{O}C (Daze 2007).

Evidently precipitation amount and distribution in Ghana has fluctuated over the years. Results from Anim-Kwapong and Frimpong (2006) show that there has been a fifteen percent (15%) decrease in the seasonal rainfall pattern and distribution globally particularly in the south coastal regions of West Africa between the years of 1931-1960 and 1961-1990. These changes were however reported to have been due to the changes in global ocean spread due to alteration in the sea surface temperatures, changes in land cover in the region and finally alterations in global make-up of the atmosphere (Hulme, 1992). In Ghana, the rainfall amount and runoff are been reported to have reduced by 20 percent and 30 percent respectively within the past 30 years (Daze, 2007).

The yearly rainfall in the country is projected to reduce by between 9%-27% by the year 2100 (Daze, 2007). Notwithstanding, the Sudan savannah agro-ecological zone is nonetheless predicted to experience the highest decrease in the amount of rainfall of 170.0mm by that year, followed by Deciduous Forest, Transitional zone and Guinea savannah, by 99.0mm, 78.0mm and 74.0mm respectively by the year 2100 with rainforest predicted to experience a rise of 110.0mm in the amount of rainfall by the year 2100. Daze (2007) reported that although the amount of rainfall is projected to decrease more in the years ahead in Ghana even though it has decreased over the years, the level of the sea has been reported to have increased by 2.1mm per year over the past 30 years. This is estimated to further increase by 1mm by the year 2100 and subsequently result in future scenarios of earthquakes due to intrusion of salt water into surface and ground sources and coastal erosion (Daze, 2007).

2.2.4 Evidence of climate change and its effects in Central Region

In the last few years, yields have further declined in many parts of the country (Braimoh & Vlek, 2006; Abu, 2011; Owusu-Sekyere et al. 2011). Although other contributing factors exist, increasing temperatures and irregularity in rainfall has been cited as the primary cause of the continuous reduction in yields in the Central Region (Abu, 2011). According to

Barimah et al. (2014) there is the existence of climate change in the Central region which is affecting agricultural activities especially productivity levels of farming. Osei (2017) concluded in his work that indeed climate change is occurring in the central region of Ghana. He discovered that rainfall has decreased by 62% over the studied period and would continue to decrease farther.

From the study done by Owusu-Sekyere et al. (2011) they found out that rainfall pattern has not been stable but fluctuates between high and low values; onset of the rainy seasons also fluctuates between March and April and the frequency of rainfall has been declining over the years; gradual decrease in peak monthly rainfall and relative humidity; an increase in temperature and evaporation which is a clear indication of a changing climate and yields of all major crops in the region have been declining gradually over the period due to the gradual change in the pattern of the major climatic elements.

In the work done by Akaba and Akuamoah (2018), the erratic rainfall, strong wind/storm with high tides, hot sunshine and high temperatures, drought and flood and heavy precipitation were the main climate effects experienced by the respondents in the Central Region of Ghana. The negative impacts of climate change experienced by these respondents in the fishing business include increasing risk and uncertainty in fishing, fluctuation in fish and wild stock distributions, reduction in the duration of fishing seasons and high fish spoilage and mortality. These effects, the respondents opined, lead to low productivity, reduced income, food insecurity and labour emigration. The respondents have therefore resorted to changing fishing methods, seasonal migrations and livelihoods diversification as responses to the climate change effects.

2.2.5 Climate change impact on agriculture

Africa's agribusiness has been portrayed as extremely susceptible to alterations in atmosphere's unpredictability, regular shifts, and rainfall arrangement (WRI AND UNDP, 1996). According to Meadows (2006) and IPCC (2007a), climate affects economic development at different sectors including agribusiness and food security, forestry, hydrology and water assets, manufacturing and health and tourism. Thus any change in climatic variables will affect these sectors. Due to the size and sensitivity of the agricultural sector, the largest known impact of climate change affect this subdivision (Mendelsohn, 2009).

The sort and level of data sources utilized for farming (Dimes et al. 2008) as well as climatic scenarios will ascertain the size of damage by climate change (Mendelsohn, 2009). Furthermore, Kurukulasuriya et al. (2006), noted that Africa is the mainland that will be most influenced by alteration in climate with expanded temperature and diminished precipitation, even though the fact that effects of climate alteration are probably not going to be homogeneous crosswise over Africa (Seo et al. 2008) as more hotter and drier territories, for example, central, southern and western Africa are probably going to be influenced most.

Furthermore, Seo et al. (2008), tested the affectability of homestead incomes to future atmosphere situations and concluded that African farms were sensitive to climatic elements particularly temperature. It (affectability) was greater for dry land farms with the affectability flexibilities for temperature and rainfall being 1.6 and 0.5 respectively than irrigation farms. Hence, it is disturbing to note that, rain fed agriculture represented over 95% of Sub-Saharan African croplands (You et al. 2010; Alexandratos & Bruinsma 2012).

There are possible yield benefits since increased atmospheric CO_2 concentrations will result in increased photosynthesis for both Carbon-3 and Carbon-4 crop sort. Development reaction to upgrade CO_2 fixation is for the most part known to be greater more noteworthy for Carbon-3 than for Carbon-4 sort (Lawlor, 2004; IPCC, 2007a). Again, crop and pasture yields may possibly improve due to higher water utilize productivity resulting from the decreased stomatal delivery under heavy CO_2 concentrations (Tubiello et al. 2007). On the other hand, increased temperature and changes in precipitation may limit plant response to enhanced CO_2 concentrations (Tubiello *et al.*, 2007). In addition, in many parts of Africa, low soil nitrogen and phosphorus may likewise constrain plant reaction to expanded limit plant reaction to increased CO_2 concentrations (Tubiello *et al.*, 2007).

Furthermore, over-short period, higher CO_2 concentration may arouse cation release from soil and raise plant growth, but CO_2-induced cation discharge may encourage cation losses and soil acidification over the long-term. According to Gordo and Sanz (2010) diminish in possible yields is probably going to happen because of rushed development and advancement because of increased temperatures and reduced amount of precipitation resulting in water stress for the Southern Africa region.

Yields of crops in the African region are expected to reduce under future climate (Meadows, 2006; IPCC 2007b; Schlenker & Lobell, 2010). As a result, localities in Africa, particularly those in the sub-Saharan area, are considered to be the most defenceless due to several stressors and limited adaptive capacity (Challinor et al. 2007; Barrios et al. 2008; Mertz et al. 2009). The defencelessness of Sub-Saharan African area is attributed to the fact that the area as of now encounters high temperatures; low and exceedingly factor precipitation; and the nations' economies are very dependent on cultivation as well as low selection or adoption of current innovation (Kurukulasuriya *et al*., 2006).

In a survey and deduction of agricultural effects of climate change by Tubiello and Rosenzweig (2008) reasoned that, modest warming (up to 2^{o}C) in the earliest part of the 21st century may have positive effect on yields of pasture and crops in the temperate areas, but have negative impact on yields of crop in the semi-arid and tropical areas. Then again, extra warming that is normal amid the second half of the century will contrarily influence yields of crop (Hertel & Rosch, 2010).

Rainfall in the transition zone in Ghana has witness a decrease in both the major and minor stormy periods and an infilling amid the short drought following in a high danger of product disappointment amid the minor rainy period as the inception of the rain delays and early cessation occurs (Owusu & Waylen 2013).

2.3. Climate Change Adaptation Strategies

2.3.1 Adaptation defined

The response to expected climatic stimuli or effects of climate change that reduces the dangers or brings out the good opportunities refers to Adaptation (Parry et al. 2007; IPCC, 2007a; IPCC, 2014). Adaptation to climate change constitutes a persistent stream of exercises, choices, and modification in states of mind by people, families, networks, gatherings, divisions, or governments in light of effects produced by or possibly created by environmental change or fluctuation. The size of adjustment varies from the adjustment of an individual or family unit to a specific climatic stress to the adjustment of a community to numerous worries to that of the worldwide framework to all stresses and powers (Smit & Wandel 2006).

Adaptation or adjustment can be anticipatory or reactive, self-governing or planned, structural or non-structural, in situ or ex situ, and incremental or transformational (Bardsley & Hugo 2010; Kates et al. 2012). Self-governing adaptation also known as spontaneous refers to "adaptation that does not consist of a conscious response to climatic stimuli, but is triggered by ecological changes in natural systems and by market or welfare changes in human systems" (IPCC 2007a). Conversely, planned adaptation is "the outcome of a planned policy decision, based on an consciousness that conditions have changed or are about to change and that action is required to return, maintain, or achieve a desired state" (IPCC, 2007a).

Adaptation to climate change is at this point occurring in agriculture as farming communities have a long record of adapting to the effects of weather and climate (Kurukulasuriya *et al*., 2006; IPCC, 2007a; Mano & Nhemachena, 2007). It (adaptation) includes making a move to decrease either the harmful impacts or to take advantage of the positive effects of climate change (Anim-Kwapong & Frimpong, 2006).

Agricultural adaptations mainly consist of two kinds of adjustment in production systems. The first is augmented assortment that involves participating in production action that are dry spell tolerant as well as opposing to temperature stress as well as actions that make proficient utilization and take full advantages of existing water and temperature conditions, among other components. Different crops are affected in a different way by climate actions therefore assortment in cocoa and non-cocoa sub-sectors can serve as insurance against precipitation changeability. The second strategy centres around crop administration or management practices geared towards guaranteeing that vital crop development stages do not concur with extremely very bitter climate condition such as mid-period droughts (Oyekele, Bolaji & Olowa, 2009).

Climate change and inconsistency have had shattering impacts on local actors (IPCC, 2007b), inciting awareness to adjust to this occurrence. Climate change reactions depend on the sort of effects to be expected at the local level. The reaction can comprise of lessening introduction to the perils or raising the adaptive capacity and/or diminishing climate defencelessness or vulnerability.

2.3.2 Adaptation strategies

The truth of climate alteration has been found in the new positions and activities the world, countries, communities, households or individuals have taken when there are intense climate factors. The reaction has been portrayed as climate change adaptations schemes or strategies. Agribusiness household adaptation to climate change extent from short term adjustment measures, for example decreasing the quantity of everyday meal times, through movement to other places, to adaptation schemes, for example embracing efficient upgrading measures like adopting productivity-improving measures such as the use of hybrid seed and intercropping with trees and fruits (FAO, 2008). Smit et al. (2000) noted that adaptation is simply seen as a reaction to concerns about climate alteration. They declare that adaptation depends basically on the features of the system of interest including its reactivity and susceptibilities. Chambers (1989) also indicated that susceptibility does not mean lack or want but helplessness.

Acquah and Onumah (2011) observed that farmers saw climate change as unrelenting dry season and utilized a blend of crop varieties to adapt with the test. Taylor et al. (2010) also said that coping strategies are efforts or combination of activities employed by households to decrease their vulnerability to coastal erosion, droughts, floods among others.

The term coping strategies can be used to represent the scope, blend and choice of actions that people compose or do in order to get their livelihood goals in a given vulnerability context such as climate change (DFID, 1999). In other words the term coping strategies can be used interchangeably to represent livelihood strategies in a livelihood framework.

The adaptation strategies to climate change in the literature include crop diversification, mixed farming system, crop varieties, changing planting and harvesting dates, mixed cropping, market based insurance products which allow farmers to cover their crops against weather variability and other market uncertainties (Jagtap, 1995).

Farmers have advanced innovative reactions to ecological alterations, including climatic inconsistency to generate more systems of sustainable production (Challinor et al. 2007). In the last four decades, severe crisis such as arid trances that have happened in Africa particularly in sub-Saharan Africa have indicated that individual or community adjustment abilities may not sufficiently deal with these changes (Challinor *et al*. 2007). Management of crop can be changed in a several ways to deal with the effect of climate change. Some author suggested some possible strategies that can be used to deal with the effects (Challinor *et al.* 2007; Howden et al. 2007; Mano & Nhemachena 2007). These strategies include intercropping; crop varieties; mulching; changing planting date, water management practices; diversifying income and raising livestock.

Hassan and Nhemachena (2008) also explained that potential adaptation strategies to climate change involve the utilization of fertilizers, pesticides and insuring agricultural crops. But there are some adaptation strategies that are specific to tree crops such as shade management strategies; crop diversification; soil fertility management; strategies for land preparation; farm size strategies and lining and pegging strategies (Codjoe et al. 2013).

With regards to land-use management, coping methods could incorporate water-gathering procedures and erosion protection such as dikes and water pans, yet additionally enhanced irrigation systems or more drought or salt-tolerant crop assortment (Agrawal & Perrin, 2008). Trees have many features that can help reduce vulnerability to climate impacts so it can be integrated into cereal and legumes crops. A study done by Codjoe et al., (2013), revealed that the adaptation strategies employed by farmers in the cocoa sector to maintain unfavourable effect of climate change were shade administration strategy, soil fruitfulness strategy, land preparation strategy, farm size strategy and lining and pegging strategy.

2.3.3 Barriers of adaptation to climate change

The constraints that farmers come across as they try to adjust to the effect of climate change are the barriers that hinder their adaptation to climate change. Deressa (2008) outline the following limits to adaptation:

- Deficiency of weather data (example deficiency of justification framework for generating weather information)
- Inadequate Financial resource (lack of collateral to access financial resource)
- Poor irrigation potential (example lack of new irrigation technology for farmers to adopt)
- Deficiency of access to appropriate seed (example deficiency of access to hybrid seeds)

- Labour shortage (example deficiency of access to machinery)

Capacities to adjust and manage with climate change are the basic adaptation requirement for farmers. Farmers need climate information and knowledge to mitigate the hash effect of the changes in climate but this information is not available to farmer. This hinder farmers from planning their farming exercises in order to lessen the effect of climate change. Ozor et al. (2010) outline that inadequate information and access to weather forecast innovation are the major limitation to climate change adaptation. Kassahun (2009) further confirmed this information in Ethiopia.

Agricultural finance or credit is inadequate for farmers and this deprives or prevents farmers from acquiring sustainable strategy that will assist them to mitigate the impact of climate alteration on their farming business. Farmers do not have monetary resources to adapt since adaptation is expensive and the barriers to adaptation are most often linked with poverty. Mabe et al. (2014) reiterated that a number of farmers may not have the capability to use any adaptation schemes to decrease the effects of the change. The strategies may be existing for use but they may not be easy to get. Benhin (2006) recorded that inadequate access to credit or saving are some of the main challenges faced by farmers. Kassahun (2009) additionally established inadequate credit as the main challenge to climate change adaptation.

The soaring cost of farm inputs prevents farmers from accessing various inputs for their farming activities. Ozor et al. (2010) revealed that soaring input cost is a key limit to adapting to climate change.

Factors influencing farmers' decision to adaptation are gender, education, credit access, non-farm income, extension service and farm size (Mabe et al. 2014). Deressa et al. (2008) also stated that experience and weather information access can influence farmers' strength to adapt. Work done by Bryan et al. (2009) showed that 23% of the respondents in Ethiopia had inadequate climate information as a barrier to adaptation; 21% of respondent in Ethiopia lacked finance/credit; 3% of respondent in Ethiopia were faced with poor irrigation systems and 6% of the respondents were faced with shortage of farm inputs as barrier to adaptation.

Jones (2010) also identified three classes of restrictions to adaptation to climate change. These classes include:

i) Natural restrictions (both physical and environmental restrictions),

ii) Human and data resource-based restrictions (knowledge, technological and economical restrictions) and

iii) Social limitations (psychological, behavioural and socio-institutional elements that establish how individuals and societies react to climate pressure).

A major constituent of adaptation is the evolution of the adaptive capacities of players actors in the context of changeability of the weather.

2.4 Adaptive Capacity: Definitions, Concepts and Determinants

2.4.1 Definitions and concepts in adaptive capacity

Adaptive capacity is a country's, community's, household's and individual's ability to adjust in a way to decrease the vulnerability to climate alteration effects and recover from the consequences (IPCC, 2014). Woodward (2007) also elaborated that adaptive capacity can be understood as a trait of evolution: being healthy ensures the competence to adapt; basic education and knowledge boost the ability to judge how to adapt; wealthy allows assets for adjustment; and all-encompassing governance offers freedoms, opportunities and the liberty to adapt. Adaptive capacity is ability of an entity to adjust to climate change effects. The strength of an entity to align with climate change in order to moderate its potential damage and take vantage opportunities from its consequences also represents adaptive capacity (FAO, 2008).

Adaptive capacity does not only vary in conditions of its worth but also in agreement with its nature. The size of adaptive capacity are not independent or detached: the adaptive capacity of the individual is reflective of the resources and procedures of the network and the ability of a person to deal with climate risks depends, to some level on the enabling environment (Smit & Pilifosova, 2003; Yohe & Tol, 2002).

Adaptive capacity reflects adjustments in the framework to better manage with tricky exposures and sensitivities. Many ways in which adaptations can be classified including i) by timing relative to stimulus (anticipatory, concurrent, reactive), ii) intent (autonomous, planned), iii) spatial scope (local, widespread) and iv) form (technological, behavioural, financial, institutional, informational) (Smit et al. 2000; Smit & Skinner, 2002; Huq et al. 2003). In addition, Risbey et al. (1999), said that adaptations can be differentiated easily based on the degree of adjustment or change required from or to the original system. For example a basic adjustment for a farming framework confronting water deficiency exposures may be the utilization of drier spell safe cultivars.

The local capacity to tackle climate change is the gathering of indicators of access to resources namely information, technology, wealth and finance and institutional resources (Eakin & Bojorquez-Tapia, 2008). Past studies have endeavoured to survey adaptive capacities at different scales, such as communities (Smit & Wandel 2006), sub-divisions

(Eakin et al. 2011), districts (Sharma & Patwardhan 2008), nations (Tol & Yohe 2006), and territorial frameworks (Schneiderbauer et al. 2013). Fundamentally, these studies concur that the improvement of adaptive capacity is mainly subject to assets (Wagner et al. 2014). Bebbington and Perreault (1999) contends that a family unit can build adaptive capacity by growing its resource base, including the touchable assets used to uphold livelihoods and abilities to do so. The learning of activities encompassing past pressure actions has been utilized as a intermediary for how frameworks might build and mobilize their adaptive capacity to plan for and react to potential climate change (Engle 2011).

2.4.2 Determinants of adaptive capacity

Adaptation to climate change and dangers happens in a vigorous biophysical, financial, and social, innovation and political setting that differ over time, area, and sub-division. This difficult blend of conditions decides the capacity of frameworks to adjust. Despite the fact that studies on adaptive capacity is to a greater degree constrained in the climate change field, there is impressive apprehension of the conditions that impact the flexibility of societies to climate input in the fields of perils, asset administration, and practical improvement. From this, it is feasible to recognize the primary characteristics of individuals, districts that appear to resolve adaptive capacity using the five capitals: Social, Financial, Physical, Human and Natural.

2.4.2.1 Social capital

The flow of information, agreement and set of network refers to social capital (Adger et al. 2005). Social capital was also defined by Pelling and High (2005) and Adger and Vincent

(2005) as a lens for investigating how social networks and social norms, including reciprocity, contribute to adaptive capacity particularly in coping with danger and ecological change. Social capital encourages teamwork and participation among neighbourhood and nonlocal actors in the midst of stress and the helpful delivery of administration endeavours to adapt to dangers to assets and assets clients (Armitage, 2005). Social capital can likely be utilized to deliver material mediations guided at decreasing susceptibility to climate change (Pelling & High 2005).

Trust, mutuality and networks are the three facets of social capital which is likely to manipulate adaptive capacity. Even though there is universal acknowledgment that conviction is significant in adaptive capacity but the way it sways the construct remains vague (Adger & Vincent 2005; Folke et al. 2005). The most grounded proof originates from the adaptive co-management literature, which shows that techniques for building teamwork and faith aids in the administration of danger and conflict in multifaceted multilevel frameworks (Armitage et al. 2009). Other works have also differentiated among the trust that develops among persons and between persons and networks in the natural resource management literature (Berry et al. 2011; Morrison et al. 2011; Sharp et al. 2012).

Pelling et al. (2008) showed how trust can make social commitment, taking part in corresponding activities and such connections add to the gathering of trust and correspondence between partners, aiding in the development of arranged adjustment to climate change.

Formal and informal systems have imperative part in social learning processes for controlling climate change and are a key structural characteristic of governance regimes, as well as informal network flow Pretty and Ward (2001) and Pahl-Wostl (2009). Networks can be constructed vertically or horizontally. Vertical networks bring persons who differ in terms of hierarchy or dependence together and horizontal networks join persons of the same status and power together (Pretty & Ward, 2001). They said that, horizontal networks can be alluded to as far as:

a. Neighbourhood associations: These are association between people within groups;

b. Neighbourhood nearby associations: It is the association between people and communities;

c. Neighbourhood outside associations: It is the association between local groups nearby and external agencies;

d. External-external associations: It is the associations between external agencies, which lead to community oriented associations.

For instance, Raymond and Robinson (2013) found that adaptation can be swayed by the interpersonal organizations among administrative offices, network of training, e.g. farm system groups and also confided counsels, e.g., farm consultants, who can decipher complex ecological change ideas into locally appropriate advice.

2.4.2.2 Financial capital

Regardless of whether it is explained as the capital assets, monetary means, financial resources, riches, or neediness, the monetary state of countries or people is a determinant of adaptive capacity (Burton, Soussan & Hammill, 2003; Kates, 2000). It is widely recognized that well off countries are better arranged to endure the expenses of adjustment to climate change effects and dangers than poorer countries (Burton, 1996).

Despite the fact that destitution ought not to be viewed as equivalent to susceptibility, it is "an unpleasant indicator of the ability to survive" (Dow, 1992). It is usually the poor who are among the most susceptible to malnutrition, starvation and hunger (Bohle et al. 1994). Deshingkar (1998) depicts a circumstance in India in which pastoralist networks are "locked into" a helpless circumstance to some degree as a result of an absence of money related influence that would enable them to broaden and take part in different sources of income.

Kelly and Adger (1999) showed the impact of destitution on an area's adapting ability; poor areas have a tendency to have less assorted and not so much entitlements and an absence of empowering to adjust. There is abundant proof that poorer countries and deprived groups inside countries are particularly defenceless against catastrophes (Banuri, 1998; Munasinghe & Swart, 2000).

Money related capital assumes an extremely vital part in deciding employment choices and systems accessible to the general population (Hammill et al. 2008; Islam, 2008). In climate danger zones of developing nations, monetary capital pulls together different types of capital resources (human capital, common capital, social capital) required for an effective work system. This therefore implies that, access to formal financial administrations from banks, and microfinance industry (microcredit, smaller scale protection and miniaturized scale reserve funds) will enhance adaptive capacity and diminish the susceptibility of the poor to climate events (Hammill et al. 2008; Dowla, 2006).

2.4.2.3 Physical capital

Physical capital involves the essential infrastructure and producer goods expected to aid livelihoods, such as good transport system; safe house and structures; water; energy and data access (DFID, 2000). Its effect on the sustainability of a livelihood framework is best fit for portrayal through the thought of chance expenses, as worn out infrastructure can rule out education, access to good health services and income generation. For instance, Calow (2001) noted that without water facilities, time is spent in gathering of water which require extra labour which could have been used elsewhere. Again, absence or lack of good transport system, distribution of fertilizer cannot be achieved and farm outputs remain low. It also become hard and costly to convey limited output to the market resulting into low capacity to adopt.

With a specific end goal of successful

productivity, individuals require physical capital like land, infrastructure, farm animals, money/investment funds and apparatus (Regmi & Adhikari, 2008) utilized in manufacturing. A general public and individual with constrained or no physical capital is in danger of not producing which is probably going to impede their adaptive capacity and their livelihood. Physical capital is required in order to build up strategies that would enhance their adaptive capacity. They require land for farming and for livestock grazing. Physical capital enables individuals to create business techniques that enhance their adaptability.

2.4.2.4 Human capital

At the farmer level, human capital is an attribute of the quantity and quality of manual labour available and it differs according to size of the household, management potential and health standing. It includes the skills, health (including mental health) and education.

According to Vanclay (2011), human capital can be created by training individuals on the precondition that cognition is a limiting deed. Group approaches allow co-learning among resource managers, planners and scientists (Plummer 2009). They can also facilitate deliberation on approaches to transforming natural capital into physical and financial capital to ensure that natural capital is not 'mined' or used unsustainably. Groups can, for instance, build up material innovation to deal with local problems through effective funding of action research that includes development and extension. Such process-driven and outcome-oriented work aims to effectively harness the diverse knowledge of the range individuals and backgrounds (human capital) within the group, rather than to provide technical information in a top-down manner to individuals.

2.4.2.5 Natural capital

Natural capital has been described by Scoones (1998) as natural resources, and it includes soil, water, air, forest and environmental services used for livelihood. It is also the natural asset stocks from which asset flows and services useful for livelihoods are derived (DFID, 2000).

Nicol (2000) noticed that natural capital is extremely basic to the individuals who obtain all or part of their livelihoods from asset-based exercises (farming, fishing, gathering in forests and mineral extraction). Nevertheless, its significance goes further than this.

Furthermore, in spite of the fact that our comprehension of linkages between assets stays constrained, farmers realize that their wellbeing and prosperity depend on the continued working of complex ecosystems (which are regularly underestimated until the point that the unfavourable impacts of disturbing them wind up clear).

2.5. Institutions and Adaptation to Climate Change

2.5.1 Perspectives on concepts and applications

Adapting to climate change involves actions that aim at decreasing risk and vulnerability, formation of opportunities and building the capacity of groups, individuals and natural systems to adjust with climate effects while at the same time taking and implementing strong decisions to ensure a flourishing adjustment process. Adaptation to climate alteration has also been identified to be a socio-institutional learning process that distinguishes stakeholder goals and processes and uses information at different degrees and in different ways (Ziervogel & Ericksen, 2010).

Geographical and socio-cultural settings, age, gender, wealth among others are the key factors to be considered in adaptation option available to communities and individuals (IPCC, 2013). Climate change adaptation is also location specific because of the differentiated nature of societies, exposure and impacts (Penalba et al. 2012; IPCC, 2013). Institutional support or connection provides the needed surroundings for the implementation of adaptation options therefore adaptation cannot be achieved without it (Moser & Ekstrom, 2010). This shows that institutions at the community level in the climate change dialogue is very important as they are very important in determining adaptation and improving capabilities of the most susceptible social groups within the society (Penalba *et al.*, 2012).

Rodima-Tylor *et al.* (2011) describe institutions to be ubiquitous and serve varied purposes of adaptation and therefore are necessary in ensuring a successful adaptation. Again, institutions also affect community and individual conduct through their sets of norms and events that legalize conduct and manage its effects thereby creating incentives for adaptation (Agrawal et al. 2011). However, within the social system, there are diverse types of institutions that manage human interaction (Agrawal, 2010; Agrawal *et al*. 2011). Three types of institutions were identified from literature and these are private, public and civic or participatory institutions (Agrawal *et al*. 2011).

Public sector institutions usually possess commanding action and have the capability to direct financial and technical into rural areas and act in ways the community wants as they find themselves in office through the electoral system most often (Gortner et al. 2007; Agrawal *et al.* 2011). For this reason, the local level public institutions have been acknowledged to have a superior ability to channel resources to providing adaptation support in strategies related to community pooling, storage and diversification (Agrawal *et al.* 2011).

Private institutions conversely own goals, they venture into adaptation strategies that promote market exchange and in a few cases communal pooling since they have more financial resources (Agrawal, 2010). Civic and participatory institutions due to their flexibility are able to redefine their goals to take up new procedures and improve upon different adaptation strategies (Agrawal & Perrin, 2008).

According to Agrawal et al. (2011), institutions are described to exist in two forms, formal and informal. In human societies informal institutions have been identified to be the initiators of adaptation actions (Ajaya et al. 2009), while, formal institutions are noted to develop strategies and improve upon the reaction strategies established by informal institutions so as to make interventions sustainable and reduce mal-adaptation (Agrawal, 2010). Institutions involved in climate change adaptation have been recognized to exist in a hierarchy ranging from the local level, national to international level (Agrawal, 2010; Moser & Ekstrom, 2010; IPCC 2013).

At the local level, institutions have the capability of reinforcing existing adaptation strategies and make them more sustainable and in some cases introduce new adaptation strategies that meet the adaptation needs of households and communities they serve (Agrawal, 2010). In addition, institutions in rural areas have been noted to help in integrating smallholder farmers into the national economic system by applying modern methods that will make the smallholder farmer more competitive to be given enhanced prices and have right of entry to investment resources. Likewise, Agrawal *et al*. (2011) observed that local institutions must tolerate characteristics of responsiveness, flexibility and aptitude to adapt to the doubts that surround climate change before adaptations can be effective.

The interaction between the different types of institutions determines the efficiency of adaptation (Agrawal 2010; Agrawal *et al*., 2011; Tiwari & Joshi 2014). IPCC (2013) and Tiwari and Joshi also said that institutions interact with each other in either horizontal or vertical relationship and in some cases both. Agrawal *et al*., (2011) propose that, one has to give concentration to the nature and goals of institutions, how they make easy particular interventions and how institutions associate with each other and the rural households when studying the role of local institutions in adaptation. Rodima-Taylor et al. (2012) noted that this is so because, individuals have been documented to adapt through complex multidirectional contacts between institutions and all actors within the system at different scales.

Rodima-Taylor et al. (2012) also said that local innovations and adaptations are interlinked with those from the global scene thus, becoming an integral component of adaptation between institutions and actors. Institutions involved in the adaptation process are interdependent and equally important in the adaptation process from the above dialogue.

2.5.2. Institutions and adaptation in Ghana

Institutions are needed to develop the adaptation capacities of individuals and communities to climate change (Musah-Surughu & Ahenkan 2014). Belden (2010) and Laube et al. (2012) noted that in adaptation, both formal and informal institutions have roles to play. The relations and interaction between institutions can encourage or challenge adaptation efforts (Belden, 2010; Yaro et al. 2015).

From the empirical studies done by Stanturf et al. (2011) and Darko and Atazona (2013), the adaptation process in Ghana involves all forms of institutions within the vertical column of institution (international, national and local). Stanturf et al. (2011) reported that, international institutions have been known to put forward financial support for execution of climate change projects sometimes while working together with government or with locally based NGOs. However, national institutions are not in a straight line involved in adaptation while through policies and service provision they ensure that conditions are met for adaptation and sometimes run adaptation driven projects (Yaro *et al*. 2015).

NGOs also spearhead adaptation by building the capacities of people through education, provision of livelihood choices and introduction of new opportunities (Stanturf *et al.* 2011; Yaro *et al*. 2015).

Adjei-Nsiah and Kermah (2012) also concluded that institutions that are public such as the Ministry of Food and Agriculture (MoFA) and the Forestry Commission (FC) provided improved cocoa seedlings and training in cocoa agronomy to rural farmers in Wenchi to help them take the edge off and adapt to the negative impacts of climate change. Public institution such as MoFA and Forest Commission partnering with informal institutions such as family heads to execute forest protection regulations meant at enabling rural households take the edge off and adapt to climate change (Egyir *et al.* 2013).

2.5.3. Institutional support and smallholder farmer's ability to adapt

Stresses and shocks from the environment, economic and social changes highly affect the agricultural sector. Some of these changes take place at a quick pace while others may occur gradually and may be unpredictable in nature (World Bank (2013). In order to cope with these changing trends, farmers will therefore have to adopt new innovations and technologies.

Climate change has now become a great threat to the agricultural sector with farmers being described to be mostly at risk due to their dependence on the climate. This is factual because all the parts of the socio-economic system are affected by climate change and changes in climatic variables tend to affect productivity especially in agriculture thereby, leading to price increases and exacerbating poverty especially within smallholder farmers (Ziervogel & Ericksen, 2010).

Various studies on climate change concerning smallholder farmers have advanced that, smallholders usually react to climate change by migrating to other areas to take on either on-farm or off farm activities, growing new varieties of crops, mixed farming, irrigation, communal pooling, storage depending on wild foods and market exchange (Hassan & Nhemachena, 2008; Agrawal, 2010). But the decision of individuals and households to adopt one adaptation strategy or the other cannot be taken without any form of institutional manipulation (Agrawal *et al.* 2011).

Moreover, institutions have been known to serve as modes of transmitting innovations and initiatives to farmers and other stakeholders in the agricultural sector (Hall *et al.* 2006).

The IPCC (2013) recognizes the input of institutions to adaptation and they noted that institutions associated with the local level are the most important when it comes to adaptation support. These institutions include local governments and the private sector (the participatory, civil based organizations and non-governmental organizations). These institutions have been known for the roles they play in the development of adaptive capacities of individuals and information sharing (Agrawal, 2010). When adaptation is well planned and receives the required institutional backing to ensure its success, adaptation tends to serve its purpose and bring down the effects of climate change on households and individuals (Smit & Pilifosova, 2003).

Agrawal (2010) found out that the aptitude of public institutions at the local level to successfully give support to smallholder farmers or communities depends on political issues which may obstruct or boost the provision of the support. Officials of public institutions are inclined to act to go well with their benefactors rather than the people whom they have to serve owing to the fact that they were either elected or nominated by a higher body (Agrawal, 2010; Measham *et al.* 2011). The rate of access individuals and households have to institutions is determined by the rate at which households and individuals access strategies introduced by institutions (Agrawal 2010; Agrawal *et al*. 2011).

Rajalahti *et al.* (2008), found out that if farmers and other actors in the agricultural system are to adapt successfully to climate change, they must innovate incessantly and within helpful surroundings which allow for development in technology and evolution of institutions. Thus, creating the enabling surroundings for farmers who happen to be the key actors in the agricultural sector to successfully adapt. Hassan and Nhemachena (2008) in their work found out that by rising farmers market access, extension contact and credit services, innovation and farm assets (in the form of labour, land and capital) the aptitude of farmers to adapt to climate change would be improved.

2.6 Factors Affecting Adoption of Technology

Factors influencing adoption of agricultural technology include age, gender, formal education, residential status, total farm income, total off farm income, attending technology demonstration, effectiveness extension service, number of cocoa farms owned and capital assets (social, physical, human, financial and natural)

Atala (1980) discover factors like age, formal education, income, and community/social status as influencing adoption of agricultural technology. According to Adesina and Chinu (2000), gender of the farmer influences adoption differently depending on the innovation.

Buyinza and Wambede (2008) found an affirmative impact of education on taking up. However, Chagunda *et al.* (2006), found education not to have any effect on farmers willingness to adopt exotic cattle rearing in Malawi. But Oyekale and Idjesa (2009) reported a relationship between education and adoption to be negative. Baffoe-Asare et al. (2013) also identify age, gender, farm size and social capital as positively influencing adoption of technology.

Mijindadi and Njoku (1985) in a study to assess the extent to which tomato innovations were adopted in cooperative and individual farms in Ikara area of Zaria found significant associations between extension contact, membership of associations and credit availability. The availability and accessibility of extension agents to farmers as well as frequent visits will help farmers to obtain and update their knowledge on current technologies. There exists a positive relationship between extension contact and taking up of enhanced maize seeds (Adeogun *et al.* 2008). Similarly, Adekoya and Ajayi (2000) also identified membership of cooperatives, social position/cultural positioning, extension agent contact as factors influencing adoption of innovation.

Off-farm income could positively affect adoption by minimizing the financial problems that the farmer would encounter in making his or her adoption decision. Furthermore, households with low levels of off-farm income or poor access to credit facilities are less probable to be able to afford newer and capital-intensive technologies.

Egyir et al. (2015) identified factors like age, total-farm income, origin, off-farm income, farm size, physical and human capital influence adoption of technology. In a similar study by

Owusu (2016), he also noticed that age, extension contact and education positively influence the adoption of agricultural technology. According to Mabe et al. (2014) factors influencing farmers' decision to adaptation are gender, education, credit access, non- farm income, extension contact and farm size. Deressa et al. (2008), also stated that access to weather information and experience can also affect farmers' ability to adjust to climate change.

2.7 Livelihood

2.7.1 Strategies

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base (Scoones, 2000).

Livelihoods are the means of gaining a living (Chambers, 1995). It involves combining resources such as entrepreneurial skills, financial, physical and natural resources through a well-defined strategy. Livelihood strategies therefore refers to activities undertaken by household members such as farm activities, off farm activities resulting in outcomes such as food or income security (Ellis, 2005). These strategies may lead to the creation a sustainable livelihood. Sustainable livelihood outcomes include poverty reduction, improved well-being, improved capabilities, livelihood adaptation and enhanced resilience to risks and shocks, and natural resources that are sustainable (Scoones, 1998).

Livelihood diversification is a persistent and enduring characteristic of rural survival, reflecting the vulnerability of rural livelihoods (Ellis 2000). Diversified livelihood systems are less susceptible than undiversified ones; and livelihood units spread their income sources to spread risk and smooth consumption. The agricultural industry compared to other industries is unique, for the reason that production depends on climatic conditions, which introduces an element of risk. Agriculture production decisions are made in the face of uncertainty and risk.

2.7.2 Factors that influence livelihood diversification

According to Ellis (1998) the causes and consequences of diversification vary in different locations and economies (Ellis, 1998) and thus factors found in literature to influence diversification are generally policy or community level factors or farm specific and individual or household characteristics. For example, according to Pingali et al.(1997), small and marginal farmers engage in diversification of crops to increase household income and reduce risk. Again the flexibility of farmers in responding to diversification opportunities in most cases are influenced by the size of markets, price risks, soil suitability, quality of irrigation infrastructure, availability and cost of labour and the socio-economic characteristics of the farmer. Ashok and Balasubramania (2006) also found out that access to road, market and irrigation determines the extent, success and profitability of diversification through high paying crops. Singh et al. (2006) adds that several factors can influence or affect the degree or extent of diversification in a particular locality. These include government policies that promote specific crops, development of infrastructure like roads and markets, and relative profitability of crops.

2.7.3 Livelihood Outcomes

Livelihood outcomes are defined as the achievements or outputs from livelihood strategies (Department for International Development, 1997). These may take the form of increased income, increased well-being, reduced vulnerability, improved food security, and/or more sustainable use of the natural resource base. According to DFID (1999) there is a close relationship between livelihood outcomes and livelihood assets, the two being linked through livelihood strategies. For example, a person may choose to reinvest most or all of any increased income in assets, with a view to catalysing a virtuous circle of asset accumulation and increased income.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the methodology used in conducting the research. It specifically deals with theoretical framework, analytical framework, method of data analysis, data collection methods and the sampling procedure. The final section is on the scope and limitations of the study.

3.2 Theoretical Framework

This thesis is informed by the perception theory (Langton, 1970), capability theory (Sen, 1999), and diffusion and utility maximization theory (Rogers & Shoemaker, 1971; Cascetta, 2009: Kalinda et al. 2014).

3.2.1. Theory of Perception

The perception theory by Langton (1970), stipulates that an individual makes decisions based on information gathered from the environment in which they live. This information is intellectual past experience on which a farmer takes a decision.

A farmer will take an adaptation strategy based on knowledge of climate change experienced on their farms. These adaptation strategies are adopted based on the experience and signals taken from the environment. Farmers experience with climate change will inform the choice that they make on their farms. These choice are selected from several strategies available to the farmer. To take a meaningful decision, a farmer must combine the information that has been gathered from the environment to what they have in memory.

An individual farmer will perceive or react to climate change of an area depending on the experience or a known information of the area. Farmer's perception of climate change will shape their agronomic practices. Their perception of the climate change which informs their adoption of strategies will also guard their livelihood (income, welfare and food security).

3.2.2. Capability Theory

The capability theory by Sen (1999) measures the level of a person's substantive liberty to achieve a functioning life. These functions represent the various things a person is able to do. The basic appeal of capability theory is its emphasis on what a person is effectively able to do and to become.

Climate change will affect what an individual or community is capability of doing with the available scarce resources. If climate change affects farming then farm work will be limited, making climate change a barrier to functioning lives (Schlosberg 2009).

The individuals should define their own risk and vulnerabilities, this will help in designing adaptation policies and measures that will aid them to mitigate the effects of climate change.

This theory provides a way of analyzing the precise needs of an individual or community and identifying the barriers people encounter to adapt to climate change. It also aids in designing and applying adaptation policy towards the preservation of specific abilities under threat from climate change and determining the achievement through adaptation measures.

3.2.3. Diffusion and Utility Maximization Theory

The choice to consider an innovation emerges from two main theories. Firstly, the theory of diffusion explains the process of adoption (Rogers & Shoemaker, 1971). From the diffusion theory, an adoption procedure emerges slowly at the preliminary stages, gets to its highest and then begins to turn down. This diffusion process is influenced by the mode in which innovators interpret the message to the adopters. Secondly, there is the theory of utility maximization behaviour of the consumer. From the theory of utility maximization, individuals are assumed to adopt the innovation package if it yields highest satisfaction at a lower cost (Cascetta, 2009: Kalinda et al. 2014). This utility is influenced by some personal characteristics of the individual, the innovation package itself and the capacity of the individual in terms of social, financial, physical, human and natural capitals or assets (Kalinda, Tembo & Kuntashula, 2014). Farmers will need to adopt to certain adaptation strategies in order to reduce their vulnerability to climate change.

A system needs time to appreciate its adaptive capacity before an important adaptation since adaptation does not occur immediately (Valdivia, 2001). The hypothesis is that for any framework that embraces adjustment or adaptation, there is a threshold level of capacity that must be gained. It consequently takes after that a framework or person that have completely adapted to stimuli, have accomplished a high level of adaptive capacity over the doorsill for adoption. A framework faced with excessive dangers will either adopt by utilizing the adaptive alternatives and procedures accessible to it or neglect to adopt (Adopted $Y = 1$, Not adopted $Y = 0$). This displays a discrete decision circumstance of adaptation that can be depicted utilizing the latent variable model or the threshold concept for discrete variables (Long, 1997).

3.3 Method of Data Analyses

Data analysis depends on the objectives and the research design chosen for the study. The research objectives and the kind of data obtained for the study, allowed joint use of both the quantitative and qualitative analytical approaches (Moser & Kalton 2017; Hoeper 1991).

3.3.1 Describing the climate change adaptation strategies known and employed by cocoa farmers in the study area

The strategies (on-farm/off-farm) were then presented to the sampled cocoa farmers to choose the one they know and employed to safeguard their livelihoods in the face of the climate change challenge. The relative frequency of responses was then determined and plotted as a graph. The proportion of farmers who employed the various strategies was estimated and used to describe the strategies they employ:

$$N = \frac{A}{A+B} \; X \; 100 \qquad 3.1$$

Where N= Percent of adaptation strategies employed by cocoa farmers

A= Population of cocoa farmers who employed the adaptation strategies

B= Population of cocoa farmers who did not employed the adaptation strategies

3.3.2 Determining the level of farmers adaptive capacity to climate change adaptation strategies and adaptive capacity of farmers based on the capital assets

I compute two variables for farmer *i* for analyses:

a) Adaptation strategy (on-farm and off-farm strategies)

b) Adaptive capacity (using farmer capital assets)

A. Adaptation strategy (on-farm and off-farm strategies)

Farmers' adaptive capacity (AC_1) was based on elements and measures of the strategies scored on elements they employed.

The adaptation strategy (AC_1) of an *i*th farmer to *j*th strategy is calculated as in equation (3.2) below:

$$AC_1 = \frac{X_1 + X_2 + \dots\dots\dots\dots . X_n}{N_A} \qquad 3.2$$

Where

AC_1 = the adaptive capacity of an ith farmer on the particular strategy

X = the score of the ith farmer on the particular strategy;

N_A = the total sum of the applicable attributes.

n = the number of strategies (9 for on-farm and 9 for off-farm)

From Table (Appendix 3) for on-farm and Table (Appendix 4) for off-farm each statement to the particular strategy elicits a response of Yes (score 1) or No (score 0). Application of chemical fertilizer therefore has a total score of 4, based on the four factors; application of insecticide also has a total score of 4 based on the four factors, and so on. The total maximum score, based on a farmer responding Yes to all the factors is 36 for on-farm adaptation strategy (scaled to 1) and 36 for off-farm adaptation strategy (scaled to 1).

B. Adaptive capacity based on the capital assets

Farmers' adaptive capacity (AC_2) was based on elements and measures of the capital assets scored on elements they employed (Appendix 5). From table in Appendix 5 each statement to the capital assets elicit a response of Yes (score 1) or No (score 0). Financial capital therefore has a total score of 7, based on the seven factors; physical capital also has a total score of 7 based on the seven factors, and so on. The total maximum score, based on a farmer responding Yes to all the factors is 26 (scaled to 1). The thesis uses a similar score categorization approach to analyze cocoa farmers adaptive capacity based on the capital assets. The overall adaptive capacity (AC_2) of an *i*th farmer to *j*th capital asset employed is calculated as shown in equation (3.3) below:

$$AC_2 = \frac{F_2+P_2+H_2+S_2+N_2}{N_A} \qquad 3.3$$

Where

AC_{qr} = the adaptive capacity of an ith farmer

F_2 = the score of the ith farmer on financial factors;

P_2 = the score of the ith farmer on physical factors;

H_2 = the score of the ith farmer on human factors;

S_2 = the score of the ith farmer on social factors;

N_2 = the score of the ith farmer on natural factors;

N_A = the total sum of the applicable attributes.

The average adaptive capacity of farmers, AAC_2 is calculated using the equation (3.4) below.

$$AAC_2 = \frac{\sum AC_2}{N} \qquad 3.4$$

Where

AAC2 = Average adaptive capacity for the farmers

AC_2 = Adaptive capacity of ith farmer

N = The number of observations (farmers)

AC_2 lies between 0 and 1 ($0 \leq AC \leq 1$)

Some authors have also used similar formulae for their work (Nakuja et al., 2012 and Mabe et al., 2014). Generally, there is no rule for classifying adaptive capacity levels, cut off points were based on previous studies (Asante, Boakye, Egyir & Jatoe, 2012; Nakuja et al. 2012; Mabe et al., 2014; Gosh et al. 2015) and the dispersion of data. Low, moderate and high were the three categorization which each farmer falls within (Table 3.3).

The adaptive capacity (AC_2) score of farmers are re-classified as follows following (Nakuja et al., 2012; Asante et al., 2012; Mabe et al., 2014; Gosh et al. 2015)

Low	$0 < AC \leq 0.33$
Moderate	$0.34 \leq AC \leq 0.66$
High	$0.67 \leq AC \leq 1.00$

I describe the distributions in these two variables (AC_1 and AC_2) for the cocoa farmers and employ AC_2 as a variable in the regression for analyses for the adoption of PIS and effects on livelihoods

3.4.3 Estimating the magnitudes in the factors influencing adoption of Productivity Improving Strategies (PIS)

Firstly, I identify the PIS available that cocoa farmers are to adopt in the face of climatic changes to enhance cocoa production (appendix 6). In the focus group discussion with COCOBOD and selected farmers, it was noted that for maximum result from the use of PIS, farmers were to have employed more than three of the PIS, hence, employing 1-3 PIS (non-Adopter and scored 0), employing 4-6 PIS (adopter and scored 1). The adaptation strategies are described as productivity- improving. The productivity improving strategies included hybrid seed, chemical fertilizer, insecticides, fungicides, weedicides and intercropping with trees (COCOBOD, 2001).

Secondly, the Logit model (and extract marginal effects) was employed, following from (Akudugu et al. 2012; Mohammed et al. 2019)

A cocoa farmer will decide whether or not to adopt the productivity-improving strategy relying upon the utility levels linked with the two decisions. In this case, choice models are utilized to examine a farmer's decision to adopt or not to adopt productivity-improving strategy. The models are utilized relying on the dependent variable which takes the form of a dummy variable (0 or 1). The models that can be use are the logit and probit models. These models can be derived from an underlying hidden variable:

$$Y^* = \beta_0 + X\beta + \varepsilon \qquad 3.5$$

$$Y = 1(Y^* > 0)$$

Where y^* indicates the secret, or idle variable; x represents the explanatory variables, ε signifies the error term and $1(y^* > 0)$ defines the binary outcome.

The logistic model for 'k' independent variables ($X1$, $X2$, $X3$, …., Xk) is given by

$$LogitP(X) = \alpha + \sum_{i=1}^{k} \beta_i X_i \qquad 3.6$$

Where α signifies a constant and βi signifies the regression coefficient.

Model Specification

The empirical model relating the probability of adoption of PIS to selected exogenous factors is specified as (see table 3.5 for variable definition and measurements):

$$PIS = \beta_0 + \beta_1 Age + \beta_2 Age^2 + \beta_3 Gender + \beta_4 Edu + \beta_5 Origin + \beta_6 Exp + \beta_7 TFIncome + \beta_8 TOIncome + \beta_9 AFC + \beta_{10} IS + \beta_{11} AC_2 + \varepsilon \qquad 3.7$$

Table 3.1. Explanation of variables employed in the thesis

Variable	Definition	Measurement	A priori expected Sign
Dependent (Y)	PIS adoption level	Y=1, adopting the package Y=0, not adopting the package	
Independent variables			
Age	Age of farmer	Measured in years	+/-
Age^2	Age of farmer squared	Measured in years	+/-
Exp	Experience of farmer	Measured in years	+/-
Gender	Gender of farmer	Dummy (male=1; female=0)	+/-
Edu	Education	Number of years spent in formal education	+/-
Origin	Residential status of farmer	Dummy (indigene=1; migrant=0)	+/-
ASF	Access to storage facility	Dummy (Yes=1; No=0)	+/-
TFIncome	Total on-farm income	Measured in cedis	+/-
TOIncome	Total off- farm income	Measured in cedis	+/-
FBO	Membership of an association	Dummy (Yes=1; No=0)	+/_
IS	Receive institutional support	Dummy (Yes=1; No=0)	+
Ext	Extension contact in the past year	Dummy (Yes=1; No=0)	+
HHsize	Number of persons in the house under the care of the farmer	Measured in numbers	+/-
FarmSize	Size of farm	Measure in hectares	+
Inc	Total income (total on-farm and off-farm income)	Measured in GH₵	+/-
Yield	Yield of cocoa produced	Measured in bags of cocoa	
AC*	Adaptive capacity	Computed	+

* The components of the capital items used in calculating the indices are shown in Table 3.2

Statement of Hypotheses and Significant Test

H_O: Farmer adaptive capacity (AC_2) has no effect on adoption of productivity improving strategies

H_A: Farmer adaptive capacity (AC_2) has positive effect on adoption of productivity improving strategies

H_O: Institutional support (IS) has no effect on adoption of productivity improving strategies

H_A: Institutional support (IS) has positive effect on adoption of productivity improving strategies

H_O: Other variables (eg. Exp, Origin, Edu) has no effect on adoption of productivity improving strategies

H_A: Other variables (eg. Exp, Origin, Edu) has positive effect on adoption of productivity improving strategies

Validation of hypothesis:

The z-test at a 5% significance level is used to establish the significance of the estimated coefficients. Specified as: $z\ cal = \frac{\beta i}{SE\ (\beta i)}$ … 3.8

Where βi = Estimated Parameter

SE = Standard Error

Decision rule: if $z\ cal \geq z\ crit$, the null hypothesis (Ho) would be rejected in favour of the alternative hypothesis (H_A)

Measurement of variables

Dependent variable (Y): It is defined as adoption of the package (that is more than four of the technology). This is measured as a probability between (0 and 1). The probability that a farmer adopt (use more than four of the technology) =1 and the probability that a farmer does not adopt (use less than four of the technology) =0.

Independent variables:

Age of Farmer: This variable was measured in years. It is utilized widely as informative variable in numerous studies of adoption, however its effect is unclear and relies upon numerous components. Older agriculturists have collected enough capital and more probable to invest in innovation (Baffoe-Asare et al. 2013). Seniority increases with conservativeness and contrarily affect adoption while youthful agriculturists have a tendency to be more inventive and hazard antagonistic (Baffoe-Asare et al. 2013; Zhang et al. 2012, Adejumo et al. 2014).

Experience is a measure of the number of years a farmer has spent in the farming business. Experience improves abilities and encourages the ability to address specialized or practical issues identified with agronomic standards on the field. Experienced farmers adopt more technologies which tend to enhance production (Idrisa et al., 2012)

Gender is a dummy variable for sex measured as 1 for male and 0 for female. It is utilized as a part of the model to indicate sex of cocoa farmers. Male cocoa agriculturists are frequently more asset enriched than females. Male agriculturist is relied upon to embrace more innovation frequently and at a higher intensity than female agriculturists. Females are more defenceless against innovation presentation (Goldner et al. 2010) which could prompt a diminished adoption of innovation among female agriculturist.

Education is estimated as the number of years the cocoa farmer has spent in formal education. Education also enhances the farmer's skill and encourages the ability to address specialized and handy issues identified with agronomic standards on the field. With expanding instruction, farmer might have the capacity to settle on basic choice concerning selection of new innovation. Hence, education is expected to be positively related to adoption (Enete & Igbokwe, 2009; Caleb & Alhassan, 2013).

Origin is a dummy variable for residential status of farmers which was measured as 1 for indigene and 0 for migrant. Access to storage facility is a dummy variable which was measured as 1 for access and 0 for no access. It is utilized as a part of the model to indicate availability of storage facility in the community for the farmers. FBO is a dummy variable for membership of a farmer based organization which was measured as 1 for member and 0 for non member.

Total on-farm income is measured as the total income from cocoa farm in a year in cedis. It is noticed that cocoa pay positively affects farmers selection of new innovation (Taneja, Pal, Joshi, Aggarwal, & Tyagi, 2014; Zakaria, Abujaja, Adam, Nabila, & Mohammed, 2014). Total off-farm income measured as the total off-farm income in a year in cedis. It is noted that total off-farm income will have negative effect on adoption of technology by a farmer if his/her off-farm income increases.

Institutional support was measured as a dummy variable measured as 1 for receiving support and 0 for not receiving support. The support can be in the form of attending cocoa innovation training which will enhance the understanding of the farmer on the innovation. It expands the level of competency of agriculturist which will help reception of innovation. It is additionally anticipated that receiving institutional support on innovation may persuade the agriculturist to embrace the innovation.

Extension contact was a dummy variable for whether a farmer had extension contact for the last year which was measured as 1 for receiving extension services from agricultural extension agents and 0 for not receiving extension contact for the past 10 years. Extension agent would give the agriculturist essential data about the accessibility of required assets, market and costs and the gainfulness status of the new innovation to clear any questions and vulnerabilities concerning it to expand the likelihood of its adoption. It is therefore hypothesis that entrance to extension contacts would positively affect selection of innovation.

The adaptive capacity score (AC) for each farmer is obtain as follows:

Financial Capital is a measure of the ability of a farmer to obtain long term capital (> 12 month); farmer able to obtain large credit (> ₵3000 per annum); receives financial assistance/subsidy from government/NGO/DP; remittance received; have savings with a financial institution; accessed formal credit in last 3 years and accessed informal credit in last 3 years. Questions were asked on the attributes raised in table 3.4 to calculate each cocoa farmer's financial capital. Financial capital expands the capacity of a person to purchase and use productivity enhancing technology or shift from an old technology to a new one and also getting data about current technology and its benefit from other members. It likewise builds singular agriculturist's mindfulness and accordingly improves the probability for adoption of new innovation. If a farmer answers yes to any of the questions asked, the farmer is scored 1 and 0 for no.

Physical Capital is a measure of type of land ownership, cocoa farm size , access to formal storage facility, access to portable water, access to health facility, access to good road from farm to market, access to the productivity improving strategies, percentage of adults in the household and source of irrigation. Questions were asked on issue raised in table 3.4 to compute their physical capital. If a farmer answers yes to any of the questions asked, the farmer is scored 1 and 0 for no.

Human Capital is a measure of farming for more than 10 years or more, literacy (receive 10 years of education or more), received formal on the job training and household member working outside the community. Questions were asked on attributes in table 3.4 to compute each cocoa farmer's human capital.

Natural Capital is a measure of the access to land resources, access to water resources and access to forest resources. Table 3.4 shows the attributes based on which questions were asked to compute each cocoa farmer's natural capital. If a farmer answers yes to any of the questions asked, the farmer is scored 1 and 0 for no.

Social capital is a measure of participation in group activities, social trust, social network and receiving social support. Social capital expands the capacity of a person to get data about current technology and its advantages from different individuals. It additionally builds singular farmer's mindfulness and thus improves the probability for adoption of new innovation (Nato, Shauri, & Kadere, 2016). If a farmer answers yes to any of these attribute, the farmer is scored 1 and 0 for no.

3.4.4. Estimating the extent to which adoption of productivity-improving strategies (PIS) impact the livelihoods of cocoa farmers

The effects of adoption of PIS on the livelihood of farmers were determined using semi-structured questionnaire containing open-ended questions. Questions were asked to get information on the effect of PIS on yield of cocoa and income which are components of farmer's livelihood. These questions were asked to get the effects of adoption of PIS on the livelihoods of cocoa farmers. Livelihood in this study comprises of cocoa yield and total income.

Following from (Ding et al. 2010**;** Hailu et al. 2014) Ordinary Least Square (OLS) Regression was employed. The OLS regression model was considered as impact measurement tool. Furthermore, with the classical linear model, OLS estimators are with unbiased estimators with minimum variance. (Gujarati, 2006).

$$Y = \beta_0 + \beta_i X_i + u_i \qquad (\ i = 1,2, \dots \dots \dots \dots \dots, N) \qquad 3.9$$

Where: Y is the dependent variable (yield and income), Xi is a vector of explanatory variables, βi is a vector of estimated coefficient of the explanatory variables and ui indicates disturbance term which is assumed to satisfy all OLS assumptions (Gujarati, 2006).

Model specification for yield

The empirical model relating the effect of adoption of PIS on the income of cocoa is specified as:

$$Y = \beta_0 + \beta_1 Age + \beta_2 Gender + \beta_3 Edu + \beta_4 IS + \beta_5 Exp + \beta_6 PIS + \beta_7 ASF + \beta_8 FBO + \beta_9 AC + u_i \quad 3.10$$

Where:

Y = Total income (livelihood)

Statement of Hypotheses

H_0: The adoption of PIS has no effect on the income of cocoa farmers.

H_A: The adoption of PIS has positive effect on the income of cocoa farmers.

Validation of hypothesis:

Equation 3.7 was used to establish the significance of the estimated coefficients.

Decision rule: if $z\ cal \geq z\ crit$, the null hypothesis (Ho) would be rejected in favour of the alternative hypothesis (H_A)

3.5. Method of Data Collection

3.5.1 The study area of the thesis

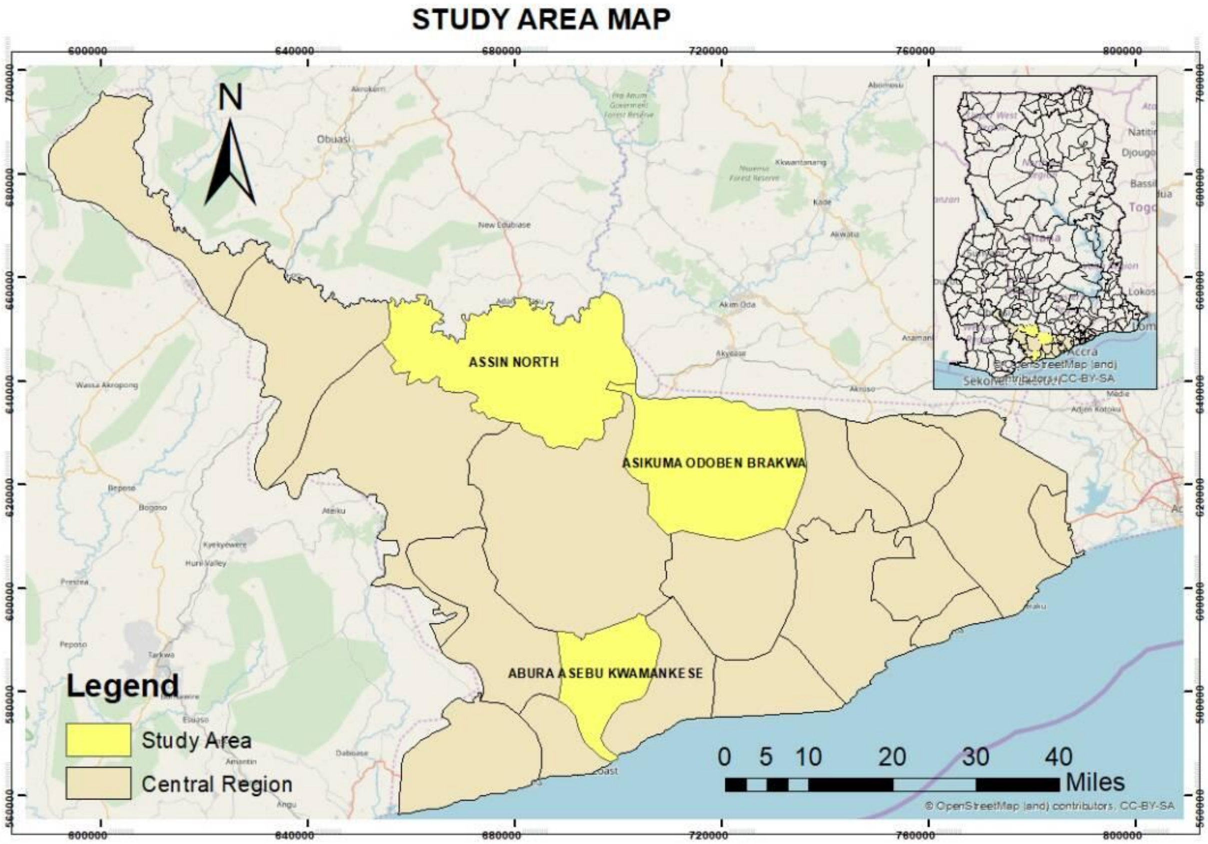
The Central Region was purposively selected because of the poverty status, cocoa being a key livelihood activity and the region not exempted from climatic changes (Abu, 2011; Owusu-Sekyere et al., 2011; Akaba & Akuamoah, 2018). The region is not exempted from the current climate change which invariably affect cocoa crop yield.

The Central Region was purposively selected because it is the third largest cocoa growing region in the season 2015/2016 (Appendix 3 for time series data). Cocoa production in the region was classified into three groups: high producing (≥ 451 kg/ha), medium producing (≥391 kg/ha ≤ 450) and low producing (≤ 390 kg/ha). The classification was done together with the officials of COCOBOD. Three (3) cocoa districts were then selected randomly; one from each group, then five (5) communities each from the three (3) districts was selected randomly for the data collection.

Geographically, the Central Region is surrounded on the south by the Atlantic Ocean, Northwest by Ashanti Region, Southeast by Greater Accra and Western Region on the West. It has a population of about 2,201,863 people with about 1,163,985 being in the rural area with 526,764 as the total number of household. Farming and fishing are the main occupation with few of them engaged in industrial and commercial activities. With 182,211 females engaged in agriculture and 196,330 Males (GSS, 2012).

The study was conducted in three Districts namely Assin North municipal (Betwease, Dompem, Fosu, Juaso and Senkyem), Asikuma / Odoben / Brakwa (Asikuma, Baako, Benin, Kuntanase and Odoben) and Abura/Asebu/Kwamankese (Abakrampa, Abura Dunkwa, Asuansi, Egotsia Kokodo and Nyamedom).

The area experiences two Climatic Seasons in the year as in the case of southern Ghana, namely the wet and dry seasons. The wet season usually extends from the middle of March to early November with a peak in October. The period between November and March is relatively dry when the area is subjected to the north-east trade winds locally referred to as Harmattan.



Source: Centre for Remote Sensing and Geographic Information Services (CERSGIS)

Figure 3.1: Map of study area

3.5.2 Sampling procedure and sample size determination

The sampling procedure

Multi stage sampling techniques was used. The first stage was purposively selecting the Region. The second stage was randomly selecting one district from the categorization of cocoa production in the area. That is one district from high producers (Assin North), one from medium producers (Asikuma/Odoben/Brakwa) and one from low producers (Abura Asebu Kwamankese). The third stage was randomly selecting five communities from each of the selected districts. The next stage was randomly selecting 150 cocoa farmers (owners) from each district. Eight local institutions were also purposively selected. Broadly, all the smallholder cocoa farmers face the same climatic conditions; have common livelihood assets, market and soil conditions as well as similar capacity. They also have similar socioeconomic characteristics. Therefore, this sampling approach provided the farmers equal likelihood of being selected to be part of the study.

Sample size determination

The sample size was determined by assuming that the total number of cocoa farmers in the districts was unknown. The sample size was then determined by using the following formula (Dohoo, Martin & Stryhn, 2003; Thrusfield, 2007);

$$n = \frac{pqZ^2}{E^2} \qquad 3.14$$

Where; n = Sample size; Z= confidence level (α=0.05); p = sample frame q = 1-p; E= error allowed. Since the proportion of the population is not known, p= 0.5, q= 1-0.5=0.5, Z= 1.96 and E = 0.08 (Dohoo *et al*, 2003; Thrusfield, 2007). Putting in the values:

$n = \frac{(0.5)(0.5)(1.96)}{(0.05)^2}$ n = p (0.5) (0.5) $(0.05)^2$/ $(0.05)^2$

n=384

To account for non-response, the study aimed to reach 450 cocoa farmers but returned 443 complete questionnaires. Hence, in each of the three districts 150 farmers were targeted and a total of 450 farmers chosen (Table 3.5).

3.5.3 Source of data

In order to gather reliable and valid data, the study employed a methodological approach in which primary data was collected. Data collected from farmers and the public local institutions and private service providers in the area. The selected method for primary data collection was in the form of semi-structured and in depth interviews by using a questionnaire. It was useful in gathering suitable and dependable data appropriate to the research questions and objectives as well as provide first-hand and new information concerning the topic under study.

The survey questions were made up of both closed-ended and open-ended questions in a focus group discussion. The questions sought answers to questions such as farm-level and demographic information; cocoa farmers' adaptation strategies employed, farmers' capacity for adopting productivity improving strategies, factors affecting adoption of productivity improving strategy and institutional support farmers receive (Appendix 1). On the part of the local institutions, questions were directed at finding answers to whether institutions offered assistance or support to farmers and the kind of support they offer to farmers (Appendix 2).

Questionnaires were administered to farmers on their farms and in their homes. In cases where farmers could not read or write, the questionnaire was administered in the form of a structured interview. Institutional interviews were conducted with representatives of the selected institutions either during break times on their official timetable or at an appointed time pre-arranged with them. To save time in writing, the permission of participants were sought to enable recording of the interview.

Table 3.2: Distribution of sample by community

District	Community	Sample frequency
Assin north municipal	Betwease	30
	Dompem	30
	Fosu	30
	Juaso	30
	Senkyem	30
Asikuma / Odoben / Brakwa	Asikuma	30
	Baako	30
	Benin	30
	Kuntanase	30
	Odoben	30
Abura/Asebu/Kwamankese	Abakrampa	30
	Abura Dunkwa	30
	Asuansi	30
	Egotsia Kokodo	30
	Nyamedom	23
TOTAL	15	443

Source: Survey data (2017)

3.5.4 Software applications used for data analysis

The Statistical Package of Social Science (SPSS) Version 20 software was used for data entry, cleaning and descriptive statistics. Excel software was used for drawing graphs/charts and for the descriptive statistics. Tables, graphs and charts were used to present the analysed data for easy discussion and interpretation of the results. STATA 16 software was used for the estimation of the Logit and Tobit models.

3.6 Scope and Limitation of the Study

A couple of restrictions could be identified with this study. The study was on the adaptation strategies employed by farmers in the face of climate change and their adaptive capacity. The study was not on the effect of climate change but rather on the effect of adoption of productivity improving strategies on the livelihood of farmers. For this reason the study did not make use of time series data of climate change and also did not use climate change as a variable in the analysis. Getting farmers during the on-farm season was difficult as farmers were busy and were not ready to listen to or administer the questionnaire. The research therefore took the strategy of meeting farmers very early in the morning before they left for their farms or late afternoon when they return home. Some of the respondents approached were fatigued from being called upon to fill out questionnaires or forms as they put it without seeing any significant difference in their lives and some therefore asked to be paid before they gave information or in some cases gave outright refusal to answer the questionnaire.

Lastly, record keeping was also a problem since most of the farmers interviewed do not keep farm records. They only try to recollect information from their memories, and the assumption that they remembered and gave accurate information is not entirely true.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the results obtained from the study. The first section is a description of socio-economic characteristics of farmers surveyed. The next is a presentation and discussion on adaptation strategies known and employed by the farmers and adaptive capacity levels. The estimates of magnitudes in the factors influencing adoption of PIS is then discussed in the next section. Finally, the results on the estimates of the extent to which adoption of productivity-improving strategies (PIS) change the livelihoods of cocoa farmers is presented and discussed.

4.2. Background of Respondents

The background of respondents describes the socio-economic features of the cocoa farmers interviewed. The personal characteristics include age, gender, education and marital status. Household characteristics include status of respondent as head, household size, origin and ethnicity. The farm characteristics include farm experience, farm size and ownership and age of trees. Other characteristics obtained from focus group discussions included type of farming system practiced by majority, source of farm inputs and information and availability of socio-economic facilities such as financial institutions, cocoa licensed buying companies and food stuff market.

4.2.1 Personal characteristics

The ages of the respondents ranged from 35years to 86 years (Table 4.1). 35 years was the minimum age; the maximum was 86 years and the mean age of 56.54 years. That is, the cocoa business is dominated by farmers between the ages of 36-85 (85%) with only fifteen percent (15%) of the farmers that could be classified as youth according to the Ghana youth policy. The result revealed that majority of the respondents are old and there is low involvement of the youths in cocoa farming, consequently there is need to encourage youth involvement in cocoa production. This implies that cocoa farmers are getting older and replacement by younger ones is needed. The presence of older farmers on the farm will negatively impact on labour availability (Ladele, 1998). The youth that were found to be in the cocoa business said they joined their parent to the farm and they realised it was a good business so they started their own farm after their secondary education when their parent were not able to further their education and they have been in it for more than twelve years. The finding is consistent with the work of Nmadu et al. (2015).

Most 59% of the respondents in the area were males while 41% of them were females (Table 4.1). This shows that men are dominate in cocoa production than the female, though the female farmers have their own roles to play, especially, in the maintenance and processing of cocoa beans as indicated by Adetunji *et al*. (2007). The result is supported by the work of Nmadu et al. (2015).

The educational background ranged from no education to tertiary education. Majority (70%) of the respondents had obtained formal education (Table 4.1). One hundred and thirty-three (30%) of the respondents either had no education or had not been to school, one hundred and seventy (38%) of the respondents had primary education, twenty-one percent (21%) of the respondents had middle school/junior secondary education, nine percent (9%) of the respondents had attained the senior secondary/vocational/technical level of education and two percent (2%) had tertiary education. This means that education level is low and is consistent with the findings of Aneani et al. (2012) and Anang et al. (2013).

The marital status of the respondents was grouped into two, which were married and single (Table 4.1). The single comprises widowed, not married and divorced. Out of these two groups, eighty-one percent (81%) said they were married and nineteen percent (19%) said they were single. The large percentage of married farmers implies that more members of the family are likely going to be available for cocoa production in the area. Farm labour force used to be restricted to family population and the size of active family members. The finding of the work is in line with the work of Nmadu et al. (2015).

Table 4.1 shows that the farmers have a mean household size of approximately 5 people. Since majority (52%) of respondents have household size of 5-8 people, it therefore means that the farmers have a fairly large household which could probably serve as an insurance against short falls in supply of farm labour. Household size has a great role to play in family labour provision in the agricultural sector (Sule *et al.*, 2002). This is consistent with the work of Nmadu et al. (2015).

Majority (71%) of the respondents said they were the heads of the household and the remaining thirty-nine percent (39%) of respondents said they were not the household heads. The household size of the respondents ranged from 1-7 (Table 4.1). The highest household size was 5-6 (42%), followed by 3-4 (38%). The minimum household size was one (1), a maximum of seven (7) and a mean of 5.11 (approximately 5). This implies that farmers have available labour within their household and this will influence adoption of new technology. This finding is supported by the work of Nmadu et al (2015).

The results on the origin of respondents showed that majority (74%) were indigenes (natives) of the area. This is confirmed by the distribution of ethnic groups (Table 4.1). Majority (88%) of the respondents belonged to the Akan ethnic group, which originate from the Southern part of Ghana (Central, Eastern, Western, Ashanti and Brong-Ahofo regions). The Northern ethnic groups were the Kotokoli, Moshie and Sisala (5%). There were other Southern ethnic groups such as the Ewes (4%) and the Ga-Adangbes (3%). Most of the non indigenes in the study area were working for the indigenes. This finding is supported by the work of Carr (2005) in Guatemala.

In the study only farmers who had practiced cocoa farming for 10 years or more were interviewed. This shows that farmers interviewed had knowledge and experience of climate change. Majority (93%) were within the 10-40 year bracket and few (7%) were above 40 years (Table 4.1). The mean farming experience was approximately about 23 years. These findings imply that the respondents have had long period of farming experience.

Majority 60.8% of the respondents as shows in Table 4.1 cultivate farm lands of more than 2 hectares and 31% cultivate 1 to 2 hectares of land, with farm size per household averaged 5.3 hectares of cultivated land.

Other farm and community characteristics

From researcher observations and focus group discussions following conclusions were made: The major type of farming system was the conventional type that used hybrid seed, inorganic fertilizers, and chemical pesticides for weed, insect and disease control as well as for storage of grains. Fertilizer use is being promoted among farms with old cocoa trees. The major source of farm inputs (including tools, machinery, seed and chemicals) was from the district capital, where input dealers' shops are located. Most of the dealers are licensed to sell agro-chemicals by the Environmental Protection Agency. Farm information, agronomic, and marketing, are usually obtained from friends, public agricultural extension service officers or the audio and visual media. The communities have access roads, some linked to trunk road and majority unpaved. There are food stuff markets that are organised in specific days in each community. Most of the communities access district level commercial banks, Rural Banks, Savings and Loans companies and microfinance schemes. In each community there are at least three cocoa licensed buying company (LBC) agents who operate depots to stock purchased cocoa beans from farmers. Most farmers travel less than one kilometre to access an LBC. The result is consistent with the work of Egyir et al. (2015)

Table 4.1: Demographic and socio-economic characteristics of farmers

	Frequency	Percentage	Minimum	Maximum	Mean	Std. Dev.
Age of respondent			35	86	56.5	12.0
≤ 35 (Youth)	68	15				
> 35 (Adult)	375	85				
Gender of respondent						
Male	262	59				
Female	181	41				
Formal Education	311	70				
No education	132	29				
Origin of respondent						
Native of the area	328	74				
Migrant	115	26				
Marital status						
Married	359	81				
Single	84	19				
Household size			4	7	5.2	0.6
1-4	211	48				
5-8	222	52				
Farming experience			10	45	23.2	10.5
10-30 years	322	73				
31-50	121	27				
Farm size			1	10	5.3	3.0
≤ 2 hectares	139	31				
> 2 hectares	304	69				
Ethnic groups						
Akan	390	88				
Ewe	18	4				
Ga-Adangbe	13	3				
Other	22	5				

4.2.4 Institutional characteristics

The institutions surveyed included private and public institutions in the area. Majority (81.8%) were in the age bracket of 46-60 (Figure 4.1). This shows that the respondent were good for the studies. None of the respondents was below 40 years.

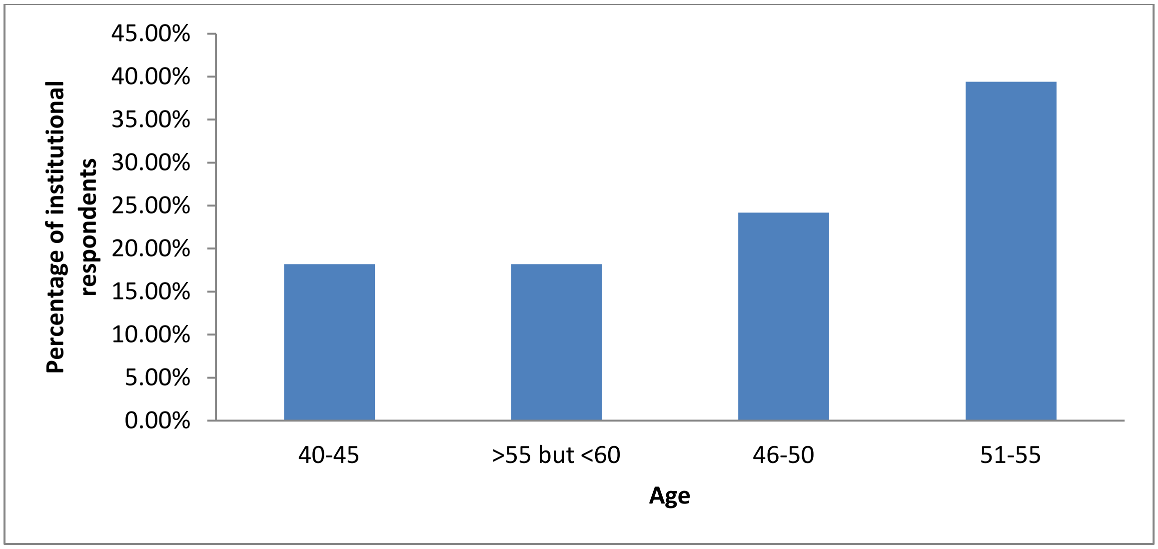


Figure 4.1: Age of institutional respondents
Source: Survey data (2017)

In Table 4.2 shown the numbers of year's respondents have spent in the institution. None of the respondents had spent less than 10 years in the institution. Majority (72.8%) had spent more than 15 years in the institution. This shows that the respondents selected for the work have adequate experience in the institution.

Table 4.2 Number of years spent in institution by institutional respondent

Age of respondents	Frequency	Percent
10-15	9	27.3
16-20	11	33.3
21-30	13	39.4

Source: Survey data (2017)

The institutions surveyed were made up of both public and private. Seventy-three percent (73%) of the institutions were from the public sector and twenty-seven percent (27%) from the private sector (Figure 4.2). The study area is dominated with public institutions.

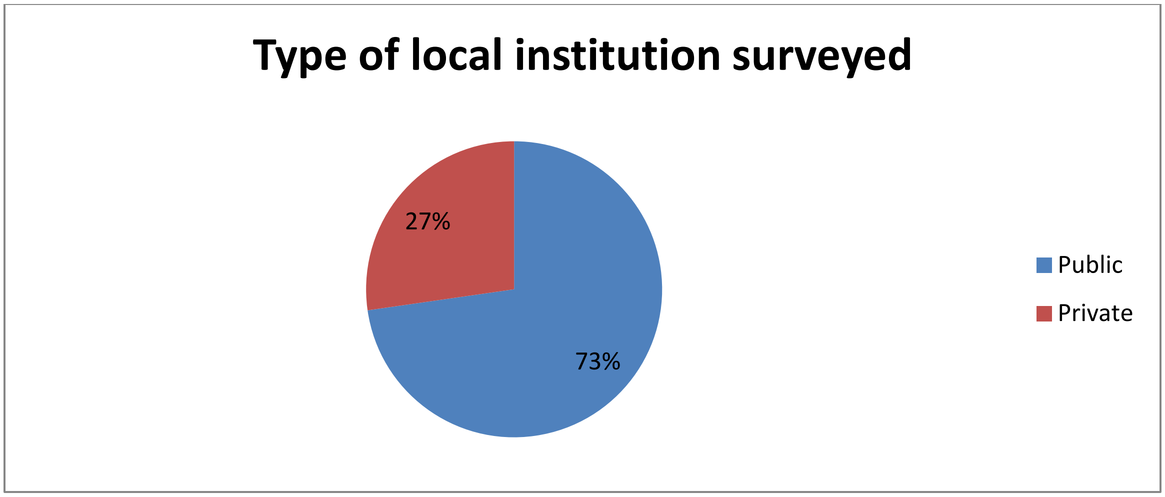


Figure 4.2: Types of local institutions surveyed

Source: Survey data (2017)

4.2.5 Farmers' awareness of changes in climate

Farmers' awareness on climatic conditions are often based on observations from past and recent climatic events, which influence their decisions on adaptive behaviour (Ndamani & Watanabe, 2015; Ehiakpor *et al.*, 2016). The main climatic variables (Rainfall, Temperature and Sunshine, drought and humidity) used as indicators for this study. From Table 4., all the farmers agreed to an increase in temperature, with 85% indicating that the is above the last decade and 15% indicating that the increase is not above the last decade. Farmers also agreed that there has been changes in rainfall in the area. 40% of the farmers indicated that rain has increased and 60% of them indicating decrease in rain. Again there also agreed that there has been changes in the onset of rain, with 97% indicating late onset of rain and 13% indication early onset of rain. In addition, the majority (84%) of the farmers said drought has increased, 11% of said drought has decreased and 5% said drought is moderate.

Table 4.3 Farmers awareness of climate change

	Temperature	Rain	Wind	Humidity	Drought
Increase	443 (100%)	179 (40%)			373 (84%)
Decrease	0 (0%)	264 (60%)			48 (11%)
Late on-set		429 (97%)			
Early on-set		14 (3%)			
Increased above last decade	377 (85%)				
Decreased below last decade	66 (15%)				
High/strong			62 (14%)	19 (4%)	
Moderate			19 (4%)	67 (15%)	22 (5%)
Low			346 (78%)	13 (3%)	

Source: Survey data (2017)

Determining whether socio-demographic characteristics relates to farmers notice of climate change

The majority of the farmers had realized climate change in the last decades. To understand this phenomenon, cross-tabulation and chi-square test of independence were used to determine whether age of farmers and farming experience had some significant relationship with how long they had noticed this climate change.

There is a significant relationship between the age of farmers and how long they have realized this changes in the rainfall pattern, temperature and sunlight, wind, humidity and drought in the area (X2 = 16.85, p = 0.00) (Table 4.4). 0% of the youth had not realized the change in climatic element above 30 years. That is, how long these farmers have realized these changes in climate, vary significantly by the age of the farmer.

Table 4.4 Cross-tabulation of how long farmers have realized the change in climate against age of farmers

Variable	Realized of climate change, Frequency and percentages			
Significance = $p < 0.05$	10-20 years	21-30 years	Above 30 years	Total
Youth (≤ 35 years)	39 (57.4%)	29 (42.6%)	0 (0.0%)	68 (100%)
Adult (> 35 years)	210 (56.0%)	100 (26.7%)	65 (17.3%)	375 (100%)
Total number of farmers	249 (56.2%)	129 (29.1%)	65 (14.7%)	443 (100%)
$X^2 = 16.85$ df = 2	p = 0.00			

Source: Survey data (2017)

Again, there is a significant relationship between farmers' experience in farming and how long they have realized these changes in climatic elements such as rainfall patterns, temperature and sunlight, wind, humidity and drought in the area (X2 =215.86, p = 0.00) (Table 4.5). None (0%) of the farmers who have farmed for 10 to 30 years had realized the changes above 30 years. Most (70.5%) of farmers who have farm within 10-30 years have realized the changes in climate within 10-20 years. Also, 53.7% representing the majority of respondents who have farmed within 30-50 years happen to have realized the changes for more than 30years.

That is, how long these farmers have realized the changes in climate; vary significantly by the farmers experience in farming.

Table 4.5 Cross-tabulation of how long farmers have realized the change in climate against experience of farmers

Variable	Realized of climate change, Frequency and percentages			
Significance = $p < 0.05$	10-20 years	21-30 years	Above 30 years	Total
10-30 years	227 (70.5%)	95 (29.5%)	0 (0.0%)	68 (100%)
31-50 years	22 (18.2%)	34 (28.1%)	65 (53.7%)	375 (100%)
Total number of farmers	249 (56.2%)	129 (29.1%)	65 (14.7%)	443 (100%)
$X^2 = 215.86$ df = 2 p = 0.00				

Source: Survey data (2017)

4.3. Climate Change Adaptation Strategies of Cocoa farmers in the Central Region

4.3.1. On-farm adaptation strategies known to and employed by cocoa farmers in the study area

Smallholder farmers would employ different collections of adaptation strategies in the face of a changing climate to preserve their livelihoods (Ellis, 1998 and DFID, 1999). The strategies were categories as on-farm and off-farm.

Although majority (87%) of the cocoa farmers were aware of various on-farm adaptation strategies, sixty-one percent (61%) of the farmers employed some on-farm adaptation strategies (Figure 4.3). Of the entire on-farm adaptation strategies known to the smallholder cocoa farmers in the area, fifty-nine percent (59%) of the cocoa farmers know that irrigation is an adaptation strategy in cocoa production but thirty-three percent (33%) employed it. They said that, they need to water/irrigate their seedlings so that it does not die out.

Eighty-seven percent (87%) of the cocoa farmers know that intercropping with trees and other crops is an adaptation strategy and seventy-one percent (71%) employed it. Those that employ this strategy said that they do this so that the trees would provide shades for the cocoa plant and also serve as windbreaks to prevent the wind from uprooting and destroying the cocoa tree especially when the cocoa tree is flowering in times of strong wind. Those who do not intercrop with trees rather intercrop with plantain. Their reason is that, they will rather intercrop with plantain which will serve as a source of food to them than intercropping with trees which will serve as breeding grounds for pest and diseases. Those that did not employ it said that, they stopped employing this strategy because they use hybrid seed which require full sun. Again, they obtained higher yields with hybrid in full sun than in the shade.

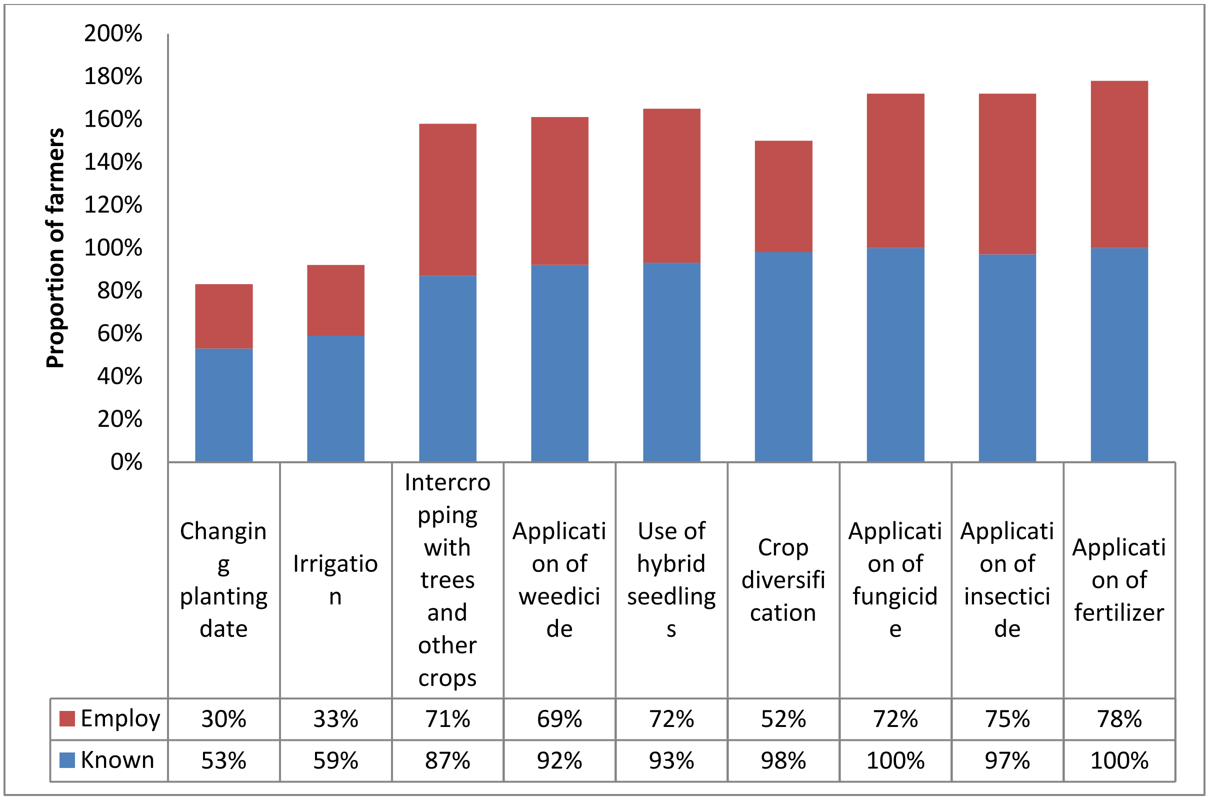


Figure 4.3: On-farm adaptation strategies known and employed by farmers
Source: Survey data (2017)

They added that there is high infestation of fungal disease due to the shaded trees. "Trees and branches can also fall on us" was one of their reasons for not employing it. Most of those who did not employ intercropping with trees are the young farmers.. This result confirms the work done by Ruf (2011), on the The Myth of Complex Cocoa Agro forests: The Case of Ghana. This result is in contrast with the work done by Oluwatusin (2014), he found out that 73% of the cocoa farmers in the study area employed shading technique as a strategy. However, Denkyirah et al. (2017), noted 36% cocoa farmers employed planting trees for shade and this confirms the findings of this study as well. This was so because, the farmers in the area were rather using improved variety and disease tolerant seed and seedlings but not hybrid varieties that the yield will only increase under direct sunlight over a short period. These varieties do well in humid environment.

Fifty-three percent (53%) of the cocoa farmers know that changing planting date is an adaptation strategy but only few (30%) of the farmers employed it. Their reason is that they do not have money to buy improved variety or fertilizer or pesticide so they rather delay their planting date to favour them. Ninety-three percent (93%) of the cocoa farmers know that the use of hybrid seedlings is an adaptation strategy and most (72%) of the farmers employed it. Their reason was that they need to survive so they would rather go in for a hybrid that can withstand the changes in climate and also increase their produce, so that they earn more income. The study revealed that only 77% farmers used improved hybrid cocoa as an adaptation strategy. This shows that there is the need for education on the benefit of using hybrid. The result is supported by Oluwatusin (2014), who found out that 59% of farmers use hybrid cocoa seedlings as an adaptation strategy. Also, Boon and Ahenkan (2012) also had similar results in their study.

All the cocoa farmers know that application of fungicide is an adaptation strategy. Fungicides such as ridomil, nordox, champion, kocide and funguran were the fungicides used by the farmers. Seventy-two percent (72%) of the farmers employed it. They said they need to apply fungicide due to the increasing infestation of fungus. This result also confirms that of Danquah, Kowornu & Baffoe-Asare (2015).

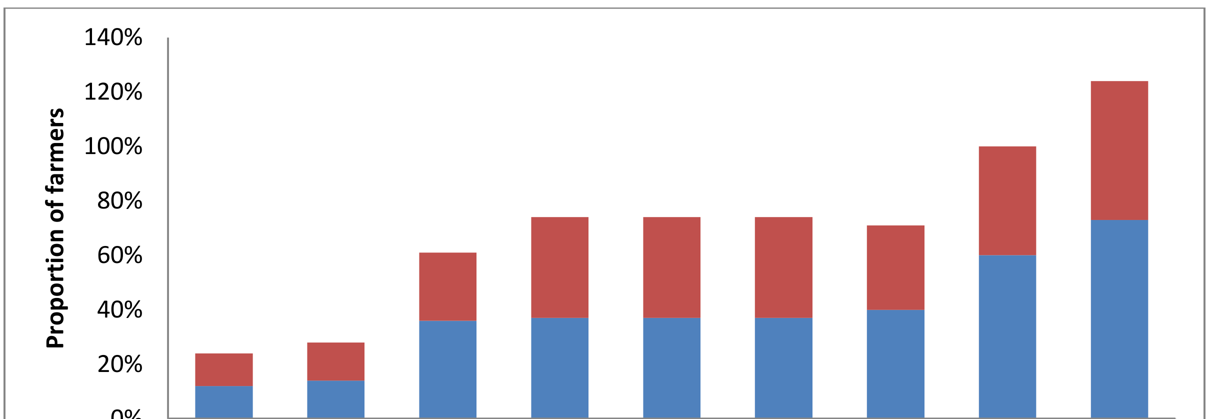
Ninety-seven percent (97%) of the farmers know that application of insecticide is an adaptation strategy. Akatemaster, actara and confidor were the insecticides that were employed by the farmers. Seventy-five percent (75%) of the farmers employed this. Their reason for the application of insecticide was there was high rate of insect infestation due to the change in climate. They apply this so that they can sustain their produce. Danquah et al.

(2015), had similar result in their work. All the cocoa farmers know that application of fertilizer is an adaptation strategy. Assasewura, sidalco, cocoafeed were the fertilizer they apply. Seventy-eight percent (78%) of the farmers employed this as an adaptation strategy against climate change. They argue that, they apply fertilizer to increase production so that they can get more from the investment they have made. Ninety-two percent (92%) of the respondents know that the application of weedicides is an adaptation strategy but seventy-nine percent (79%) of them employed it. They apply these weedicides so that that the weeds does not take their farms and compete with the cocoa the nutrients in the soil.

Ninety-eight percent (98%) of the farmers said they know crop diversification as an adaptation strategy. Fifty-two percent (52%) the farmers employed it. Their reason was that, the weather has been unpredictable of late so they have to change from the planting of cocoa to different crops such as plantain and cassava and that they are farmers with families so they needed to cultivate other crops to take care of their families. The finding here support that of Denkyirah et al. (2017), they found out that 64% of cocoa farmers employed crop diversification as strategy. The findings of this research is in line with the work done by some authors who asserted that during severe climate change activity such as rainfall, temperature, droughts and wind, farmers employ on-farm strategies such as the use of hybrid seedlings, changing planting date as well as application of fertilizer to preserve their livelihoods. These authors are FAO (2011) and Gecho *et al.* (2014).

4.3.2. Off-farm adaptation strategies known to and employed by cocoa farmers in the study area

Few (38%) of the farmers were aware of various off-farm adaptation strategies, thirty-two percent (32%) of the farmers employed some off-farm adaptation strategies. In Figure 4.4 shown off-farm adaptation strategies known and employed by cocoa farmers in the study area. Thirty-seven percent (37%) of the farmers said they know that working on other people's farm as a strategy and all (37%) of them employed it. They said they do this work when the climate is bad as labourers to get some supplementary income. The finding is supported by Paavola (2008)



	Teaching at secondary school	Masonry and carpentry	Petty trade	Processing of agricultural produce	Sale of agricultural produce from other peoples farm	Wage labour from other peoples farm	Income from investment	Migration	Remittance received
Employ	12%	14%	25%	37%	37%	37%	31%	40%	51%
Known	12%	14%	36%	37%	37%	37%	40%	60%	73%

Figure 4.4: Off-farm adaptation strategies employed by farmers.
Source: Survey data (2017)

Again thirty-seven percent (37%) of the farmers know that processing of agricultural produce from other peoples farm and sale of agricultural produce from other peoples farm as an adaptation strategy and all (37%) the farmers employed these strategy. Their reason was that in the processing area, they make money which helps them to carter for their families and also uses some to buy some farm inputs. They said this business is not affected by rain, temperature, drought or wind. This result is supported by the work of Denkyirah et al. (2017).

Majority (73%) of the cocoa farmers know that remittance received is an adaptation strategy and fifty-one percent (51%) of the farmers employed the remittances they received from their relatives outside their communities as an adaptation strategy. Few (40%) of the farmers know that income from investment is an adaptation strategy and thirty-one of the farmers employed it. They have properties in the form of stores, livestock and houses which provides some source of income for them. Most (60%) of the farmers said they know that migration is an adaptation strategy but forty percent (40%) of the farmers employed it. They said they usually travel to the cities to work when the climate changes so that the money they get, they can invest it into their cocoa business. Few (36%) of the cocoa farmers know that petty trading is an adaptation strategy and only twenty-five percent (25%) of the farmers employed this as a strategy. They also said that they shift to petty trading when the climate changes. They said that they do this so that they can get extra income to take care of their families since petty trading is not affected by weather. Most of the petty traders were women; they trade in agricultural and non-agricultural produce. The result is consistent with that of Paavola (2008).

Fourteen percent (14%) of the cocoa farmers who said they know that masonry and carpentry is an adaptation strategy and all (14%) employed it. They said that, these are their profession so they go back to it when the weather is bad so that they can get money to feed their families. They were basically men. All the farmers who said they are aware that teaching is a non-farm adaptation strategy employed it. They said teaching is their profession so they use the money they get from teaching to take care of their families and also invest some in their cocoa business when the weather is not favourable. The finding confirms the study of Paavola (2008). Denkyirah et al. (2017), noted that, off-farm activities accounted for 53% of adaptation strategies employed by cocoa farmers; this confirms the findings of this thesis. Barrett *et al*. (2001) argued that household dependence on off-farm income diversification is general but not all households enjoy equal access to off-farm opportunities and the results or findings of this thesis is in line with the work of Barrett et al. (2001).

In order to achieve a sustainable flow of income over time a good number of rural farmers support their livelihoods strategies on numerous actions to adopt with dangerous actions. This means that, diversifying from an undependable agricultural income source towards a dependable non-agricultural/non-farm income resource with high income in order to improve wellbeing (Ellis *et al*. 2003). According to Ellis (2000), non-farm strategies symbolize actions other than agricultural connected undertaken by rural households with less peril and doubt, to raise income, get better wellbeing, decrease susceptibility as well as increase food security. Non-farm strategies include wage employments from non-agricultural sources such as masonry, carpentry, migration, teaching, remittances, property income, government transfers, pensions and insurance. Non-farm income accounts for thirty-five to fifty percent (35-50%) of total rural household income in developing countries (Haggblade *et al*. 2010).

4.4 Cocoa farmers' level of adaptive capacity to climate change adaptation Strategies

(I) Level of adaptation strategies of farmers

The adaptation strategies are grouped into two; on-farm and off-farm adaptation strategies. The degree of cocoa farmers' adaptive capacity to the various on-farm adaptation strategies is illustrated in Table 4.6.

The cocoa farmers were found to be highly adaptive to the application of chemical fertilizers with adaptive capacity score of 0.68. This capacity score falls within the range of high capacity ($0.67 \leq ACj \leq 1.00$).

Table 4.6: Level of adaptation strategies of farmers (on-farm) (pooled)

Adaptation strategy	Level	Capacity score
Application of fertilizer	High	0.68
Application of insecticide	Moderate	0.56
Application of fungicide	Moderate	0.55
Hybrid seed use	Moderate	0.50
Application of weedicides	Moderate	0.48
Crop diversification	Moderate	0.46
Intercropping with trees and other crop	Low	0.33
Changing planting date	Low	0.29
Irrigation	Low	0.27
Average	**Moderate**	**0.46**

Source: Survey data (2017)

The adaptation strategies with moderate adaptive capacities were application of insecticide (score of 0.56), application of fungicides (score of 0.55), use of hybrid seeds (score of 0.5), application of weedicides (score of 0.48) and crop diversification (score of 0.46). Intercropping with trees and other crops, changing planting date and irrigation were the strategies with low capacity on the part of the farmers. The Farmers need to be empowered to increase their adaptive capacity status for these adaptation strategies with both moderate and low adaptive capacity values. 0.46 was the average adaptive capacity of the respondents. This connotes that farmers in the study area are moderate adapters to on-farm climate change adaptation strategies. The finding of this thesis is in line with the works of Asante et al. (2012), Defiesta and Rapera (2014) and Mabe et al., (2014). They all found out that farmers had inadequate resources to assist them.

The degree of cocoa farmers' adaptive capacity to the different off-farm adaptation strategies is illustrated in Table 4.7.

Table 4.7: Level of adaptation strategies of farmers (off-farm) (pooled)

Adaptation strategies	Level	Adaptive capacity score
Remittance received	Moderate	0.51
Wage labour on other peoples farm	Moderate	0.41
Sale of agricultural produce from other peoples farm	Moderate	0.38
Processing of agricultural produce from other peoples farm	Low	0.30
Income from investment	Low	0.30
Petty trading	Low	0.29
Migration to the cities	Low	0.29
Masonry and carpentry	Low	0.27
Teaching in the basic and secondary schools	Low	0.26
Average	**Low**	**0.33**

Source: Survey data (2017)

The adaptation strategies with moderate adaptive capacities were remittances received and wage labour on other people's farm and sale of agricultural produce from other people's farm with adaptive capacity scores of 0.51 and 0.41 and 0.38 respectively. Cocoa farmers have low adaptive capacity to processing of agricultural produce (0.30), income from investment (0.30), petty trading (0.29), migration to cities to work (0.29), masonry and carpentry (0.27) and teaching in basic and secondary schools (0.26). Cocoa farmers have an average adaptive capacity of 0.33 for off-farm climate change adaptation strategies. This shows that cocoa farmers in the study area are low adapters to off-farm climate change adaptation strategies.

The finding of this thesis is supported by the works of Asante et al. (2012), Defiesta and Rapera (2014) and Mabe et al., (2014). They all found out that farmers had inadequate resources to assist them.

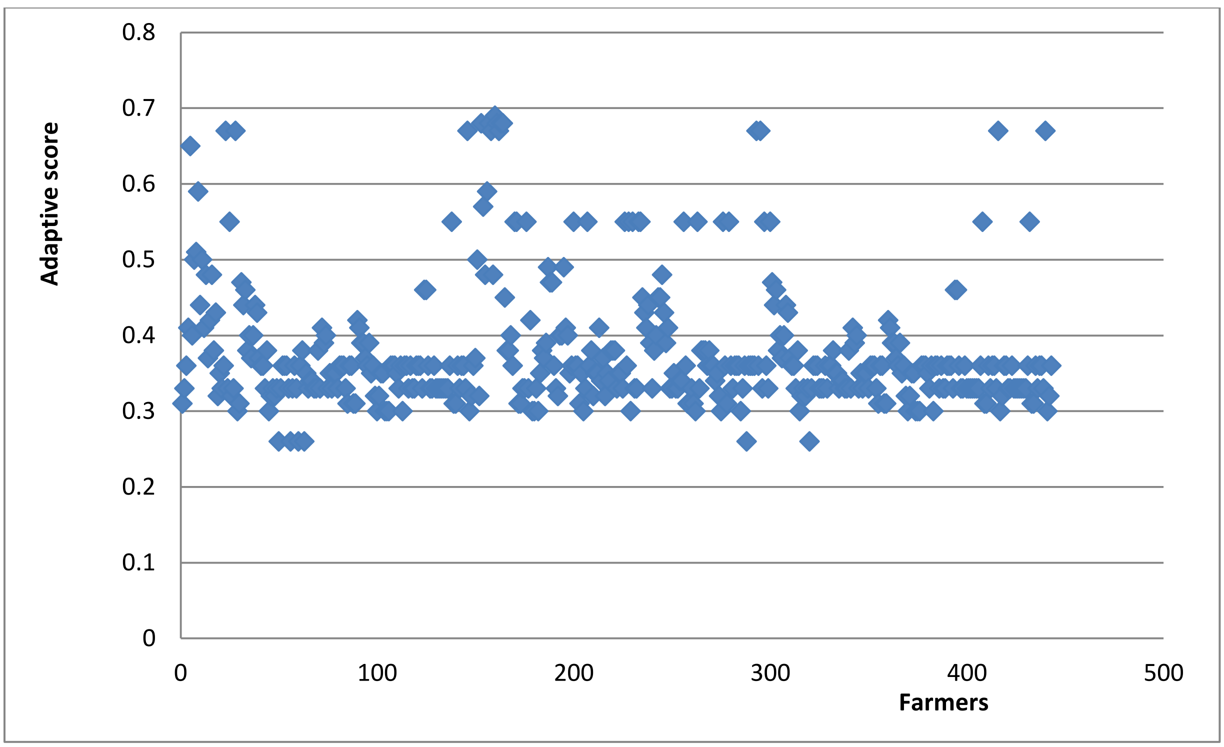


Figure 4.5: Distribution of farmers adaptation strategies.
Source: Survey data (2017)

In Figure 4.5 shown the distribution in farmer adaptation strategy. The score is concentrated between 0.3 and 0.4 with no farmer with a score above 0.7 with mean of 0.32, mode of 0.32 and minimum of 0.25 and maximum of 0.68.

(II) Level of farmers adaptive capacity based on capital assets

It is vital to identify whether farmers are able to realize their adaptive capacity into actual adoptions of productivity improving strategies.

Table 4.8 presents the percentage of cocoa farmers and their adaptive capacity based on the capital assets. Fifteen percent (15%) are high adapters based capital assets. Also, fifty percent (50%) are moderate adapters. Alternatively, thirty-five percent (35%) are low adapters. 0.46 was the average adaptive capacity of farmers. This shows that farmers are moderate adapters and also implies farmers have inadequate resources to aid them adapt highly and effectively to climate change. The finding of this study is in line with the works of Defiesta and Rapera (2014), Mabe et al. (2014) and Egyir et al. (2015). They all found out that farmers had inadequate resources to assist them.

Table 4.8: Level of adaptive capacity of farmers based on the capital assets (pooled)

Adaptive capacity	Mean adaptive capacity	Frequency	Percentage
High	0.71	67	15
Moderate	0.45	221	50
Low	0.21	155	35

Source: Survey data (2017)

Farmers with more resources will most possible be able to adapt better to climate change all other things being equal.

Figure 4.6 represents the distribution in farmer adaptive capacity based on capital assets. The score is concentrated between 0.3 and 0.4 with few farmers with a score above 0.71 with mean of 0.34, mode of 0.34, minimum of 0.27

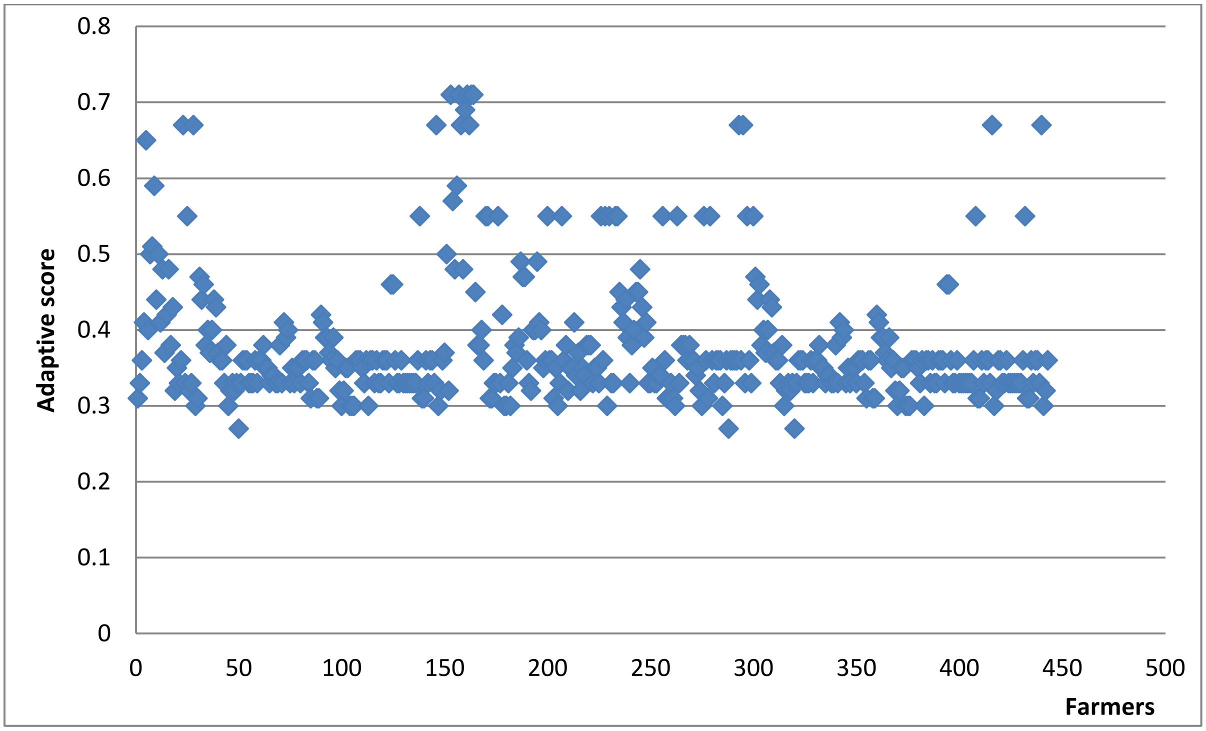


Figure 4.6: Distribution of adaptive capacity based on capital asset.
Source: Survey data (2017)

Table 4.9: Farmers' five capital asset

Capital	Minimum	Maximum	Mean	Std. Deviation
Human Capital	0.2	0.8	0.3473	0.1603
Financial Capital	0.14	0.71	0.2485	0.1433
Physical Capital	0.13	0.88	0.3571	0.1465
Social Capital	0.29	0.86	0.3569	0.1091
Natural Capital	0.25	0.75	0.4035	0.1438

Source: Survey data (2017)

Financial asset had the lowest mean (0.2485) (Table 4.9). Generally, majority of the farmers had moderate capital levels in all capitals except financial and natural capitals (Table 4.10). This means that, cocoa farmers do not have all the necessary resources (physical, social, human, financial and natural) to assist them adapt highly and effectively to climate change. The finding of this study is in line with the works of Defiesta and Rapera (2014), Mabe et al., (2014) and Egyir et al., (2015). They all found out that farmers had inadequate resources to assist them.

Table 4.10: Level of capital assets of farmers in the area

Level	Average indicator score									
	Human		Financial		Physical		Social		Natural	
	Score	Percent	Score	Percent	Score	Percent	Score	Percent	Score	Percent
Low	0.2	37.0	0.22	70.0	0.22	27.0	0.32	32.0	0.2	50.0
Moderate	0.47	50.0	0.37	25.0	0.56	47.0	0.49	48.0	0.48	37.0
High	0.70	13.0	0.68	5.0	0.88	26.0	0.84	20.0	0.8	13.0

Source: Survey data (2017)

4.4.1 The situation of the five capitals (physical, social, human, financial and natural) of farmers in the study area

Human capital:

Skills, number of working household members and quality of labour represents the human capital of a farmer (Ellis, 2000). In Table 4.11 is presented the human capital asset attributes of farmers. In terms of number of years in cocoa business, it was better since most (51%) of the respondents have spent more than 15 years in the cocoa farming business. This shows that, farmers have enough experience in cocoa farming and also enough knowledge on climate change issues and adaptation strategies.

Table.4.11: Distribution of farmers human capital attributes

Capital attribute	Frequency	Percent
A. Farming for more than 15 years		
Yes (16-40 years)	226	51
No (10-15 years)	217	49
B. Formal education		
Yes	310	70
No	133	30
C. Adults in the household		
Yes	408	92
No	35	8
D. Adults in the household working outside the community		
Yes	249	56
No	194	44
E. On the job training		
Yes	198	45
No	245	55

Source: Survey data (2017)

On the issue of formal education, majority (70%) of the farmers had some form of formal education. The educated farmers in the area were able to take advantage of some resources such as information and technologies in adapting to climate change since they have superior access to these resources.

Majority of the farmers (92%) have adults in their household. The number of adults in the household refers to the number of adults who are independent and can support the farming business. Households with more adults have superior human capital. Again, out of those who have adults in their houses, most (56%) of them work outside the community. This means that there is another source of income that the farmer can rely on in times of need for the acquisition of any form of adaptation strategy (Table 4.11). This finding supports Egyir et al., (2015), work on adaptive capacity and coping strategies in the face of climate change, they found out that human capital varies from community to community. Again, it is also in line with the work done by Defiesta and Rapera (2014) who found out that human capital various from farmers to farmer.

Financial capital

Enhanced financial status means higher aptitude to finance adaptation strategies and revival actions to climate change risks. The ability of farmers to save was high (74%) in the study area but majority of them save with informal sector and in small amounts (Table 4.12).

Due to this, they are not able to obtain adequate and long term credit from informal and formal sources. Few (5%) of the respondents in the area have been able to obtained large capital (> 3000 per annum) and long-term capital for more than two years.

On the other hand, most of the respondents received remittances from their relatives outside the communities with an average amount of ₵100 a mouth and also subsidy from government in the form of fertilizer or improved seed or pesticides . This serves as a buffer to most of the farmers when they are not able to make adequate sales out of their cocoa produce. This finding supports what Egyir et al., (2015), found out in their study, that financial capital varies.

Table 4.12: Distribution of farmers financial capital attributes

Capital attribute	Frequency	Percent
Remittances received from relatives		
Yes	223	50.4
No	220	49.6
Receives subsidy from government/NGO		
Yes	229	55
No	214	46
Savings		
Yes	328	74.0
No	115	26.0
Have savings with formal institution		
Yes	131	26
No	312	74
Accessed credit from formal financial institution in the past years		
Yes	31	7
No	412	93
Accessed credit from informal financial institution in the past years		
Yes	93	21
No	350	79
Obtained large capital (>3000)		
Yes	22	5
No	421	95
Obtained long-term capital (> 2 years payment terms)		
Yes	22	5
No	421	95

Source: Survey data (2017)

Physical capital:

In general, more farmers in study area had easy access to socio-economic infrastructure. However, with respect to land for farming, most (71%) farmers in the study area are using own land whiles few (29%) farmers use rented and family lands and .

Majority (69%) of the farmers farm on lands that are more than 2 hectares. This influence their cocoa production positive. Again, quite a number of farmers had access to health facility (55%) and this enhance their productivity since farmers do not have to travel longer distance to access health care. Access to technology was good since most of the farmers (78%) had access to technology and this influence their productivity (Table 4.13).

Majority of the farmers (75%) had adequate number of farm implements to help them adopt some technologies to mitigate climate change effects. Possession of farm implements enables farmers to utilize enhanced farming technology. This finding supports what Egyir et al., (2015), noticed in their work that, physical capital varies.

Table.4.13: Distribution of farmers physical capital attributes

Capital attribute	Frequency	Percent
Ownership of land		
Yes	315	71
No	128	29
Farm size > than 2 hectares		
Yes	306	69
No	137	31
Own farm implements/machines more than 7		
Yes	332	75
No	111	25
Access to health facility in the community		
Yes	245	55
No	198	45
Access to technology (PIS)		
Yes	346	78
No	97	22

Source: Survey data (2017)

Social capital:

Most of the farmers were members of a farmer-based organization or community-based organization and they belong to more than one group. Table 4.14 presents the social capitals of the area. They said previous groups did not succeed in the area due to lack of commitment on the part of members and leaders. The socio-economic networking of farmers was also high (70%). Few of the farmers were group leaders, this was so because most of the non-group leaders said it is time demanding when you are a group leader. Participation in community activities was moderate in the area (53%) (Table 4.14).

A vital information source to farmers especially on agronomic practices and climate comes from technical assistance (Hassan and Nhemachena, 2008). Most of the farmers (75%) get technical assistance from public institution and just a few (29%) receive technical assistance from private institutions (Table 4.11). The public technical assistance is supplied to farmers by extension workers from COCOBOD through farm visits and direct provision of farming advice, whereas those from the private institution is from Nyonkopa cocoa buying Limited. They said that the assistance they receive from the private institutions comes with high cost so they most often stay away from the private institutions. This finding supports what Egyir et al., (2015) discovered that, social capital varies from community to community.

Table.4.14: Distribution of farmers social capital attributes

Attribute	Frequency	Percent
Group involvement		
Membership of an FBO or a group		
Yes	225	51.0
No	218	49.0
Participating in group/communal activities		
Yes	335	76
No	108	24
Social trust		
Yes	347	78
No	96	22
Social network		
Yes	368	83
No	75	17
Social support		
Technical assistance from public institution in the past ten years		
Yes	335	75
No	108	25
Technical assistance from private institution in the past ten years		
Yes	130	29
No	313	71
Social status		
Non opinion leaders	87	20
Opinion leaders	356	80

Source: Survey data (2017)

Natural capital

Farmers' access to forest resource was low (59%). This was so because it is against the forest protection act (ACT 1974: NRCD 243) that any person who is found in the forest without the written consent of the competent forest authority is guilty. Table 4.15 presents the results for the natural capital attributes for the area. Those who access the forest mostly use the forest for game to enrich their food security status and also use some of the income they get from selling the game meat to buy farm inputs. Access to water resources was also low (37%), those who access water resources are mostly those from Abura/Asebu/Kwamankese. They sell the fish they catch from the sea and use the income to purchase farm input to enhance their cocoa production.

Table.4.15: Distribution of farmers natural capital attributes

Capital attribute	Frequency	Percent
Access to natural resources in the community		
a. Yes	301	68
b. No	142	32
Access to land resources in the area		
a. Yes	292	66
b. No	151	37
Access to forest resources in the area		
a. Yes	184	41
b. No	259	59
Access to water resources in the area		
a. Yes	159	37
b. No	284	64

Source: Survey data (2017)

Majority (66%) of the farmers have access to land (Table 4.12). This finding supports what Egyir et al., (2015) noticed, natural capital varies from community to community.

4.5. Estimating the magnitudes in the factors influencing adoption of productivity improving strategies (PIS)

Adoption of innovation is also influenced by adaptive capacity in terms of the five capitals or assets.

Farmers with relatively moderate adaptive capacity are able to adopt better to climate change by shifting from one adaptation method to more productivity-improving strategies. Employing different PIS enabled farmers to adapt differently with the changing climate stresses being experienced.

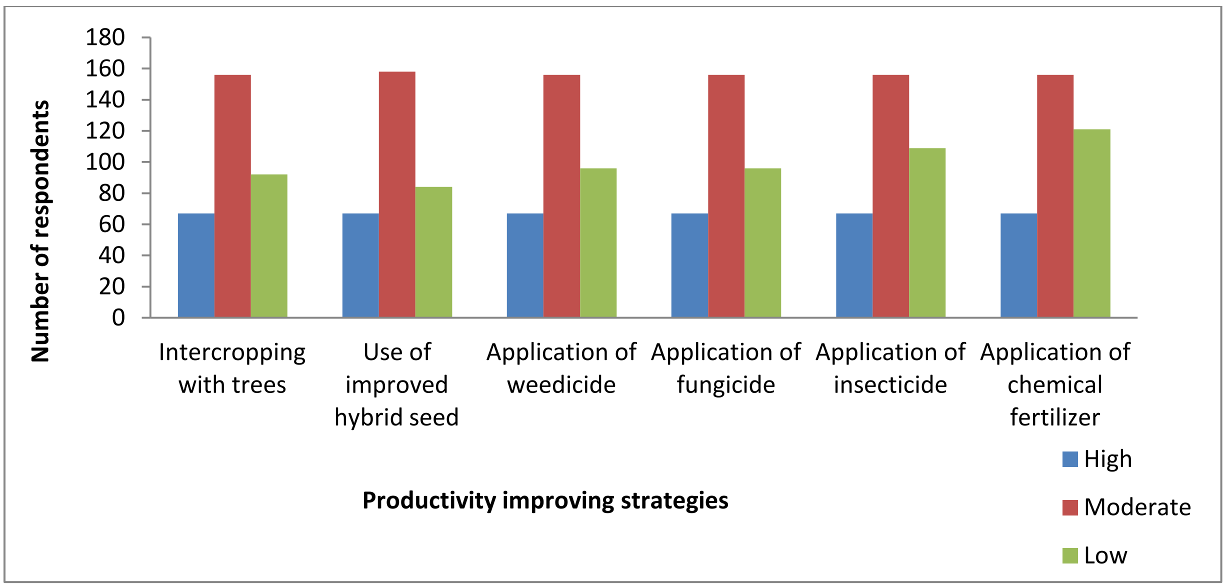


Figure 4.7 Adoption of productivity improving strategies by cocoa farmers
Source: Survey data (2017)

According to the respondents, they choose hybrid seed because these are higher yielding, have shorter period of maturity and heat/water tolerant. Their yields have increased since they started using it.

The other types of PIS are application of fertilizer, insecticide and fungicide use, weedicides and intercropping with trees and other crops. Farmers said they use these strategies because; changes in climate had resulted in declining soil fertility and high infestation of insects and fungi. Due to these reasons, farmers who employed these strategies do it to protect crops and enhance soil fertility for better crop survival amidst climate change.

Again, they elaborated that the change in climate has also helped them in the drying process. The number of days they used in drying the beans has reduced and it is a positive effect for them. They said that previously, they were fermenting and drying for more than ten days but the changes in climate had reduce the fermentation and drying days to 5-7 days. This result is supported by the works of Egyir et al. (2015) and Ghosh et al. (2015).

In general, majority (72%) of the farmers adopted the PIS whiles twenty-eight percent (28%) did not adopt PIS (Figure 4.8).

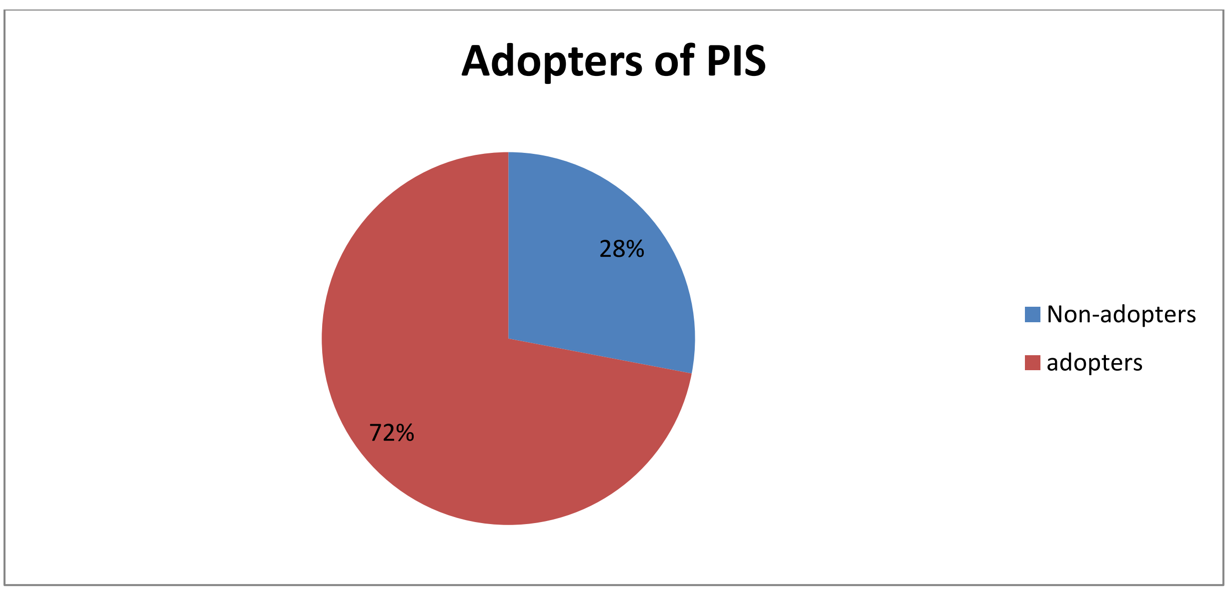


Figure 4.8 Adopters and non-adopters of productivity improving strategies

Source: Survey data (2017)

However, as the level of adaptive capacity increases, the percentage of adopters also increases (Table 4.16). All the farmers with high (100%) and majority of the farmers with moderate (88%) adaptive capacity adopt the productivity improving strategies introduced to them by COCOBOD. This shows that the higher your asset or capital, the higher the rate of adoption of technology.

Table 4.16: Adoption of productivity improving strategies by farmer adaptive capacity level

Adopt PIS	Level of adaptive capacity					
	Low		Moderate		High	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Adopt	95	48.0	157	88.0	67	100.0
Not Adopt	104	52.0	20	12.0	0	0.0
Total	199	100.0	177	100.0	67	100.0

Source: Survey data (2017)

Those who did not adopt the PIS said they have been applying the same farming strategies throughout their farming years and do not see the need for additional strategies. This was so because those strategies (PIS) require more time, skills and finance. This result shows that as the adaptive capacity of farmer's increase their adoption rate also increases.

In Table 4.17 the regression results of factors influencing the level of adoption of PIS by cocoa farmers are presented. The Wald chi^2 of 107.83 which is significant at 1% means that at least one or all the explanatory variables jointly explain the dependent variable. The Log-pseudo likelihood was also found to be significant at 1 percent level. This implies that, all the explanatory variables included in the model jointly influence farmers' decision of adoption of

PIS. The indications from the logit results were that age, gender, total on-farm income, institutional support, and adaptive capacity were all significant and influenced the adoption of productivity improving strategies. The marginal effect on age was 0.003 and significant at 10%.

Table 4.17: Logit regression results of factors that influence adoption of productivity improving strategies.

Variable	Coefficient	Probability	Marginal effect
Constant	-7.039	0.000	
Age (in years)	0.021*	0.063	0.003
Gender (Male =1)	0.685**	0.012	0.090
Edu (number of years)	0.221	0.468	0.029
Origin (Native =1)	-0.0861	0.740	-0.011
Experience (in years)	0.013	0.287	0.002
Total on-farm income (GH₵)	0.000**	0.010	0.000
Total off-farm income (GH₵)	-0.001	0.589	-0.000
Institutional Support (Yes =1)	3.993***	0.000	0.526
Access to credit (Yes =1)	0.572	0.155	0.075
AC_2 (Farmer Adaptive Capacity from Assets)	4.847***	0.000	0.638

Significant levels: * at 1%, ** at 5% and * at 10%** Source: Survey data (2017)

Number of obs	= 443	Wald chi^2 (10)	= 90.21
Prob > chi^2	= 0.0000***	Pseudo R^2	= 0.3895
Log pseudo likelihood	= -184.71709		

This implies that as the farmer grows in age by one year, there is approximately 0.3 percent probability that a farmer will adopt improved farm practices that are productivity improving. This means that older farmers were likely to adopt productivity improving strategies. This was so because they said adopting to these PIS eased their work on the field.

Gender was found to be positively related to the adoption of PIS by cocoa farmers. It was significant at 5 percent level. This result is supported by the findings of Denkyirah et al., (2016) and Akudugu et al. (2012). The marginal effect on gender was 0.090 percent. This means that males cocoa farmers will increase their adoption of PIS by 9 percent compare to a female cocoa farmer. This is so because male farmers are more risk takers than females. Female farmers will prefer to practice what they have been doing over and over again while male farmers will want to try some new farm practices. Again, men are the production decisions makers and also in charge of productive resources such as land, labour and capital which are decisive for the adoption of new innovations. This result supports the work of Akudugu et al. (2012), on adoption of modern agricultural production technologies by farm households in Ghana: what factors influence their decision.

On-farm income was statistically significant at 5% with a marginal effect of 0.000. This implies that if the on-farm income of the farmer increases by GH₵ 1.00, there is approximately 0.0% increase in adoption of PIS by the farmer. Off-farm income was statistically insignificant but had a negative relationship with adoption of productivity improving strategies. This implies that as farmer invests in other financial activities, the probability of the cocoa farmer to adopt productivity improving strategies as an option reduces. This could be explained by the fact that the farmer invests resource in the other financial activities that he is engaged in other than the productivity improving strategies (De-Graft & Onumah, 2011).

There was 0.526 marginal effect for farmers who receive institutional support at 1% significant level. This means that as a farmer receives support from an institution by one unit, there is approximately 53% probability that the farmer will adopt new technologies that will improve their production. This is so because a farmer's connection with an institution increases the farmer's knowledge and understanding of the available technology. Again, the farmer can easily access information and training facilitates on available technology which will modify the skills of the farmers which constantly improve adoption of new innovation. It also decreases the doubt about a technology's performance that a person perceives about a particular technology resulting in the individual's change of mind and therefore facilitating adoption. This finding is in harmony with the observations of Mariano et al. (2012) and Ghimire and Huang (2016). Kafle and Shah (2012) also found that it is vital to improve the activities of institution because they have a positive influence on technology adoption. Similarly, Piya et al. (2013), also found that institutional services enhance the possibility of adoption.

The likelihood that a household with good adaptive capacity will adopt productivity improving strategies was 0.638 and significant at 1%. This implies that when the adaptive capacity of a farmer is enhance by one unit, the adoption of productivity improving strategies will increase by approximately 64 percent. This is was so because once the capital assets of a farmer is enhanced, it will improve their adoption of new innovation. This result is in harmony with the works of Egyir et al. (2015) and Ghosh et al. (2015).

Factors such as education, origin, experience, total off-farm income, and access to credit were all not significant but met the *a priori* expected signs except number of cocoa farms that did not meet the a priori sign. The findings also conforms to the works of Egyir et al. (2014) and Defiesta and Rapera (2014).

4.6. Effects of Productivity improving strategies (PIS) on the Livelihoods (income) of Farmers

From table 4.18, the OLS regression result with the F-statistics of 53.47 is statistically significant at 1% significance level. This indicate a joint influence of the independent variables on the income (livelihood) of the farmers (dependent variable). The model coefficient of determination shows that the combine effect of all the independent variables accounts for 66.7% variation in cocoa farmers' livelihood (income). This indicates that adoption of PIS by cocoa farmers have high effect on the livelihood (income) of cocoa farmers. This result is in harmony with the findings of Huda (2015).

The age of farmers was negatively significant at 5% level. The coefficient is 13.701, this implies that when a farmer's age is increased by one (1) year, their livelihood (income) will decrease by GH₵ 13.7. This finding is supported by the work of Ding et al. (2010).

The coefficient of education is 504.95. This means that when the farmer's education increases by one level, the income increases by GH₵ 504.95. This connotes that education has positive effect on the livelihood of farmers in terms of income. This is so because as the farmer gets educated, it gives him/her confidence to bargain for a higher price than farmers who have no educational level. It was significant at 1% level. The Durbin Watson value of 2.27 also shows that there is no serial correlation. This result is consistent with the findings of Ding et al.(2010).

The coefficient of farm size is 115.7 and is positively significant at 1% level. This also implies that as the farm size increases by one hectare, their income also increases by GH₵ 115.7. That is it has a positive effect on the income. This was so because as the farmer increases the farm size the cocoa output will also increase resulting in higher income. This result is in harmony with that of Hailu et al. (2014) on adoption and impact of Agricultural technologies on farm income as well the findings of Ding et al. (2010). Adoption of PIS was positively significant at 1% level. The coefficient of adoption of PIS is 694.802. This implies that when a farmer adopts PIS technology there will be GH₵ 694.802 increase in the income. This is so because increase in technology adoption increases yield. The result is supported by the findings of Ding et al. (2010) and Hailu et al. (2014).

Table 4.18: OLS estimates of the effect of adoption of PIS on income

Variable	Coefficient	Robust Std. Err.	P > | t |
Cons	3347.743	956.291	0.001
Age (in years)	-13.7005**	6.320	0.031
Gender (Male =1)	-51.771	175.738	0.768
Education (in years)	508.953***	166.862	0.002
Farm size (Hectare)	115.714***	40.163	0.004
Household size (number of wards in the house)	-145.804	155.277	0.348
Irrigation (Yes =1)	349.880	248.521	0.160
Experience (Years)	161.670	157.552	0.305
Obtain large capital (Yes =1)	-1.254	7.451	0.866
AC_2 (computed from capital assets)	390.22**	178.320	0.029
PIS (Yes =1)	694.802***	128.833	0.000

Significant levels: * at 1%, ** at 5% and * at 10%** Source: Survey data (2017)

Number of obs	= 443	F(11, 431)	= 53.47
Prob > F	= 0.0000***	R- squared	= 0.6862
Adj R-squared	= 0.6672	Root MSE	= 14229
DW= 2.27			

The variables gender, experience, household size, irrigation and obtaining large capital were all not significant. Previous studies by Becerril and Abdulai (2010); Kassie et al. (2011); Wu et al. (2010); Ghimire and Huang (2016) and Danso-Abbeam and Baiyegunhi (2019) in different contexts have also shown that the adoption of technology has a positive impact on household welfare

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary, conclusions and recommendations drawn from results of the thesis. The foremost indication is to recapture the main findings of the study and provide some policy recommendations.

5.2 Summary and Major findings

The study aimed at describing the adaptation strategies to climate change known to and employed by the cocoa farmers, determine the level of cocoa farmers' adaptive capacity to climate change adaptation strategies, estimate the magnitudes in the factors influencing adoption of the Productivity-Improving Strategies and estimate the extent to which adoption of Productivity-Improving Strategies impact the livelihoods of cocoa farmers.

Primary data was used and an index of adaptive capacity based on the adaptation strategies as well as the five capitals was constructed. The thesis was conducted in the Central Region of Ghana. Apart from simple descriptive statistics, the logit , and OLS estimation methods were employed in the analysis of data and the STATA 16 software was used.

Majority (85%) of the farmers were adults with ages between 36-85 years old. Most (70%) of the respondents had spent some years in formal education. Majority (79%) of the farmers had spent more than fifteen years in the cocoa farming business.

Farmers employ different strategies to mitigate climate change. Farmers in the study area employ both on-farm strategies as well as off-farm strategies. The on-farm adaptation strategies employed included application of chemical fertilizer, application of insecticide, application of fungicide, application of weedicides, crop diversification, use of hybrid seedlings, intercropping with trees and other crops, irrigation and changing planting date. The off-farm adaptation strategies employed included remittances from relatives, migration to the cities, wage labour on other people's farm, income from investment, sale of agricultural produce from other people's farm, processing of agricultural produce from other peoples farm, petty trading, masonry and carpentry and teaching in secondary schools.

Farmers were found to have high adaptive capacity to on-farm strategies such as application of chemical fertilizers, insecticide and fungicide. They had moderate adaptive capacities for the use of hybrid seedlings, application of weedicides, intercropping with trees and other crops and crop diversification. With strategies such as changing planting date, irrigation and having drainage channels on the farms had low capacity since farmers saw those strategies as not part of cocoa farming.

With off-farm adaptation strategies, farmers had moderate adaptive capacities for remittances received and wage labour on other people's farm with adaptive capacity. Sale of agricultural produce from other peoples farm, processing of agricultural produce, income from investment, petty trading, masonry and carpentry, migration to cities to work and teaching in basic and secondary schools were those that farmers had low adaptive capacities for.

The average adaptive capacity for on-farm adaptation strategies is 0.46 which is moderate and 0.33 for off-farm which is low. The overall capital level of cocoa farmers in terms of the five capital in the study area is that majority (45%) had low capital, followed by moderate (40%) and small portion of the farmers (15%) having high capital.

From the findings, factors influencing adoption of productivity improving strategies positively were age, gender, total on-farm income, institutional support, extension contact, physical capital, social capital and adaptive capacity. Off-farm income even though was not statistically significant but it also influences adoption of productivity negatively. Factors such as education, origin, experience, human capital, financial capital and natural capital did not influence adoption of productivity improving strategies but all met their a priori expected signs.

From the result from the OLS regression education, farm size, adaptive capacity from capital assets (AC_2) and PIS had positive effect on income.

5.3 Conclusions of the Thesis

More farmers know that application of fertilizers (100%), fungicide (100%), insecticide (97%) and weedicides (92%), intercropping with trees and other crop (87%), use of hybrid seed (93%) and crop diversification (98%) are adaptation strategies. Few farmers (50%) employ the strategies except for fertilizers, fungicide, insecticide and weedicides application, intercropping with trees and other crop, use of hybrid seed that over 70% of the farmers employ. Few farmers know and employ Wage labour on other peoples farm; sale of agricultural produce from other peoples farm and processing of agricultural produce, masonry and carpentry, teaching and income from investment as adaptation strategies (< 50%). Over 60% of the farmers know migration and receiving remittance from other relatives outside their communities as adaptation strategy but only 50% migrated and received remittance. Farmers know (90%) and employ (70%) on-farm adaptation strategies. Farmers know (55%) and employ (35%) off-farm adaptation strategies

On Adaptation strategies, farmers had high capacity for fertilizer application, moderate for insecticide, fungicide, weedicides and hybrid seedlings and low capacity for irrigation, changing planting date, intercropping with trees and other crops. The low capacity for these key crop management practices affect the way farmers mitigate climate change. On the average, the cocoa farmers had moderate capacity for on-farm adaptation strategies and had low capacity for adapting to off-farm strategies. About 15% of the farmers had high adaptive capacity, 50% had moderate and 35% had low adaptive capacity for capital assets. Over 80% of the farmers had moderate and low capacity for capital asset.

PIS adoption high (72%) and was on farm. Young cocoa farmers positively and significantly adopt PIS. Youth relatively are prone to adopting new technologies, more flexible, more often exposed to new ideas and more likely to bear risk than their adult cocoa farmers (negative and significant). Farmer adaptive capacity built from farm capital assets positively and significantly influence adoption of PIS. Farmers that have access to assets such as physical (spraying machines), human (education), financial (including subsidies from government), social (belonging to FBO) and natural (water resources) likely adopt.

Institutional support was also positive and significant. Farmers that can easily access information and training facilities on available technology could impact the skills of the farmers.

Adoption of PIS had a positive and significant effect on farm livelihood (income). Adopters benefit economically from PIS adoption with 695 cedis in magnitude. Farm size and yield had a positive and significant effect on income.

These finding are consistent with the hypothesis of the thesis and support previous literature that adoption of technology influences the livelihood of farmers.

5.4. Recommendations

The thesis has identified adaptation strategies used by cocoa farmers to mitigate climate change effects and farmers had moderate capacity for on-farm strategies and low for off-farm strategies. COCOBOD should continue engaging farmers on the types of adaptation strategies and its benefit to improve the usage of these strategies (on-farm strategies and off-farm strategies).

Awareness should be raised by the right institutions such as MoFA, COCOBOD, and Ministry of Local Government (MLG) through workshops and informal educational programs on the connection between cocoa production, climate change, adaptation strategies and adoption of PIS in order to enhance cocoa production in the region.

COCOBOD should increase the number of extension officers they have so that extension contact to farmers can be improved since extension contact enhances adoption and also increase their technology demonstration section to farmers since this also enhances the understanding of the farmer on the technology. This will encourage farmers to adopt PIS and thereby improve their livelihood.

Local institutions (cocoa LBCs) should be encouraged to provide support in the form of training and education to improve the **low capacity for the** key crop management practices required to mitigate climate change resources to farmers to enhance their capacity

Institution and stakeholders should provide support (credit, training and technology transfer) to enhance their adaptive capacity (assets, AC_2) and also to enhance their technology adoption

Farmers should be encouraged to form and join FBOs since most of the supports from the local institutions are rendered to farmers at the them at the FBO meetings. When they join FBO/CBO, it will enhance their social capital and also they can use the group as guarantor for large and long term capital. Access to financial services can be improved through capacity building for financial institutions (FIs) in the area and the farmers. Capacity building for financial institutions (FIs) will help to encourage the FIs to expand their services to include services they do not currently offer to farmers. Capacity building for the farmers will help to enhance their ability to negotiate.

The Ministry of Food and Agriculture together with COCOBOD should encourage the youth to go into cocoa farming by giving them some start-up inputs once the person has land for cultivation since the cocoa sector is dominated by old age. Again, they must also encourage group farming in areas where individual land acquisition is a problem.

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APPENDICES

Appendix 1

QUESTIONNAIRE

ADAPTATION TO CLIMATE CHANGE: EFFECTS OF PRODUCTIVITY IMPROVING STRATEGIES ON COCOA FARMERS' LIVELIHOODS IN THE CENTRAL REGION, GHANA

This questionnaire seeks to obtain information on the way farmers' mitigate climate change through the use of adaptation strategies and the effect of adoption of productivity-improving strategies on the livelihoods of cocoa farmers. This interview is purposively for academic work and entirely anonymous. No one will know your name and so you may speak quite freely to the interviewer. Thank you for your time and assistance in our work.

Reference Information

Name of Respondents……………………………………..Serial Number…..…………

Mobile Number…………………………….............. .Date of Interview… …./…./2017

Name of Community…………………………… Name of District…………..…………………

A. Demographic Information

A1. Age of respondent:..

A2. Gender of respondent: 1. Male [ ] 2. Female[ ]

A3. Years spent in school..

A4. Marital Status: 1. Single [ ] 2. Married [ ] 3. Divorced/Separated [ ]
4. Widowed[ ]

A5. Religion: 1. Traditional religion [ ] 2. Christian [ ] 3. Muslim [ ]
4. Other specify………………

A6. Ethnicity: 1. Akan [ ] 2. Ewe [ ] 3. Ga-Adangbe [ ] 4. Other,
specify…………………………………..…

A7. Place of Origin of respondent: 1. Native [ ] 2. Settler/Migrant [ ]
3. Other specify….................................

A8. How often do you stay/reside in the community/village:
1. Stay during the farming season [ ] 2. Stay throughout the year [ ]

A9. Years of farming experience of respondent:...

A10. Is the respondent the head of household: 1. Yes[ ] 2. No[ ]

A11. If no, provide name of household head: ……………………………………………..

A12. Sex of Household Head: 1. Male [ ] 2. Female[ ]

A13. Age of Household Head:..

A14. Educational background of household head Primary Education [ ] 2. Middle/JSS [ ]
3. SSS/Tech/Voc[ ] 4.Training College [ ] 5. University/Polytechnic [ ]
6. None [ ]

A15. Household Size:...

A16. Number of adults in the household..

A17. Age of cocoa tree...

B. AWARENESS AND TREND OF CLIMATE CHANGE

13. Do you feel the pattern of climate changing over the last three decades? (a) Yes (b) No

14. If yes, for how long have you realized these changes in the climate? ……………….
1. 1-10 years [ ] 2. 11-20 years [ ] 3. Above 20 years [ ]

15. Did you observed any change in temperature? 1. Yes [ ] 2. No [ ]

16. If yes please indicate the changes you observed in sunlight and temperature (multiple responses) 1. average temperature increase [ ] 2. Average temperature decrease [ ] 3. High sunlight intensity [ ]. 4. Low sun light intensity [ ] 5. Increase above the last decade [ ] 6. Decreased below the last decade [ ]

17. Did you observed any change in rain? 1. Yes [ ] 2. No [ ]

18. If yes please indicate the changes you observed in rain pattern (multiple responses)
1. Late unset of rain [ ] 2. Early unset of rain [ ] 3. Increase average amount of rain [ ] 4. Decreased average amount of rain

19. Did you observed any change in wind? 1. Yes [ ] 2. No [ ]

20. If yes please indicate the changes you observed in the wind (multiple responses)
1. Strong wind [ ] 2. Weak wind [ ] 3. Normal wind [ ]

21. Did you observed any change in humidity? 1. Yes [ ] 2. No [ ]

22. If yes please indicate the changes you observed in humidity (multiple responses)
1. High [ ] 2. Moderate [ ] 3. Low [ ]

23. Did you observed any change in drought? 1. Yes [ ] 2. No [ ]

24. If yes please indicate the changes you observed in drought (multiple responses) 1.
1. High over long period [ ] 2. Moderate period [ ] 3. Low over long period [ ] 4. High over short period [ ]. 5. Low over short period [ ]

25. Have you heard of climate change before? 1. Yes [ ] 2. No [ ]

26. If yes, how did you hear about it?
1. Radio [ ] 2. Television [ ] 3. Extension officers [ ] 4. Family and Friends [ ] 5. Fellow farmers [ ] 6. FBOs [ ] 7. NGOs [ ] 8. Local government authorities [ ] 9. Newspaper [ ]

C. Adaptation Strategies Known and Employed by Cocoa Farmers

Which of the following do you know to be a climate change adaptation strategy?

Adaptation Strategies	**Known**
A. On-Farm Strategies	
1. Crop diversification	
2. Usage of hybrid seedling	
3. Changing planting date	
4. Intercropping with tress and other crops	
5. Irrigation	
6. Application of fertilizer	
7. Application of weedicides	
8. Application of insecticide	
9. Application of fungicide	
10. Application of pesticide	
B. Off -Farm Strategies	
11. Wage labour on other peoples farm	
12. Processing of agricultural produce	
13. Sales of agricultural produce,)	
14. Petty trading	
15. Carpentry and masonry	
16. Teaching	
17. Migration to cities	
18. Remittances (e.g. from relatives and friends)	
19. Property income (such as houses, stores, land, etc.)	

Which of the following climate change adaptation strategy do you employ?

Adaptation Strategies	**Reason for choosing this strategy**
A. On-Farm Strategies	
20. Crop diversification	
21. Usage of hybrid seedling	
22. Changing planting date	
23. Intercropping with tress and other crops	
24. Irrigation	
25. Application of fertilizer	
26. Application of weedicides	
27. Application of insecticide	
28. Application of fungicide	
29. Application of pesticide	
B. Off -Farm Strategies	
30. Wage labour on other peoples farm	
31. Processing of agricultural produce	

32. Sales of agricultural produce,)	
33. Petty trading	
34. Carpentry and masonry	
35. Teaching	
36. Migration to cities	
37. Remittances (e.g. from relatives and friends)	
38. Property income (such as houses, stores, land, etc.)	

C. Levels of farmers' capacity for adopting climate change adaptation strategies

A. Application of chemical fertilizer

C1. Do you use this strategy?
Yes = 1 [ ]
No = 0 [ ]
C2. Do you use this strategy very often?
Yes = 1 [ ]
No = 0 [ ]

C3. Is this strategy available to you?
Yes = 1 [ ]
No = 0 [ ]

C4. Do you consult the institution/agencies who provide this to you?
Yes = 1 [ ]
No = 0 [ ]

B. Application of insecticide
C5. . Do you use this strategy?
Yes = 1 [ ]
No = 0 [ ]
C6. Do you use this strategy very often?
Yes = 1 [ ]
No = 0 [ ]

C7. Is this strategy available to you?
Yes = 1 [ ]
No = 0 [ ]

C8. Do you consult the institution/agencies who provide this to you?
Yes = 1 [ ]
No = 0 [ ]

C. Application of fungicide

C9. Do you use this strategy?

Yes = 1 [ ]
No = 0 [ ]

C10. Do you use this strategy very often?

Yes = 1 [ ]
No = 0 [ ]

C11. Is this strategy available to you?

Yes = 1 [ ]
No = 0 [ ]

C12. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]
No = 0 [ ]

D. Application of weedicides

C 13. Do you use this strategy?

Yes = 1 [ ]
No = 0 [ ]

C14. Do you use this strategy very often?

Yes = 1 [ ]
No = 0 [ ]

C15. Is this strategy available to you?

Yes = 1 [ ]
No = 0 [ ]

C16. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]
No = 0 [ ]

F. Intercropping with trees and other crops

C17 . Do you use this strategy?

Yes = 1 [ ]
No = 0 [ ]

C18. Do you use this strategy very often?

Yes = 1 [ ]
No = 0 [ ]

C19. Is this strategy available to you?

Yes = 1 [ ]
No = 0 [ ]

C20. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

G. Crop diversification

C21. . Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C22. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C23. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C24. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

H. Changing planting date

C25. Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C26. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C27. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C28. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

I. Irrigation

C29. Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C30. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C31. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C32. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

J. Drainage channels on the farm

C33. Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C34. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C35. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C36. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

K. Remittance received from friends and relatives

C37. Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C38. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C39. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C40. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

L. Wage labour on other peoples farm

C41. Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C42. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C43. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C44. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

M. Sale of agricultural produce from other peoples farm

C45. . Do you use this strategy?

Yes = 1 [ ]
No = 0 [ ]

C46. Do you use this strategy very often?

Yes = 1 [ ]
No = 0 [ ]

C47. Is this strategy available to you?

Yes = 1 [ ]
No = 0 [ ]

C48. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]
No = 0 [ ]

N. Processing of agricultural produce from other peoples farm

C49. Do you use this strategy?

Yes = 1 [ ]
No = 0 [ ]

C50. Do you use this strategy very often?

Yes = 1 [ ]
No = 0 [ ]

C51. Is this strategy available to you?

Yes = 1 [ ]
No = 0 [ ]

C52. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]
No = 0 [ ]

O. Income from investment

C53. Do you use this strategy?

Yes = 1 [ ]
No = 0 [ ]

C54. Do you use this strategy very often?

Yes = 1 [ ]
No = 0 [ ]

C55. Is this strategy available to you?

Yes = 1 [ ]
No = 0 [ ]

C56. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]
No = 0 [ ]

P. Petty trading

C57. Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C58. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C59. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C60. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

Q. Carpentry and masonry

C61. Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C62. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C63. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C64. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

R. Migration to the cities

C65. Do you use this strategy?

Yes = 1 [ ]

No = 0 [ ]

C66. Do you use this strategy very often?

Yes = 1 [ ]

No = 0 [ ]

C67. Is this strategy available to you?

Yes = 1 [ ]

No = 0 [ ]

C68. Do you consult the institution/agencies who provide this to you?

Yes = 1 [ ]

No = 0 [ ]

S. Teaching in basic and secondary schools

C69. Do you use this strategy?
Yes = 1 [ ]
No = 0 [ ]
C70. Do you use this strategy very often?
Yes = 1 [ ]
No = 0 [ ]

C71. Is this strategy available to you?
Yes = 1 [ ]
No = 0 [ ]

C72. Do you consult the institution/agencies who provide this to you?
Yes = 1 [ ]
No = 0 [ ]

Farmers' capitals

Social capital

A. Group involvement
C73. Do you belong to a Farmer Based Organizations (FBOs) or any group?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C74. Do you participate in group/communal activities?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

B. Social trust
C75. Does the association(s) you belong to trust you?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C. Social network
C76. Do you interact or have any social network?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

D. Social support

C77. Have you receive any training within the last years with respect to cocoa production from a public institution?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C78. Have you receive any training within the last years with respect to cocoa production from a private institution?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

E. Social status

C79. What is your status in the community
Opinion leader [ ] .... 1 point
Non opinion leader [ ] ....0 point

Financial capital
C80. Do you receive money from any family/relative outside this community?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C81. Do you receive agriculture subsidies from the government?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C82. Do you save?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C83. Have you accessed credit from an informal financial institution to finance your farming activities before?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C84. Have you been able to obtain large capital (> GH₵ 3000)
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C85. Have you been able to obtain long term capital (> 2 years payment period)
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

Physical capital
C86. Type of land ownership:
1. Own land (purchased/Inherited) [ ]......................... 1.0 point
2. Rented [ ]......................... 0 point
3. Shared holding [ ]........................ 0 point
4. Family land [ ] .... 0 point
5. From village chief/government [ ] .... 0 point
6. Other .... 0 point

C87. Do you have farm size greater than 2 hectares?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C88. Are you able to access storage facility?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C89. Are you able to access good road network?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C90. Do you have more than 7 farm implements/machines?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C91. Are you able to access technology in your area?

1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C92. Do you access to portable water?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C93. Do you access health facility in the community?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

Human capital
C94. Years of farming experience of respondent:
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C95. Do you have formal education?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C96. Do you have adults in your household?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C97. Do you have any of the household member working outside the community?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C98. Have you receive any on the job training?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

Natural capital
C99. Which other economic activities do you engage in?
1. Animal rearing [ ]
2. Trading [ ]
3. Mining [ ]
4. Civil service [ ]
5. Others [

C100. Do you have access to the natural resources in the area?
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C101. Do you have access to the land resources in the area
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C102. Do you have access to the forest resources in the area
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

C103. Do you have access to the water resources in the area
1. Yes [ ] .... 1 point 2. No [ ]..........0 point

IV. Adoption of productivity-improving strategy.

D1. Which of the following technologies packages have you been using in you farming business?

1) Intercropping with trees [ ]
2) Chemical fertilizer [ ]
3) Insecticide [ ]
4) Fungicide [ ]
5) Improved seed variety [ ]
6) Weedicides [ ]

D2. Adopted to productivity improving strategies

1. Yes [ ] 0. No [ ]

Others

X1. How many bags of cocoa do you get after harvesting?..

X2. Total farm Income..................................

X3. Off-farm income..

E. Support services from local institution?

For Farmers

F1. Are the members of the communities (specifically smallholder cocoa farmers) supported by any institution to help address the climate change problem?

1) Yes [ ] 2) No [ ]

F2. State the institutions involve

....

....

F3. Among the services listed in the table below, select in terms of the effectiveness of the support you receive from the institutions using the numerical values attached to it.

1. Very effective
2. Effective
3. Less effective
4. Ineffective
5. Not sure

Service	Categories	Rank				
		1	2	3	4	5
Education and training	Good planting and harvesting time					
	When to apply agrochemical and the right dosage					
	Climate change awareness creation					
	The use of drought-tolerant varieties of seed and rainwater harvesting					
	Training on preventing forest deforestation and					

	degradation						
	Financial management						
Technology transfer	Biological	Hybrid variety					
	Chemical	Chemical fertilizers					
		Pesticides (insecticide and fungicide)					
	Management	Agronomic practices on mixed farming and mixed cropping					
Credit	Cash	Short-term and small capital					
		Long-term (> 2 years payment period)					
		Large capital (> ₵3000)					
	Inputs						

Appendix 2

ADAPTATION TO CLIMATE CHANGE: EFFECTS OF PRODUCTIVITY IMPROVING STRATEGIES ON COCOA FARMERS' LIVELIHOODS IN THE CENTRAL REGION, GHANA

INTERVIEW QUESTIONS FOR INSTITUTIONS

This questionnaire seeks to obtain information on the way farmers' mitigate climate change through the use of adaptation strategies and the effect of adoption of productivity-improving strategies on the livelihoods of cocoa farmers. This interview is purposively for academic work and entirely anonymous. No one will know your name and so you may speak quite freely to the interviewer. Thank you for your time and assistance.

A. Institutional Background

1. Position of interviewee…………………… Date …. /...…/17
2. Name of Institution……………………………………
3. Type of Institution. Public [ ] Civic [ ] Private [ ]
4. How many years has the organization been in existence?..
5. How many years has the organization been operating in the community?..........................
6. How long have you been working in this organization?..
7. Its vision: ……………………………………..
8. Its mission: ……………………………………………………………………..

B. Climate Change Impacts

1. Do your institution support the cocoa farmers in the area to address the climate change issues they are faced with?

2. Indicate the support your institution provide to the cocoa farmers in your area.

Service	Categories		Tick
Education and training	Good planting and harvesting time		
	When to apply agrochemical and the right dosage		
	Climate change awareness creation		
	The use of drought-tolerant varieties of seed and rainwater harvesting		
	Training on preventing forest deforestation and degradation		
	Financial management		
Technology transfer	Biological	Hybrid variety	
	Chemical	Chemical fertilizers	
		Pesticides	
	Management	Agronomic practices on mixed farming and mixed cropping	
Credit	Cash	Short-term and small capital	
		Long-term (> 2 years payment period)	
		Large capital (> ₵3000)	
	Inputs		

3. Any additional support provided by your institution apart from those listed in the table above

....
....

4. Does every member of the community benefit from these support services?
1. YES [ ] 0. NO [ ]

5. If no, state target group of beneficiaries
....
....

6. What are the challenges your institution is facing in supporting and helping farmers manage their capacity in the community?

....
....
....
....

Appendix 3

Table 3.1. Element and measurements of adaptation strategy

On-farm adaptation Strategies	Factors	Yes=1 No=0
Hybrid seedling	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Changing planting date	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Intercropping with tress	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Irrigation	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Chemical fertilizer	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Weedicides	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Insecticides	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Fungicides	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	

Source: Modified from Nakuja et al., 2012 and Mabe et al., 2014

Appendix 4.

Table 3.2. Elements and measurements of adaptation strategy (off-farm)

Adaptation strategy	Factors	Yes= 1 No=0
Wage labour on other peoples farm	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Processing of agricultural produce	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Sales of agricultural produce	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Petty trading	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Carpentry and masonry	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Teaching	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Migration to cities	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Remittances	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	
Income from investment	Use of the strategy	
	How often the strategy is used	
	Availability of the strategy	
	Consult the Provider(s)	

Source: Modified from Nakuja et al., 2012 and Mabe et al., 2014

Appendix 5

Elements and measures of capitals considered in adaptive capacity

Capitals	Factors	Yes= 1 No= 0
Financial	1. Able to obtain long term capital (> 12 months)	
	2. Able to obtain large credit (>GH₵ 3000 per annum)	
	3. Receives financial assistance/subsidy from government/NGO/DP	
	4. Remittances received	
	5. Have savings with a financial institution	
	6. Accessed formal credit in the last 3 years	
	7. Accessed informal credit in the last 3 years	
Physical	1. Have access to farm size 2 hectares or more	
	2. Number of farm implement/machines owned by farmer	
	3. Access to formal storage facility	
	4. Access to good road from farm to market	
	5. Access to productivity improving strategies	
	6. Access to portable water	
	7. Access to health facility	
Human	1. Farming for more than 10 years or more	
	2. Literate (receive 10 years of education or more)	
	3. Member of household working outside the community	
	4. Received formal on the job training	
Natural	1. Land resources access in the area	
	2. Water resources access	
	3. Access to forest resources	
Social	1. Group involvement (collective action)	
	2. Social trust	
	3. Social network	
	4. Social support (extended family ties)	
	5. Social status (hold position in society)	

Source: Modified from (Pahl-Wostl, 2009; Gupta et al., 2010; Eakin et al., 2011; Morrison et al., 2011; Ibrahim, 2014; Defiesta and Rapera, 2014; Egyir et al., 2015)

Appendix 6

Productivity-improving strategies

Productivity-Improving Strategies	Climate change effect addressing
Hybrid seedling	High temperature, low and excess rainfall and humidity resulting in low production or yield
Fertilizer application	High temperature, low and excess rainfall and long drought resulting in decreased number of micro organism in the soil. This leads to depletion of fertility of the soil.
Insecticide application	High temperature, low and excess rainfall, prolong humidity and wind resulting in infestation of insects. This leads to decrease in yield
Weedicides	High temperature, low and excess rainfall and prolong humidity resulting in growth of weeds. This leads to decrease in yield
Fungicides	High temperature, low and excess rainfall and prolong humidity resulting in infestation of fungi. This leads to decrease in yield
Intercropping with trees and other crops	High temperature, excess rainfall and wind resulting in depletion of nutrient. This leads to decrease in yield

Appendix 7

Regional Cocoa Production

Crop Year	Ashanti	Brong Ahafo	Central	Eastern	Western	Volta	Total
1947/48	107630			56000	27970	20279	211879
1948/49	127880			81003	47062	26881	282826
1949/50	117875			68161	41146	24617	251799
1950/51	124630			70643	46116	25029	266418
1951/52	99231			60679	31194	23945	215049
1952/53	120190			62526	39863	28356	279291
1953/54	103322			52036	35676	22206	213240
1954/55	111063			53641	33727	22388	220819
1955/56	120940			50743	32666	28100	232449
1956/57	134929			55893	44804	32288	267914
1957/58	106597			42637	38942	21575	209751
1958/59	146247			37807	40322	25039	249415
1959/60	182775			58820	57285	23342	322222
1960/61	152754	92552	46821	75082	39318	30777	437304
1961/62	151646	71245	61748	81112	21176	29034	415961
1962/63	150200	83156	64889	85907	23278	21054	428484
1963/64	156586	90379	57421	76911	21871	24614	427782
1964/65	204427	130245	75697	107820	34935	27745	580869
1965/66	155816	101790	41587	72149	23800	20620	415762
1966/67	130220	87698	50125	69511	25040	18759	381353
1967/68	140844	109060	52790	71323	32329	24319	430665
1968/69	124903	85336	43845	58733	23282	19489	355588
1969/70	125406	115393	55236	69431	31113	20878	417457
1970/71	130434	112076	59813	73805	36153	15348	427629
1971/72	148935	116916	62762	76224	47516	10107	462460
1972/73	125649	112754	43469	74578	43129	22118	421697
1973/74	106977	78502	47707	65617	41338	14489	354630
1974/75	109802	81533	50766	73393	52106	14009	381609
1975/76	124334	88480	38547	69201	40343	9228	370133

1977/78	89619	69541	21553	41289	41968	7369	271339
1978/79	86913	50408	25700	50200	45873	5980	265074
1979/80	100363	74894	19034	45051	52301	4776	296419
1980/81	91537	47598	25563	46632	45148	1496	257974
1981/82	70790	49747	22069	36890	43703	1683	224882
1982/83	55310	35174	17604	31254	35109	3776	178227
1983/84	47059	29685	13818	25504	40161	2659	158886
1984/85	44692	28629	18754	28009	51412	1018	172514
1985/86	54466	36474	27636	34612	64731	1115	219034
1986/87	56870	32643	26912	33399	76038	1903	227765
1987/88	49766	28796	19115	29951	58738	1805	188171
1988/89	76268	48647	28423	39193	105894	1676	300101
1989/90	72124	45126	31208	33296	111513	1785	295052
1990/91	60958	42016	26517	32261	128955	2645	293352
1991/92	52467	33734	19356	26196	109469	1595	242817
1992/93	65353	37014	29587	34608	143288	2273	312123
1993/94	47172	30927	21936	25372	128323	924	254654
1994/95	64026	37014	20518	33667	153162	1068	309455
1995/96	81977	39048	36410	38932	206570	906	403843
1996/97	64534	34195	22415	34306	165361	1678	322489
1997/98	78909	39898	29468	29468	216955	976	395674
1998/99	74390	40212	29653	40503	210545	2060	397363
1999/00	82068	39310	31360	41526	240331	2351	436946
2000/01	72993	33110	32136	46226	203626	1681	389772
2001/02	56983	31354	29992	39348	181865	1021	340563
2002/03	82445	45308	39989	51604	276587	913	496846
2003/04	121269	69695	55819	68634	419650	1909	736976
2004/05	90535	55025	59308	48868	344246	1336	599318
2005/06	133026	72766	55497	55871	422223	1075	740458
2006/07	95427	65629	43757	51132	357827	761	614533
2007/08	125270	66921	62378	55916	369458	838	680781
2008/09	110643	61562	60686	63405	413395	951	710642
2009/10	116538	60600	57562	55736	359910	595	650941

2010/11	168916	101302	76863	78928	583589	3241	1012839
2011/12	134295	76511	71760	67713	525237	3833	879349
2012/13	137379	88034	71540	75912	458107	4495	835467
2013/14	156902	87116	85446	80692	483279	3481	896916
2014/15	136134	81896	70690	68415	380469	2650	740254
2015/16	133462	74943	75870	75787	415302	2680	778044

Appendix 8

Cocoa beans dried in the sun

10288699:sakai.docx

ORIGINALITY REPORT

10%	6%	5%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES