

Environmental sustainability of smallholders' adaptation practices to weather variability and climate change in the forest-savannah transitional agro-ecological zone of Ghana

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Dedication

To the young girls at all the fringes of the world who wish to have quality education so that their dreams may be realized.

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Abstract

Smallholders have long been adapting to climate change and have significantly been resilient to environmental changes long before the phenomenon attained societal recognition. The study uses the qualitative approach to data collection and analysis to explore how smallholders' adaptation practices negatively impact on the environment. The results indicate that the various adaptation practices adopted both indigenous and now modern practices are aimed at improving yield, increasing income and sustaining household food supply in a small farming community in the Wenchi Municipality of Ghana. Farmers' adaptive capacity were influenced by biophysical, socio-economic and institutional/political factors mainly soil fertility, financial resources, age, gender and access to extension services.

Even though smallholders are considered as the custodians of the natural environment, the chosen adaptation practices of farmers in the study area have been threatening to the environment. The practices adopted were found to have led to change in plant and animal ecology and soil nutrients with repercussions on farming activities and food security. The unintended environmental impacts caused by smallholders' adaptation practices in Wenchi were found to be driven by poverty, ignorance and inadequate information from extension services. Even though smallholders have some environmental concerns about their chosen practices, the need to maximize profit has hindered their intention of maintaining the natural environment. For smallholders to successfully adapt to climate change and still be custodians of the natural environment, specific factors that affect adaptation to climate change and sustainable agricultural practices among them should be properly tackled. This calls for collaboration between various stakeholders as smallholders remain central to the provision of food and the sustenance of the ecosystem both in the short and long term.

Keywords: *Environment, sustainability, adaptation, climate change, smallholders, impact, negative, Nkonsia, Wenchi.*

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List of abbreviations

AEO	Agricultural Extension Officer
AGRA	Alliance for a Green Revolution in Africa.
EA	Environmentalism in Accra
EW	Environmentalism in Wenchi
EPA	Environmental Protection Agency
FBO(S)	Farmer Based Organization(s)
FCCC	Framework Convention on Climate Change
FFS	Farmer Field School
FGD(S)	Focus Group Discussion(s)
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology.
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel for Climate Change
MOFA	Ministry of Food and Agriculture
NGO	Non-governmental Organization
TERI	The Energy and Resource Institute
UNCTAD	United Nations Conference on Trade and Development

CHAPTER ONE

INTRODUCTION

1.1 Background of study

Climate change is a phenomenon which is expected to affect different sectors of the economy with the agricultural sector experiencing high level of vulnerability.¹ Smallholders especially in the developing countries, who are resource constrained are expected to suffer most from the negative impact of climate change due to their inability to adequately adapt (Morton 2007, Lasco et al. 2011). However, smallholders have long had to make farming adjustments in order to adapt to variabilities in climatic conditions long before the phenomenon gained extensive societal recognition (Wolfenson 2013). Yet, even with the various negative impacts faced by resource constrained smallholders (such as reduction in crop yield, water shortages and forest fires), current and future adaptation in this case is significant as it plays a crucial role in the sustenance and improvement of their livelihood activity. For a number of years, agricultural researchers have focused on debates concerning strengthening the resilience and productivity of agricultural systems against flood and drought (Verchot et al. 2007). However, strengthening the resilience of agricultural systems against climate change also demands taking a critical look at the relationship between adaptation (and the various technologies used) and the natural environment in which such activities occur.

In this context, the central theme of this study focuses on the impact of smallholders' adaptation practices to weather variability and climate change on environmental sustainability. Environmental sustainability of smallholders' adaptation practices is recently gaining attention among researchers as they explore the relationship between the various adaptation practices and the natural environment. World-wide meeting among experts, support from world leaders, various stakeholders and organized international events (such as the Rio+20 and International Year of Family Farming-IYFF) indicate the recognition of the significance of smallholders' multi-functionality of providing food, improving rural livelihood and contributing to sustainable development both environmentally and economically (Wolfenson 2013). Wolfenson, however further notes that despite these efforts smallholders still face the challenge of being marginalized

¹ <http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=674>

both on the international and national arena due to the top-down approach to decision making process. This therefore has implications on the ability of smallholders to sustainably adapt to climate change.

In Ghana, smallholders also suffer from the negative impact of climate change as most developing economies. Several studies conducted by local researchers have indicated that smallholders across different geographical locations are already adapting to extreme weather events and climate change as researchers have explored the various adaptation practices adopted by smallholders (Etwire et al. 2013, Kuwornu et al. 2013, Owusu et al. 2015, Limantol et al. 2016, Wrigley-Asante et al. 2017). Although, much progress have been made on smallholders' adaptation options in Ghana, there still remain an incomplete dimension in this research process concerning the climate change and adaptation discourse which researchers still need to unravel. There is limited information on the environmental impact of the various adaptation practices due to little research concerning the topic as much of the discussion has focused on adaptation and strengthening resilience and less in relation to the broader environmental outcome of these practices. "In doing so, they limit the possibility of arriving at a holistic understanding of human-environment interactions at both the macro and micro level" (Misra 2017, p 2).

Empirical evidence indicates that the transition zone of Ghana is already experiencing changes in climatic conditions (Owusu and Waylen 2013a, 2013b). As observed data from a 20 year period indicates an increasing temperature (both the minimum and maximum) and a general decreasing rainfall with an increasingly unpredictable pattern in all agro-ecological zones of Ghana (Environmental Protection Agency, EPA 2011). Moreover, based on observed historical rainfall trends from 1981 to 2010 across all agro-ecological zones, annual rainfall is further expected to decrease by 2.9% by 2040 proceeded by a slight increase of 1.1% by 2060 and a later reduction by 1.7% in 2080 indicating the uncertainty in rainfall variation (EPA 2015). This implies that smallholders will no doubt have to intensify their adaptation practices in order to adjust to the future climatic changes and extreme weather events. Also, aside climate change, there is no doubt that smallholders face multiple and interlocking climatic and non-climatic stressors (both social and environmental) which make them more vulnerable in their livelihood activities (Easterling et al. 2007, Morton 2007). This re-enforces that smallholders would have to be effective in responding to the unpredictable changes in climatic conditions to reduce the adverse impacts. Since, smallholders' activity is largely dependent on the environment, it is thus

important that researchers take a new dimension in the climate change discussion and focus on the link between adaptation to climate change and environmental sustainability with a local perspective in mind.

By contributing to literature on climate change and environmental sustainability, this research will therefore assess the environmental sustainability of smallholder farmers' adaptation practices to weather variability and climate change in the Wenchi municipality² located in the western part of Brong-Ahafo Region of Ghana. The study will identify and analyse the short term and long term negative environmental impact of smallholders' adaptation options.

1.2 Research Objective

The primary aim of this research is to explore smallholders' adaptation practices to weather variability and climate change and to identify the impacts of these practices on environmental sustainability. In line with the aim of this research, the analyses of the study would be in two phases. The first will identify the adaptation practices of smallholders to weather variability and climate change. The second phase will analyse the relationship between these adaptation practices and their roles in modifying the physical environment. In order to critically examine and achieve the aim of the research the study will investigate specific issues which would include;

- Identify the adaptation practices which are related to the physical environment. Specifically;
 - a) The traditional adaptation practices.
 - b) The changing adaptation practices being adopted due to climate change and extreme weather events.
- Assess the impacts of the adaptation practices on the physical environment. That is the short and the possible long term environmental impact. Specifically;
 - a) The impact of the traditional adaptation practices on the environment.
 - b) The impact of the new adaptation practices on the environment.

Smallholders' adaptation to climate change will be discussed in relation to changes in temperature and rainfall in the area for the study. Also, the impact of changes in climatic conditions on crop production and livelihood would be discussed as well as the factors that

² In Ghana, municipality means just an administrative unit and not necessarily an urban area.

influence smallholders' adaptive choices. The purpose is to provide an insight into why smallholders in the study area make certain decisions as they adapt to climate change. Non-farm adaptation practices would be briefly discussed. The idea is not to mainly look at non-farm activities but to indicate that farmers have non-farm income generating activities which may directly or indirectly have environmental consequences.

A possible variation in the adaptation practices adopted by smallholders will be analysed in relation to gender, age, educational background, ownership of farmland and size and the major type of crops cultivated. This is because smallholders differ in characteristics in relation to the activities they engage in, the assets and resources available to them (such as financial assets) and their access to productive resources (Wolfenson 2013). It is also believed that these characteristics of smallholders may lead to different responses to weather variability and climate change and will therefore have variations in their adaptation practices. The different practices employed may likewise have different environmental impacts.

1.3 Organisation of thesis

The study is divided into six chapters. Chapter one introduces the research by giving background information to the study and the specific aim on which the research explores. To better understand this research, chapter two reviews literature from different studies. It defines key terminologies used in the climate change literature relevant for the study. Chapter three provides a conceptual framework on which the study is based and analysed. Chapter four discusses the research tools used in the data collection process and in analysing the data. It discusses the study area, the various informants interviewed for the research purpose, why and how they were recruited. The chapter further discusses challenges encountered during the study and how they were resolved. Chapter five focuses on the research analyses and is divided into two sections. Section one discusses the adaptation practices adopted both the traditional and modern practices. The section also establishes a link between the various factors influencing smallholders' adaptive capacity. Section two of the analyses discusses the environmental impacts emanating from the various adaptation practices adopted in the study area. The data is analysed in relation to the literature review and other existing literature, the conceptual framework and the researchers' knowledge about the study area. Chapter six provides a short discussion and the conclusion of

the study highlighting the major empirical findings and the possibility for further research based on the empirical findings in the study area.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Introduction

The concept of environmental sustainability has evolved over time among several fields and researchers who have put forward their opinions while making contributions to justify the need for a sustainable environment. This chapter provides an insight into the theoretical debates that centre around environmental sustainability of smallholders' adaptation practices to climate change. It also defines certain key terms which are important to the study when exploring smallholders' adaptation to climate change and extreme weather events.

2.2 Environmental sustainability and smallholder practices

The concept of environmental sustainability has been defined by several authors and researchers based on their discipline or interest of study. Nevertheless, from whichever viewpoint the concept is being defined it is mostly used in relation to human influence on the natural environment while the central idea is to preserve environmental resources. Morelli (2011) for example defines the concept as the relationship between human society and the ecosystem which enables humans to satisfy their needs without undermining the potential of the ecosystem to neither regenerate itself nor reduce the capacity of ecosystem services to provide the present and future needs.

The term smallholders on the other hand is defined by Morton (2007) as rural producers mainly in the developing countries who mostly depend on family labour for their farming activities and for whom farming provides the primary source of income. The majority of smallholders' farms are typically small in size of two hectares (ha) or less (Wiggins 2009) and are usually owned by the farmers themselves no matter how small (Singh et al. 2002). However, the 2 ha smallholding farm size is not a universal characteristics across regions and may differ from 0.5 to 10 ha and even 500 ha as in the case of smallholding in Australia (Wolfenson 2013). The activities of smallholders are very significant to the reduction of global food insecurity and the provision of employment to a majority of the world's population especially in the rural areas. Even though smallholders produce the bulk of the world's food, their activities are mostly characterized by high dependence on rain-fed agriculture. In Ghana, the majority of the agricultural producers are smallholders who are primarily rural dwellers and for whom farming

constitute the principal source of livelihood. The farming activities of smallholders in Ghana just like many in other developing countries are also climate dependent and the threat of variability in climatic conditions poses a challenge to this group of agricultural producers at various levels. For instance, Black et al. (2011) indicate that reduced rainfall and increase in temperature may cause water stress which also decrease food production among farmers and increase the risk of drought and food insecurity in Ghana.

In the field of climate change, there have been different opinions on the influence of smallholder adaptation practices in sustaining or negatively impacting on the environment. Wolfenson (2013) indicates that the practices of smallholders are regarded to hold the key in promoting a sustainable environment. A report by the International Food and Agriculture Development, (IFAD 2013) similarly notes that there is a link between the activities of smallholders and the environment and that smallholders play a significant role as custodians of the natural resources. These farmers are acknowledged to be the stewards of the natural environment at the local level mainly due to the limited use of chemicals in their farming activities as compared to large commercial farms (United Nations Conference on Trade and Development, UNCTAD 2015).

Even though the practices of smallholders are in general considered to foster a sustainable environment, it does not imply that the activities of smallholders are not associated with environmental degradation. There is a growing consensus that the adaptation practices of smallholders have adverse impact on the natural environment due to the increasing rate of extreme weather events which force farmers to use a more rigorous approach in their farming activities. An extreme weather event for the purpose of this study is explained as any weather condition whose values deviates from above or below the long term mean or threshold (Intergovernmental Panel on Climate Change, IPCC 2012). For example, high amount of rainfall can result in flood. Although the rapid changes in climatic conditions is a contributing factor which has influenced smallholders in adopting radical strategies in their farming activities, IFAD (2013) further emphasizes that the practices of smallholders can also be motivated by poverty and the desire to satisfy immediate needs which drives farmers to put pressure on the ecosystem leading to their alteration. This indicates that the impact of smallholder adaptation practices to climate change is influenced by several factors which can promote sustainable or unsustainable environmental practices.

2.3 Adaptation practices and their evolving nature

Smallholder farming is exposed to multiple non-climatic and climatic challenges (Morton 2007). However, in recent times the most pressing challenges facing smallholders are climate change and extreme weather events which are continuously posing a threat to the source of livelihood of smallholders. This threat is manifested in the form of low productivity, crop failure, crop destruction, reduction in water availability and land degradation (Recha 2011). Where such threat exists, smallholders in one way or the other will have to adapt in order to reduce their vulnerabilities to changes in climatic conditions. Farmers' adaptation to climate change is not only to reduce the impact of climate change on their farming activities but it is also geared towards ensuring that farmers are able to secure both the present and future source of their livelihood. The term adaptation is defined by Smit and Pilifosova (2003, p 881) as "changes in processes, practices, or structures to moderate or offset potential damages or take advantage of opportunities associated with changes in climate". Reddy (2015) similarly indicates that adaptation may also refer to protecting against negative impacts or taking advantage of the positive impacts or new opportunities presented by current and future changes in climatic conditions.

According to numerous authors, adaptation also involves the responses or various actions taken by individuals or communities to moderate the impacts or harm caused by changes in climatic conditions in order to reduce their vulnerabilities to changes in such climatic variables through different technologies and strategies (Smit and Wandel 2006, IPCC 2007, Skambraks 2014). It is significant to note here that there are different types of adaptation like planned, autonomous, reactive and anticipatory adaptation (Burton et al. 2004). However, this study focuses on autonomous (indigenous response) and planned adaptation (response strategy) (Brown et al. 2012). *Autonomous adaptation* is the action that takes place (among communities and individuals) in response to changes in climatic conditions without the intervention of a public agency or policy (Smit and Pilifosova 2003). It may also have to do with the innovative ways in which farmers react to extreme weather events in a manner that make sense to them in order to be resilient to climate change. *Planned adaptation* on the other hand is the outcomes of the recognition that there have been or there will be changes in conditions hence public agencies tend to make deliberate effort through policies to reduce risk or harness opportunities (The Energy and Resources Institute, TERI 2007). Egyir et al. (2015) further identify these adaptation

strategies as *indigenous adaptive strategies* and *modern productivity enhancing strategies* (MPES).

According to Skambraks (2014) adaptation entails acknowledging the need to adapt and the ability to adapt to climate change. Thus, farmers' adaptive capacity determines how well they are able to adapt to climate change and also the subsequent impacts of their adaptation practices on the environment. Smit and Pilifosova (2003, p 881) argue that "adaptive capacity is the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change". This adaptive capacity is influenced by social, political, economic (Smit and Wandel 2006) and biophysical factors (Feola et al. 2015). Farmers may not always have the opportunity to choose the best adaptation option available to them as according to Burton et al. (2004), these factors may serve as barriers or opportunities in pursuit of effective adaptation. This may therefore determine farmers' vulnerability to climate change and affect how farmers respond to changes in climatic conditions as they may choose strategies which can affect the environment in an unsustainable manner.

Smallholders in rural communities have for decades planned their farming activities by relying on indigenous knowledge to adapt to variations in weather conditions and climate change (Morton 2007, Thornton 2011, Mtambanengwe et al. 2012). By altering their farming practices, smallholders aim to reduce the effects of the negative impacts of climate change and harness the benefit of the positive ones on food production (Howden et al. 2007). Since climate change and extreme weather events pose a threat to the main source of rural livelihood, smallholders have modified their farming practices by adopting various indigenous adaptation strategies. The strategies are aimed to help farmers reduce and recover from the increasing stress associated with climate variability and other non-climatic stressors on their agricultural activities in order to sustain household income.

The indigenous adaptation which is developed by the farmers is a common practice among smallholders most especially in the developing regions and is guided by years and experience in farming. It mostly involves the use of rudimentary tools such as hoes and cutlass and largely relies on natural rainfall which makes farmers vulnerable to severe weather conditions (Ayivor et al. 2016). According to Osei-Owusu et al. (2012), indigenous adaptation practice is improved through farmer-to-farmer extension where farmers share knowledge on various ways of adapting to changes in climatic conditions and extreme weather events.

Indigenous adaptation involves practices such as manuring, tillage, ridging, mulching, fallowing, cover cropping, crop rotation, mixed cropping, traditional methods of irrigation (Below et al. 2012); weed and pest control, timing of planting, cultivating of short season local varieties and drought tolerant crops (Egyir et al. 2014).

Even though indigenous adaptation practices especially in the developing countries have been reliable in ensuring year-round crop productivity (Altieri and Koohafkan 2008, Enete and Amusa 2010, Altieri et al. 2012), the recent trends of extreme weather events and the rapid changes in climatic conditions are exceeding indigenous adaptation practices as it is reducing the capacity of smallholders to adapt and farmers are no more able to depend on historical trends for their present and future farming activities (IFAD 2015, UNCTAD 2015). Consequently, in order for farmers to enhance their resilience to climate change and extreme weather events as well as to secure the availability of food, they have integrated both the indigenous and modern adaptation practices (Osei-Owusu et al. 2012, Kuwornu et al. 2013).

The modern adaptation practices brought about through research and improved technology is geared towards enhancing farmers' resilience to climate change and its related shocks. It is also aimed at increasing the agricultural productivity of farmers while adapting to extreme weather events. This modern adaptation practice includes the application of chemicals such as fertilizers, weedicides and pesticides; improved crop varieties such as short duration crops and drought tolerant crops, tree crop planting, modern irrigation systems (Hassan and Nhemachena 2008); application of climate information, agricultural extension services, mechanized farming and development of markets.

Based on the extensive review from the on-going literature, it is increasingly being acknowledged that neither rigorous technological practices nor local practices are sufficient per se to improve smallholder's adaptive capacity to the risk and challenges associated with changes in climatic conditions (Uddin et al. 2014). The farming activities of smallholders are thus changing over the past decades as farmers are moving towards the adoption and integration of modern adaptation practices with indigenous practices which are considered to be a more climate resilient approach. However, the adoption of modern technologies among smallholders in the developing country is still evolving. Nonetheless, both the traditional and modern adaptation technologies may significantly increase productivity.

2.4 The significance of smallholder adaptation practices to rural livelihood

The integration of both the indigenous and modern adaptation practices is considered to significantly increase the agricultural productivity of smallholders (UNCTAD 2011, Osei-Owusu et al. 2012). These adaptation practices also have various impacts on farmers which are manifested in the income and livelihoods of farmers.

Improved management practices such as thinning, mulching, weeding, irrigation with fresh water can improve salinity and drought associated with climate change impact (Uddin et al. 2014). Water management practices such as rain water harvesting and drip irrigation as Reddy (2015) identifies improves crop yield, decreases poverty and boosts farmers' profitability as is the case among rain water harvesting farmers in Burkina Faso and Kenya. A study by Verchot et al. (2007) also indicate that agroforestry can help smallholders to diversify and maintain their farming systems as the practice provides the benefit of supporting farming activities during dry and wet periods. An analysis by the authors further show that the practice of improved fallow system among several farmers in East and Southern Africa significantly improve maize production on degraded soils where nitrogen is restraining production. These practices ensure the continuation of food production, reduce loss of crop productivity and minimize income risk among farmers.

A study undertaken among smallholders in Bangladesh by Uddin et al. (2014) indicates that farmers who practice crop diversification increase farm proceeds as farmers are able to reduce risk associated with climate change. This is further supported by a study in the forest savannah transition zone of Ghana by (Ayivor et al. 2016) specifying that diversified farming system such as the cultivation of early maturing maize crops and high yielding varieties of cowpea practiced among the farmers ensures food and income security. This helps farmers to sustain their household needs, escape hunger, satisfy their nutritional requirements, reduce rural poverty and sustain the environment.

Although the adaptation practices of smallholders are important in increasing food production, enhancing food security and securing their income base, these adaptation practices are also accompanied by environmental consequences. In long run, minimizing environmental risk and burden on resources and improving the welfare of the poorest individual of the society demands that adaptive capacity is improved in accordance with sustainable development goals and policies (Nhemachena and Hassan 2007).

2.5 Environmental implications of the adaptation practices

As already established in the preceding discussion, the combination of both the indigenous and modern adaptation practices have over the years improved the adaptive capacity of smallholders yet environmental problems have been an inevitable outcome of these practices. UNCTAD (2010a) and United Nations Environment Programme, UNEP (2012) point to the fact that these adaptation practices have an effect on the sustainability of the environment. Studies by IFAD (2013) and ActionAid (2015) further indicate that in the short term the present-day practices of smallholders may increase food production however these practices also have the propensity of degrading the soil and water resources in the long term, damaging the very resource base that supports rural livelihood. For instance, a study by Fintrac (2013) also indicate that the current practices of smallholders in Asia and Africa are damaging the climatic system as these practices are immensely contributing to the emission of greenhouse gases such as methane, nitrous oxide and carbon dioxide.

Despite the fact that indigenous adaptation practices may involve no use of agrochemicals, Pretty et al. (2011) observe that these practices may involve the excessive use of natural resources which can adversely affect environmental conditions as farmers are under pressure to increase productivity. The excessive use of natural resources leads to reduction in soil organic matter, water quality and quantity and soil erosion (International Assessment of Agricultural knowledge, Science and Technology, IAASTD 2009). For instance, a study by Killebrew and Wolff (2010) on the environmental impacts of agricultural technologies indicates that practices such as intensive continuous cropping and conventional tillage have reduced soil fertility in Western Kenya, Central and Eastern Uganda and Nigeria. Therefore, the adaptation practices among many indigenous people may weaken their adaptive capacity instead of strengthening resilience to climate change (Framework Convention on Climate Change, FCCC 2013).

Similarly, even with the success of modern technology (such as agrochemicals and machinery) which provides adaptation benefits to climate change, studies opine that it has significant unsustainable environmental impact (Osei-Owusu et al. 2012, Wolfenson 2013). These environmental externalities (IFAD 2013) include loss of biodiversity, pollution of water and soil nutrients, ground water depletion, loss of soil fertility and pest and disease control (IAASTD 2009, IFAD 2011, UNCTAD 2015). In sub-Saharan Africa, although indigenous

adaptation practices are widely used, smallholders are taking advantage of modern adaptation practices to better adapt to extreme weather events but these practices also come with severe environmental problems (Muzari et al. 2012, Mapfumo et al. 2013). UNCTAD (2015) asserts that such environmental problems are as a result of inappropriate use of agrochemicals both in quality and quantity which leads to the pollution of environmental resources. The harm caused by modern practices limit the ability of the land to naturally regenerate itself leading to loss of land productivity and the subsequent reduction in food production in the long term (UNEP 2012). There is therefore the need to assist farmers to adopt environmentally friendly farming practices that are climate-resilient and tailored toward conserving and restoring the environment (ActionAid 2014) from which farmers derive their source of livelihood.

According to IFAD (2013) the practices of smallholder farmers are not always detrimental to the environment. Altieri and Koohafkan (2008) argue that the adaptive agricultural systems or practices adopted by smallholders in order to be resilient to climate change may have different environmental effects. They may promote, conserve, restore or manage biodiversity or ecosystem services while others may not be ecologically sustainable or friendly in the face of climate change (UNEP 2012, Vignola et al. 2015). This therefore indicates that smallholder practices when given the right direction would no doubt help improve their contribution towards a sustainable environment.

2.6 Measures in tackling the negative environmental implications

From the preceding discussion, there is no doubt that today; the various adaptation practices adopted by smallholders may have negative impacts on the environment. Vignola et al. (2015) asserts that even though there is a widely recognized concern about environmentally sustainable based adaptation practices little has been done concerning how smallholders sustain environmental resources while they build resilience against climate change. Meeting the demand for agricultural products while maintaining biodiversity and protecting ecosystem amidst the changing climatic conditions can be very challenging (Harvey et al. 2008). However, due to the adverse impacts of smallholders' adaptation practices on the environment; promoting farming practices that is environmentally friendly among smallholders is very crucial in contributing to both mitigation and adaptation to climate change as well as conservation of the natural environment (IFAD 2013, ActionAid 2014).

Several studies have thus suggested various approaches in tackling environmental problems associated with smallholders' adaptation practices. These researchers have put forward their opinions on the need to promote sustainable agricultural practices most importantly among smallholders (Ajayi et al. 2008, Sterve 2010, ActionAid 2011, Pretty et al. 2011, Alder et al. 2012, Altieri et al. 2012). According to UNCTAD (2010b) sustainable agriculture embraces inter-related soil, crop and livestock production practices while minimizing or putting an end to harmful external inputs. The promotion of sustainable agricultural practices is vital due to the high dependence of smallholders' activities on the natural resource base for sustainable rural livelihood and therefore when the stability of the environment is maintained so will it reduce farmers' vulnerability and the associated risk of climate change. IFAD (2013) further posits that such sustainable agricultural practices if encouraged among smallholders can be a measure to promote food security, poverty reduction and environmental protection.

The various approaches include promoting ecosystem-based adaptation practices (Vignola et al. 2015); institutional support and integration of programmes that promotes environmentally friendly technologies (IFAD 2013); agroforestry (Mbow et al. 2014); integration and proper management of both the traditional and modern adaptation practices (Clements et al. 2011). Other researchers also emphasize that it is essential to acknowledge the unequal distribution of climate change impact on various social groups (FCCC 2013). Alliance for a Green Revolution in Africa, AGRA (2014) hence calls for gender-based initiatives and programmes which are aimed at targeting women since women are more likely to adopt sustainable practices better than their male counterparts when women have access to information. Likewise, IFAD (2011) notes that young farmers should also be targeted during such initiatives and programmes since they are more likely to adopt new technologies and knowledge. This is supported in a study by Ali and Erenstein (2017) showing a positive correlation associated with the adoption of numerous adaptation practices among young farmers in Pakistan. As stated by the authors the young farmers are probably open to innovation and new technologies in order to boost agriculture.

These studies emphasize that by promoting the various approaches, smallholders' adaptation practices to climate change will help conserve and restore biodiversity and reduce damages already done to the natural environment and the climate while ensuring an increase in food production. Killebrew and Wolff (2010) however point out that the environmental impacts of the various approaches are also dependent on how radical the adaptation practice adopted are. For

instance, when farmers practice agroforestry such as the intensive planting of cashew and the canopy closes it negatively affects food security as farmers may be unable to grow other food crops among the cashew plants. The geographical distribution of biodiversity on the other hand within the area can also be affected since animals which depend on other food crops or plants species may migrate to other places. In the same way, the application of organic manure (an indigenous practice) which has been considered as a more sustainable practice than inorganic fertilizer may in the long term be environmentally unfriendly when the intensive application of the manure can lead to contamination of water bodies during runoff as well as air pollution. For these reasons, the adoption of the above named sustainable approaches to farming should be practiced within a certain threshold in order that they may not have unsustainable environmental consequences in the long term. The various approaches can further be categorized into the following sustainable practices:

Sustainable land management practices such as agroforestry (Ajayi et al. 2008, Clements et al. 2011, Reddy 2015); agroecology (Alder et al. 2012, Altieri et al. 2012, Altieri et al. 2015); improving fallow systems (Ajani et al. 2013); proper grassland management (AGRA 2014).

Sustainable soil management practices such as conservation agriculture (Pretty et al. 2011, AGRA 2014, Reddy 2015); integrated soil fertility management which includes the application organic fertilizer and use of inorganic fertilizer in the appropriate quantity (Killebrew and Wolff 2010, Alder et al. 2012, Fintrac 2013); conservation tillage and zero-tillage (Ajani et al. 2013).

Sustainable crop management practices such as minimizing forest degradation and bush burning (AGRA 2014); practicing the use of cover crops, improved crop varieties, lengthening the period of crop rotation and crop diversification which includes cultivating leguminous crops (Ajani et al. 2013).

Sustainable water management practices which involves the efficient use of water resources such as surface water, underground aquifers and proper irrigation methods; wet land management and appropriate land drainage practices (Reddy 2015).

Studies by Ajayi et al. (2008), IFAD (2011) and Pretty et al. (2011) indicate that going beyond the various sustainable agricultural practices is vital to ensure a sustainable environment since their adoption among smallholders is motivated by several socio-cultural, economic and political or institutional factors. These factors include access to credit, loans and incentives (IFAD 2011); access to information and educational level of a farmer (Sterve 2010); agricultural

policies (IFAD 2013, Sullivan et al. 2013); land tenure and property right and low return on investment of many conservation practices (Alder et al. 2012). Since these factors influence farmers' choices in adopting environmentally friendly agricultural practices or not, it is important that the various factors should be considered when scaling-up sustainable practices among farmers.

2.7 Chapter Summary

The chapter pointed out that smallholders have made adjustments in their farming practices by adopting modern adaptation practices together with indigenous adaptation practices to better adapt to climate change. The adaptation practices adopted by the farmers are important to the sustenance of rural livelihood. The adaptation practices irrespective of their significance to the livelihood of smallholders may have significant negative impact on the environment. The negative environmental impacts caused by the adaptation practices of smallholders can be addressed by promoting various sustainable agricultural practices among farmers and further acknowledging the various factors that influence smallholders' behaviour in adopting sustainable or unsustainable agricultural practice.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1 Introduction

Several scholars have undertaken research in an attempt to contribute to the conceptual base of the environmental sustainability of smallholders' adaptation practices (Pretty et al. 2011, Feola et al. 2015). However, such scholarly knowledge pertaining to these concepts are still developing and therefore limited. In this respect, more needs to be done in order to provide further understanding on the wider picture of issues bordering farmers' adaptation practices and environmental sustainability. In an attempt to contribute to such theoretical base, this chapter discusses the theoretical framework that forms the basis for analysing the results and discussion of this research.

3.2 The concept of adaptation and environmental sustainability

From the literature review it can be acknowledged that smallholders tend to use unplanned adaptation as they mostly do not plan towards reducing the risk to climate change before any variations occur but rather respond to changes in weather extremes as they occur (Burton et al. 2004). Therefore, these adaptation practices such as the use of fertilizer and change in cropping pattern may be used only as ad hoc measures to changes in weather conditions but not as long term strategies since most of these strategies are unplanned. For example, Feola et al. (2015) indicate that short term adaptation practices are more common and easier to adopt among farmers than long term adaptation practices. Thus, farmers respond to changes in weather conditions as at when they happen but not in anticipation to future changes in climatic conditions with long term goals.

Climate change is known to have harmful effect on the natural environment and may result in environmental degradation and instability (Uddin et al. 2014, Egyir et al. 2015, Ndamani and Watanabe 2016) such as reduction in the quality and quantity of water resources (UNEP 2012); reduction in biodiversity (Brown et al. 2012); desertification (Muneer 2008); increase in soil erosion and changing pattern of pests (Nelson et al. 2010); salinization, diseases and soil fertility reduction (Verchot et al. 2007). Even though climate change has negative implications on the environment the adaptation practices of smallholders as already discussed have however been identified as factors also contributing to current environmental problems

(IFAD 2013). The various adaptation practices which are aimed at building resilience may undermine the very basis of sustainable agriculture and environmental stability. Even though there may be increased food production, the adaptation practices can also lead to environmental degradation such as greenhouse gas emission, pollution of water bodies, land degradation and reduction in ecosystem services which implies mal-adaptation. Planned adaptation on the other hand has the potential to improve and conserve environmental conditions such as improving infertile soils and plant health. However, this practice is less adopted among the majority of farmers due to challenges like cost and lack of institutional support.

Since the main aim of smallholders is to adapt to climate change and extreme weather events, farmers will adopt practices which they believe will have a direct effect on their household income (Fintrac 2013). As a result, farmers may not factor into their choices sustainable land use practices when using certain adaptation practices since environmental benefits concerning these practices are somewhat regarded to be externalities (Izac 1997 as cited in Ajayi et al. 2008). The decision to adopt a particular adaptation practice in order to maximize benefit is furthermore influenced by other interlocking factors which are regarded by Komba and Muchapondwa (2015) as factors significant for the availability, accessibility and affordability of that adaptation process. A review of literature and conceptual framework on adaptation and sustainable practices further illustrates that the factors determine the extent and magnitude at which smallholders adapt to climate change and weather extremes.

A conceptual framework by Feola et al. (2015) on farmer behaviour in climate change adaptation and sustainable agriculture considers farmers' behaviour and decision-making as a process which are influenced by several factors (such as biophysical, socio-economic and institutional factors) in different circumstances. The authors demonstrate that farmers' decision-making may take place at different temporal (short and long term) and spatial (micro and macro) scales and across different levels (individual, household, community and national) over a timeframe. It is therefore important to understand the underlying factors which motivate or determine farmers' decisions and behaviour in adopting certain adaptation practices which may be unsustainable to the environment. This research on this account also aims to analyse the link between climatic and non-climatic factors which contribute to unsustainable adaptation practices among smallholders. This is critical in enhancing sustainable adaptation practices among smallholders and knowledge.

In adopting a conceptual framework the study takes into consideration three questions which help to identify and understand the complex processes that make smallholders' adopt unsustainable agricultural practices in the Wenchi municipality. These are what factors determine farmers' decisions in adopting a particular adaptation practice, when do farmers deem it appropriate to adopt these practices and how does adaptation practices to climate change which has evolved over time adversely affect the environment. This study does not seek to only focus on the environmental outcome of the various adaptation practices of smallholders but in addition it examines the primary processes and drivers which influence the decision making processes of farmers involved in adapting to climate change. The factors have been identified by several authors as biophysical, socio-economic and institutional factors (Below et al. 2012, Komba and Muchapondwa 2015). These factors which determine farmers' adaptation behaviour also form the theoretical basis for this research.

The framework distinguishes between the different factors which may influence farmers' decisions in adopting a particular adaptation practice. The theory is based on the assumption that farmers' response options to climate change and extreme weather events are to a large extent influenced by biophysical or environmental, socio-economic and institutional factors. In this framework climate change particularly increase in temperature and changes in rainfall pattern is inter-linked with non-climatic factors such as access to extension, government policies, asset endowment information network and agro-ecological location of the farm as shown in Figure 1. These multiple factors determine farmers' adaptive capacity and their level of vulnerability as well as the type of adaptation response a farmer will adopt depending on how these factors exposes the farmer to climatic shocks. For example, farmers exposed to *drought (a climatic factor)* may experience varying impacts of climate change due to differences in vulnerabilities as a result of differential *endowment of resources* such as *wealth and assets (a non-climatic factor)*. This leads to different adaptation practices among farmers as the resource endowment of a farmer determines the choice of adaptation practices and their consequent impact on the environment such as pollution of water bodies or regeneration of degraded land as shown in Figure 1. Many studies indicate that wealthy farmers tend to adapt better than poor farmers as their asset endowment determines the choices they make and how they adapt (Adimassu and Kessler 2016, Ali and Erenstein 2017). A wealthy farmer can decide to engage in irrigation thereby reducing his vulnerability as compared to the poor farmer. On the other hand, lack of

knowledge and access to extension services also shown in Figure 1 may lead the farmer who engages in irrigation agriculture to over-extract water resources thus affecting the water table.

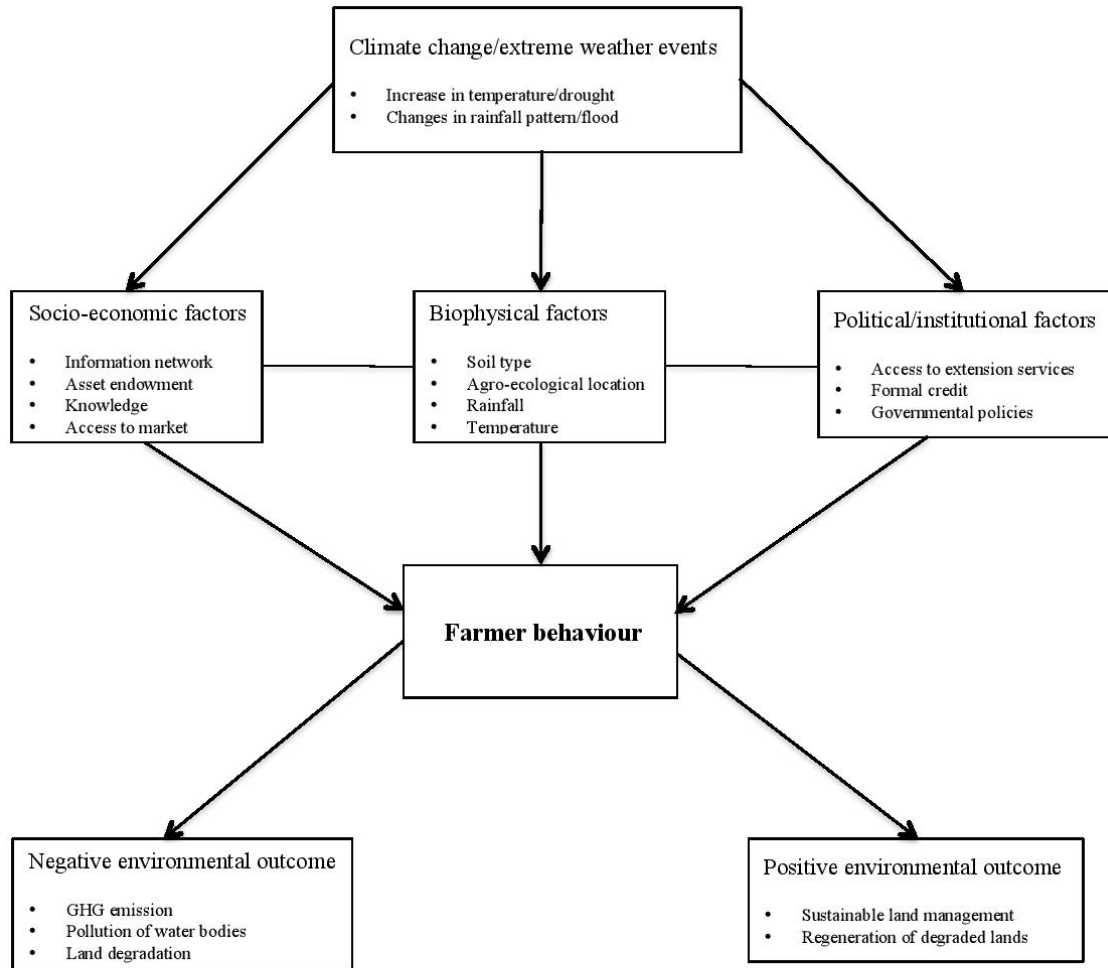


Figure 1: Conceptualising factors affecting farmers' adaptive behaviour to climate change

Some of the factors identified in the framework above may be well represented in the decision making process of a farmer while other may not. A limitation is that some of these factors may be a pressing issue affecting the adaptive choices of a farmer than the other. Apart from the study assuming climate change is the main reason for farmers' adaptation, the challenge lies in identifying which factor is most important in influencing farmers' adaptive choices.

3.3 Key factors that influence the adoption of sustainable adaptation practices

Smallholders are affected by both changes in climatic conditions and other drivers of change that may in themselves or jointly interact to affect the adaptive capacity of farmers (Burton et al. 2004). These factors also determine the level of vulnerability of smallholders to changes in climatic conditions and how smallholders are able to adapt to climate change in terms of making a decision on a particular adaptation practice and their subsequent environmental impact. In general, the factors could be looked at as: biophysical or environmental, socio-economic and political or institutional shown in Figure 1 above are discussed below.

Biophysical or environmental factors tend to affect farmers' behaviour in pursuing a particular adaptation practice and how the choices made also affect conditions of the natural environment. These factors include temperature and rainfall (Etwire et al. 2013); soil type (Feola et al. 2015), access to ecosystem (Burton et al. 2004) and the agro-ecological location of the farm (Legesse et al. 2013, Komba and Muchapondwa 2015, Menike and Arachchi 2016). The above named factors play key roles in shaping the adaptive choices among smallholders. For example, the fact that reduced rainfall total and prolonged dry season exist in the study area, farmers cannot resort to cocoa production for instance as an adaptation measure.

Socio-economic factors which shapes farmers strategic decisions include information networks, assets endowments (Feola et al. 2015, Menike and Arachchi 2016); knowledge, expertise (Burton et al. 2004); household characteristics and access to market (Hassan and Nhemachena 2008, Adimassu and Kessler 2016). A study by Ndamani and Watanabe (2016) indicate that the educational status of a farmer is important in choosing an adaptation practice since farmers who have attained higher level of education are more likely to engage in better technologies. This the authors relate to the fact that educated farmers are better informed due to their ability to obtain information on climate change and available adaptation practices.

Political and institutional factors remain a significant factor affecting the adaptation options among farmers. These include government policies on farm inputs such as insecticides, fertilizer, pesticides, availability of extension officers (Hassan and Nhemachena 2008); and access to formal credits (Menike and Arachchi 2016, Ndamani and Watanabe 2016). These factors determine how farmers are able to decide on an appropriate adaptation practice to climate change and extreme weather events. For instance, the availability of extension officers and training of farmers in the study area may influence farmers to adopt certain adaptation practices

such as planting of tree crops or the application of chemicals in the right quantity which may be environmentally friendly.

3.4 Chapter summary

The chapter explored the relationship between smallholders' adaptation practices and environmental sustainability. It identifies that the impact of smallholders' adaptation practices to climate change on the sustainability of the environment is context specific. This is because the interaction between farmers and the environment is dependent on other interlocking factors. The theoretical concept takes into consideration the various factors which serve as key drivers to the decision making process of smallholders in making a decision on a particular adaptation practice and their environmental outcome. A limitation of the framework is that it does not acknowledge which of the various factors may be more important in determining the adaptive decisions of a farmer over time and place.

The chapter in closing explained key factors that influence smallholders in adopting sustainable agricultural practices. The factors may either serve as barriers for effective adaptation or enhance the adaptive capacity of smallholders to climate change with varying environmental impacts.

CHAPTER FOUR

METHODOLOGY

4.1 Research design

A qualitative approach allows individuals to share their stories and experiences from their own perspectives and provide the truth of the issue as they see it with a better insight into the specific context and social setting that influence people's behaviour and choices. By interacting directly with participants, the researcher is able to have a "complex and detailed understanding of the issue, ... how participants in the study address the issue" (Creswell 2007, p 40) and the subsequent outcome. Since the study aims to explore in detail the complex and the changing processes involved with farmers' adaptation practices and their subsequent impact and changing effect on the environment, the qualitative approach was appropriate for this study.

Also, the choice of a qualitative research method over other research methods is to gain an in-depth understanding of what happened in the past and how that has contributed to the present situation. This can best be achieved by having a profound interaction with the people as they reflect and provide a historical account of their experiences which qualitative research method provides. Moreover, since there has been limited study on the research topic in sub-Saharan Africa (SSA) and this research sought to capture varied responses concerning the various and changing adaptation practices of smallholders as well as the subsequent modification of these practices on the environment, the qualitative method was best suited for this purpose.

During the research process, I had to keep in mind how I might influence the research process and outcome as I interact with participants. Therefore, reflexivity an important aspect of qualitative research was significant during the entire research process. I therefore had to go through self-scrutiny from the selection of the research topic, choosing a research design and also during data collection. I had to reflect on what had been said and not my own opinions so as to reduce my impact on the data collected and limit my influence on the outcome of the research as much as possible. It is also worth mentioning that I had to ponder over certain ethical issues so that participants feel comfortable sharing their experiences. I will discuss some of the challenges encountered in the field and how I overcame those challenges as well as pointing out some of the limitations of the study.

4.2 The research process

4.2.1 The area for the study

The forest-savannah agro-ecological transitional zone among the six (6) major agro-ecological zones in Ghana became the larger research area that was of an interest to me during my readings. My choice of the forest-savannah transitional agro-ecological zone was informed by the studies of other researchers indicating changes in climatic conditions within the zone over the past decades (Adjei-Nsiah and Kermah 2012, Owusu and Waylen 2013b, Egyir et al. 2014, Egyir et al. 2015). Similarly, the zone which is also said to be the breadbasket of Ghana host smallholders for whom business as usual must go on and would therefore have to adapt to the changes in climatic conditions in the area. Moreover, knowing that the zone lies between the northern and southern part of Ghana and may have different characteristics of smallholders such as indigenous and settler farmers, I deemed the zone to be an interesting area for my research.

Since the research could not be conducted in the entire transition zone, I still had to make the choice of selecting a specific community within this zone as a specific area for conducting a comprehensive study. I sought information on the various districts within the zone which have experienced changes in climatic conditions by reading from the various district's website and other statistical reports while also keeping in mind that the communities within the district should engage in some farming activities. The Wenchi municipality turned out to satisfy my interest since studies indicates that there have been changes in climatic conditions of which farmers are adapting to (Egyir et al. 2014). I further had to narrow the search down to a specific community within the municipality which would serve as my area of focus for the research as I had over 14 communities at my disposal. Even though I read over some of the profiles of the various communities within my chosen municipality the information was not enough to influence my choice. I therefore had to consult a researcher who (I will refer to as my facilitator in the next sections) had conducted several studies within the area.

I finally settled on the communities Nkonsia and Awisa before going to the field with the intention of choosing one of these communities and hoping that my choice would better help me achieve my research objective. The plan was to visit one of these communities and have an informal conversation with some farmers before finally settling on one of the communities. I however did not rule out the possibility of encountering a null case and what I would do should I come to face such a reality. Moreover, knowing that time was very essential due to my limited

stay on the field, flexibility an important component of qualitative research was a significant consideration.

According to Owusu and Waylen (2013a) the forest-savannah transitional agro-ecological zone of Ghana runs across the country from west to east approximately between 5°N and 8°N in accordance with the regional rainfall pattern and is bordered to the southwest by the tropical forest, to the southeast by the Coastal Accra Plains and to the north by the sub-humid areas. Thus, the zone occupies a landmass of 28% of the total land area of Ghana (Aquastat 2005).

The area receives an annual average rainfall ranging between 1,200 mm and 1,300 mm which is characterized by high inter-annual and multi-decadal variability and is controlled by the migrating pattern of the Inter-Tropical Convergence zone (ITCZ) (Ayivor et al. 2016). The zone experiences a bimodal distribution of rainfall with a growing period between 200-220 days in the major rainy season and 60 days in the minor rainy season (MOFA 2011, 2016). According to Egyir et al. (2014) late March/early April marks the onset of the major rainy season which lasts through to mid-July and is followed by a short dry spell in July-August and a minor rainy season in September-October preceding the November-March long dry spell. Owusu and Waylen (2013b) indicate that the area has a diversified agricultural production with major food crops being maize, cassava, yam and cash crop such as vegetables and cocoa. This indicates that the ability of farmers to effectively adapt to changes in climatic conditions is crucial as this may have a significant impact on Ghana's food security.

The research was conducted in the Wenchi municipality located in the Western part of the Brong-Ahafo region in the forest-savannah transitional agro-ecological zone of Ghana. The municipality is one of the 22 administrative districts of the Brong-Ahafo region of Ghana with a population of 166,641. It is bordered by the Sunyani municipality to the south, the Kintampo south district to the north and shares a common boundary with the Tain district and the Techiman municipality both to the west. The municipality occupies a landmass of 3,494km² with Wenchi being the capital town. With respect to climate, the municipality usually experiences high temperatures with an average temperature of 24.5°C with the hottest temperature occurring between February and April. The municipality like the other areas in the transition zone experiences two main seasons with the rainy season occurring between April and October with an average annual rainfall of about 1,140-1,270 mm and the dry season between November and

February. The municipality has several rivers and streams with the major rivers such as Tain, Subin and the Black Volta flowing all year round. Wenchi municipality has a blend of the moist semi-deciduous forest and the Guinea Savannah woodland vegetation which supports the cultivation of variety of crops such as tubers, cereals and cash crops.³

The research was specifically conducted in Nkonsia which served as the community within the Wenchi municipality for the study. The area even though closer to the Wenchi town is also connected by a major road to the Techiman municipal. The majority of smallholders within the community grow vegetables and tubers with cashew being the major cash crop cultivated within the area.

³ http://mofa.gov.gh/site/?page_id=1389 accessed 10 October 2016

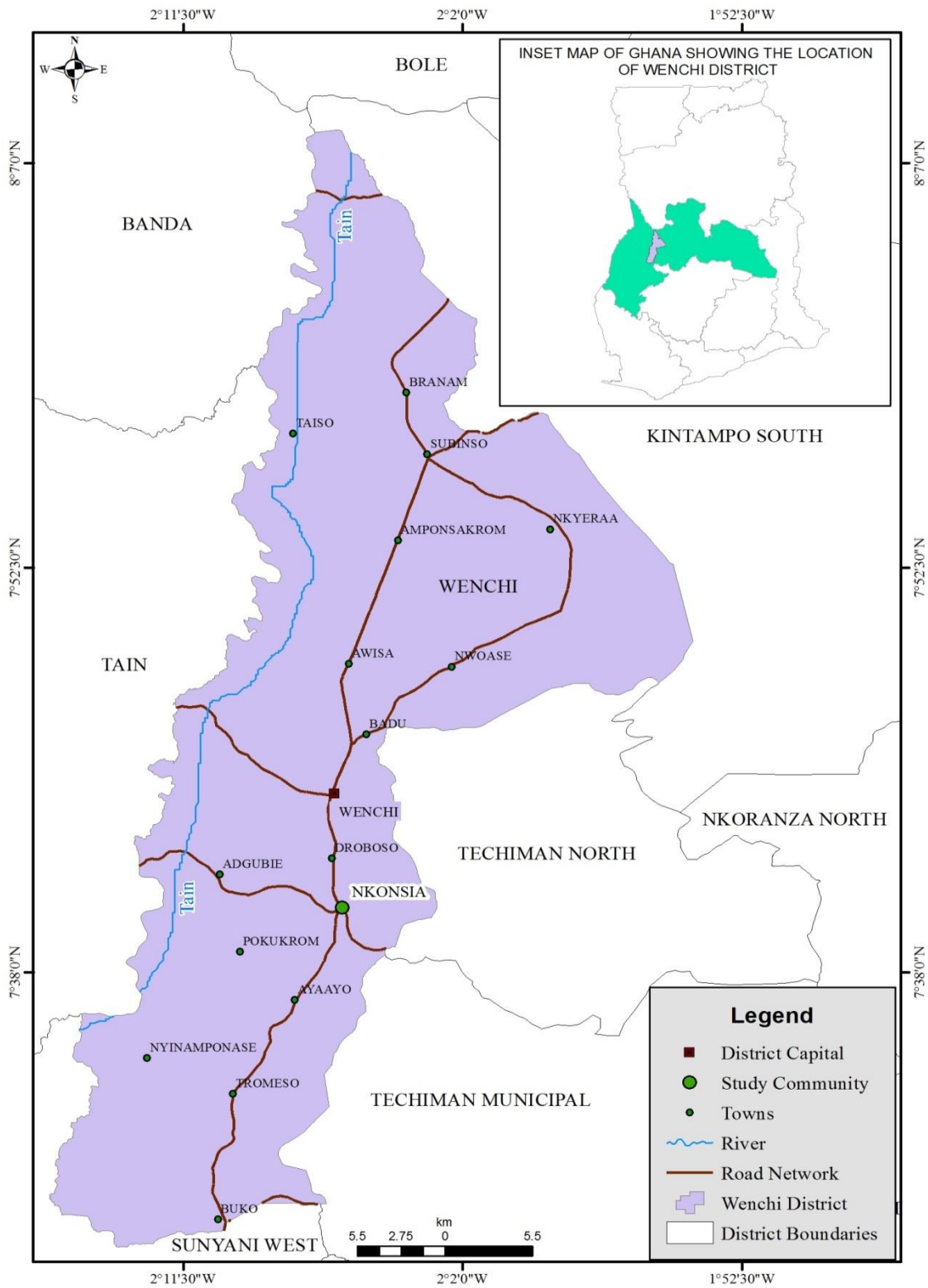


Figure 2: Map of Wenchi Municipality of Ghana.

Source: Geographic Information Systems Lab, University of Ghana, 2017.

4.3 Processes of data collection

Given that the study employed a qualitative research design, the research questions which were conducted were under the qualitative research methods such as semi-structured interviews and focus group discussion (FDG) with informants and in-depth interviews with key informants. The basis of this research was not only to understand the present outcome of the issue but also to understand the processes that have contributed to what is seen in the present. As a result, questions were structured in a way that will enable me gain insight into what happened in the past, what is happening now and to possibly predict what may happen in the future depending on the information received. There was also a review of existing literature which was of relevance to the purpose of the study in order to enhance quality of the research. Furthermore, to ensure rigour in my data collection processes I broadened my data collection by gathering information from multiple sources which according to Creswell (2007, p 43) is the “backbone” of qualitative research. The sources included field observations and captured images which also provided a better reflection of the issue under study and enhanced an understanding of the research problem.

4.3.1 Gaining access into the community

The ability of a researcher to gain entry into the research community is an important aspect of a field work. It is even more important when the researcher in this case is unknown to the research community and this can pose certain challenges to the researcher. Creswell (2007) indicates that such challenges involve persuading individuals to take part in the research, building trust and credibility and securing people to respond at the field site. The researcher will therefore have to make use of various resources that will enable him gain access into the community as this may determine how the researcher is received by and interacts with the people, how the researcher is able to identify the people who would be of relevance to the research and subsequently how the researcher goes about the field work. One of such resources in my case was the gatekeeper. A gatekeeper is one who links the researcher to the research community or the people within the research area.

Prior to my entry into the field site, I consulted my facilitator who as I have previously said has conducted several studies in the Wenchi municipality. We discussed which community will be my first point of entry as I was contemplating on two communities, my research objective, the category of informants I would interview and some possible challenges which may

occur since the research was being conducted in the rainy season when smallholders are mostly on their farms. On my first day on the field my facilitator introduced me to the gatekeeper who was the assembly man of the Nkonsia community. I then informed him about the purpose of my study, the category of farmers I intended to interview and my time on the field which was a maximum of 7 weeks. I also discussed with him my intention of conducting a pilot study to ascertain whether the farmers would provide me with answers needed to achieve my research objective. The gatekeeper also agreed to introduce me to an environmental officer in the Wenchi municipality. I must say it was much easier to discuss with the gatekeeper what I intended to do on the field as he was educated, knowledgeable and easily understood what I needed to do. I was therefore able to establish rapport with him on the first encounter. The gatekeeper was also very helpful as he provided information on when smallholders normally went to their farms and returned and therefore the most convenient time to talk to these farmers. This ushered me to prepare adequately for the interview.

Based on the information provided by the gatekeeper I conducted a pilot study during late afternoon on my second day on the field. The gatekeeper introduced me to two farmers whom I had an informal conversation with. We discussed general issues concerning their farming activities, changes in climatic conditions over the years, how they have adapted and if the farmers had observed any changes in the environmental conditions over the years. I was very tactful with my questions since I did not want to cover in details the questions I had already prepared for my main interview. The purpose of this was to avoid repeating the same questions to the farmers in question should I finally settle on Nkonsia as my research area and would have to interview some of these farmers whom I had already conducted a pilot studies with. It was also to inspire some interest in these smallholders should I interview them again during my main interview. I was however careful that my conversation with the farmers would provide me with the anticipated answers. Even though I had access to the gatekeeper I did not totally rely on him to provide me with the people I needed to talk to. Being an outsider in the community it was also very important as a researcher to get myself familiarize with the people and the community. I therefore went about from one house to another talking to famers who were willing to talk to me about my research topic.

During my pilot studies, I made some interesting discoveries which presented me the opportunity to make certain adjustments concerning how I go about my research most especially

concerning my research questions. I realised that some of the farmers even though were inhabitant of the community did not have farms within the area. These smallholders mostly came to spend some time with their families and would go back to the communities where their farms were located. For this reason, it was very important for me to ask about the location of the farm before the actual interview began. This I would never have thought to be important if I had not done the pilot studies. Secondly, my informal conversations with the famers revealed that some of the farmers had multiple lands which varied in size and served different purposes. Since one of my interview questions required that farmers indicate the size of their farms I wondered what would influence their choice. Will the farmer combine his small farms and indicate the size of the farm to be big or will the farmer indicate the size of the farm on which he cultivates his major food crop. I had to take these issues into consideration and probe further into the answers provided during the interview. Hence, the flexibility of my research which I anticipated was coming in handy. My pilot study enhanced the quality of my research since it enabled me to obtain information from the appropriate people needed and thus avoid certain errors in my research.

It is also worth mentioning here that I decided on Nkonsia as the study area after my pilot findings had indicated changes in climatic conditions and also ecological changes within the area after farmers had adopted certain adaptation practices. Hence, the area was of interest to me as both the research area and the people were appropriate for this research. In addition, considering my limited time and the fact that the research area served my research objective, there was no need to conduct a pilot study at Awisa.

4.3.2 Challenges with the gatekeeper

Every gatekeeper may exert some influence on a research and this also affects the research in respect to the people the researcher is able to interview and subsequently the information that the researcher is able to gather.

During my stay on the field, I realised that the personality of my gatekeeper had an effect on the information I was to gather. The gatekeeper helped me to gain access to the people by arranging a meeting to enable me interview them. This lightened my workload and saved me time. Even though the farmers were within the category of farmers I wanted to interview, as I had earlier discussed with the gatekeeper, I noticed during the initial stages of my interview a

constant problem. The people whom I had access to and were available for the interview were male farmers which I noticed was due to the rapport that existed between the gatekeeper and the farmers of the same gender. As a result, I discussed with the gatekeeper the need to interview female farmers at the initial stages of the interviews as they may provide varied responses to the issue and their information may also help me make certain adjustments to the study if needed. Secondly, I came to observe that the people I was interviewing were too familiar with the gatekeeper and who had some personal relationship with him. I then began to consider the effect of such a situation on the information I was gathering as information may not be so reliable. For this reason, I decided to not to rely solely on the gatekeeper but also to randomly select farmers for interviewing while keeping the category of farmers relevant for the research in mind.

Another challenge with the gatekeeper was his position as the assembly man of the community. Thus, he was able to use his position and power to coax people to make themselves available for the interview as I once witnessed such a confrontation. Even though that was in my favour as a researcher I had to think beyond numbers and consider the quality of information that I would be able to gather so as to ensure the success of the research and also be mindful of ethical requirement of the research. I therefore took the initiative of moving from one house to another to interview farmers who were particularly interested in talking to me. Thus, I was able to gain confidence in the farmers I interviewed as well as the information that I was able to gather in an ethically transparent manner. This had a positive impact on the quality of data I gathered.

4.3.3 Recruiting informants

In recruiting informants for a research work, it is important that the researcher is able to identify the *right informants* who would provide the relevant information to the issue. This means that the researcher would have to purposively select the informants who would provide answers to the research question and help the researcher achieve his research objective. Thus, the people who would be selected should have an in-depth knowledge about the research topic and who are also sensitive to the problem. Since I was exploring the environmental impact of smallholders' adaptation practices to climate change I realised that there were 3 categories of informants who could provide me with the relevant information. The informants included farmers and key informants who were an agricultural extension officer (AEO) and an environmental officer each

at the municipality and National level. These informants I believed would help me achieve my research objective.

In selecting farmers for the interview I had to consider several factors which I believed would provide the needed answers to my research questions. Thus, selection of informants was based on certain criteria. Significant attention was placed on the farming experience of the informant which I believed would reflect the farmer's knowledge on issues on environmental change due to the nature of adaptive practice used in the study area. Also, to obtain a better understanding of the current situation it was important to access informants who were engaging in farming before and after the extreme changes in climatic conditions. I believed this would also enable me have varied knowledge of their experiences on environmental changes due to their farming practices from the past to present. It was also to have a better appreciation of the realities of these environmental impacts as against perceived ones. Therefore, farmers who were above the ages of 30 satisfied my research interest prior to the interviews. Nevertheless, I had to make certain adjustment on the field as some farmers who were below the ages of 30 provided some interesting information relevant for the research. Maddison (2006) further indicate that even though experienced farmers may be aware of climate variability and change it is the educated farmers who actually respond to these changes. For this reason, the educational status of the farmers was an important consideration. Furthermore, gender, major crops cultivated and ownership of farmland and size were included in the criteria as these characteristics of farmers would have varied responses to the changes in climatic conditions.

The selection of key informants did not follow any strict criteria. My technique of selecting an (AEO) was that the informant should be stationed within the Wenchi municipality as I believed the key informant would have direct interactions with the farmers within the study area and as such would have knowledge on the research problem. With respect to the environmental officers, the decision was that two would be needed to completely inform the study. One environmental officer located within the Wenchi municipality whom I believed would be abreast with the environmental conditions within the study area and would have direct experience and knowledge on the topic. Also, another key informant who was considered relevant to the study was an environmental officer with national experience in adaptation and environmental change among smallholder farmers to offer a broader perspective on the subject.

4.3.4 Interviews

One of the common ways of gathering information which a researcher cannot provide is by interviewing. Qualitative interview approach provides people the opportunity to talk about their experiences and situation in their own words. Patton (2002) further points out that:

“The purpose of qualitative interviewing is to capture how those being interviewed view *their* world, to learn their terminology and judgement, and capture the complexities of *their* individual perceptions and experiences.”

Qualitative interviewing hence enables the researcher gain access into other people’s minds and perspective. It is therefore the responsibility of the researcher to gather quality information that will be of relevance to the research. Gathering of quality data is also dependent on the kind of interview strategies the researcher employs.

For this study, semi-structured interviews were conducted with smallholders in Nkonsia. Semi-structured interview allows the interviewer to follow up on leads provided by the informants during the interview which are not in the interview guide. This permits flexibility in the interviewing process. Though there was an interview guide it served as a reminder of issues to cover during the interview. Informal conversations held during the pilot interviews with some of the farmers assisted me to modify some of the questions with other informants.

Semi-structured interviews were conducted with 15 male farmers and 5 female farmers (as shown in appendix 1) as the male farmers were more easily available than the females and therefore variations in response from the female’s perspective was made up for by the female FGD. Each interview conducted lasted for a maximum of 50 minutes. There were also in-depth interviews with an AEO of the Ministry of Food and Agriculture (MOFA) and an environmental officer of the Environmental Protection Agency (EPA) in the Wenchi municipality and another in-depth interview with an environmental officer in the Department of Climate Change of the Environmental Protection Agency in Accra. The interview with the key informants usually lasted for over an hour. With the consent of my informants, the interviews were recorded and field notes taken to serve as backup should there be any unforeseen challenges with the audio recording. It was also to increase attentiveness during the interview and enhance the accuracy of data gathered (Patton 2002). In order to ensure rigour and enhance accuracy in the data collection, I went over the interview that I had conducted by the end of each day by listening to

the audio recordings. This was to enable me identify any mistakes in my interview such as inadequate probing of answers or demand for clarity of answers. However, as the weeks progressed the review could not be carried on after the day's interview since the research became tedious and I was mostly tired by the close of the day. Nevertheless, I reflected and wrote down under various themes the information I had gathered by the end of each day.

In terms of the place for the interview most of the interviews with the farmers were held at their homes. It is worth mentioning here that the place for the interview at the initial stages of my field work posed certain challenges however the problem was rectified in the course of my interview which has been captured under challenges at the field site. The interviews with the key informants took place in their respective offices with the exception of the AEO who was interviewed at home. My interview with the environmentalist in Accra (EA) turned out to be more of an advantage to me than I expected as the informant was able to easily access information which was available in his office. The key informant was able to show me some images concerning the environmental effects of smallholders' adaptation practices to climate change in other parts of the country. This increased my understanding of the problem and also enabled me to make certain assumptions concerning such environmental impacts in my study area. Unfortunately, my informant was unwillingly to allow me obtain those images. The interview with the environmentalist in Wenchi (EW) which was held in his office turned out to be more of a discussion among 4 people than an interview with just the key informant. Since I did not have control over the place for the interview it also turned out that I could not also have control over the people available during the interview as the EA preferred that the people in the office join in the interview with the purpose of sharing knowledge. The advantage was that there were different views on the issue under discussion. This had a positive impact on my data.

With respect to language, interviews with farmers were in the local dialect. I on certain occasions took the services of an interpreter to interpret some of the technical terms from English to the local language to facilitate farmers' understanding of the questions. It is important to note that, the interpreter had little influence on the data collected since most of the interviews were conducted by me and therefore the presence of the interpreter did not affect the quality of the data obtained. The interview with the AEO and EW were in a mixture of both English and the local language as was used by my informants. I therefore followed their lead each time the

language was switched. Interview with the EA was very formal and therefore English was the mode of communication.

4.3.5 Focus group discussion

As part of the data collection processes there was a FGD with some of the farmers. The purpose was to access the ideas; views and knowledge that individuals within the group would have concerning the issue and topic under discussion (Limb and Dwyer 2011). Furthermore, considering my limited stay on the field my intention was to gather as much information as possible within a short time period which this interview method best suited the purpose.

Two separate FGDs were conducted with each group comprising of farmers of the same gender. The purpose was to allow the women to freely express themselves and share their varied opinions on the issue. Moreover, males dominate the traditional setting and if there was a mixed focus group it might prevent the women from easily expressing their candid opinions on the issues or oppose their male counterparts should they have any varied opinion. As a result, individuals within each group were encouraged to share their differing opinions on the issue. Patton (2002) points out that the number of people in a focus group is usually between 6-10 people. Following this recommendation the FGDs comprised of 6 and 7 individuals for the male and female focus group respectively. The criteria for selecting of informants for each group were also based on the major crops cultivated, farm size, age and the level of education of the farmer. The objective was to allow for dynamics across the various groups of farmers, ensure variety in the information and allow for attentiveness within the group.

Patton (2002) asserts that during a FGD participants may not necessarily agree or may disagree with each other or reach a consensus. In my opinion such disagreement can also turn out to be an argument which if not controlled may disrupt the entire interview. The male group discussion was very interesting as I observed that the discussion was not just a learning process for me but for also for my informants as contributions made by the older farmers enlightened the younger ones. On the other hand, it also turned out to be very challenging as certain individuals did not seem to agree with each other's opinion. Such differing opinions nearly turned out to be a heated argument as an older farmer tried to impose his opinion (and in a way his seniority) on a younger farmer who also thought differently as I asked about the cause of climate change in the community. I realised that the older farmer was talking from years in farming and experience

whiles the younger farmer (though also experienced) was rather being influenced by religious beliefs concerning the issue. This made me aware of the different factors which might be influencing the divergent views of the informants. In order to prevent the argument from escalating and losing my discussion I made my informants aware that differing opinions were important for the research and that nobody was wrong if that was what they believed.

4.3.6 Field observation

I conducted a field observation with the help of one of a male farmer whom had been previously interviewed. The purpose was to experience and witness what my informants had already told me concerning changes in environmental conditions. I also took the opportunity to take pictures of some of the physical evidence of farmers' adaptation practices such as ponds created by the farmers to obtain water during the dry season and also for fish rearing during the rainy season. Pictures of some plant species which were not originally on the farm but have taken over the land due to the use of chemicals as reported by the farmers were also taken. The field observation was furthermore a learning process for me since there was the opportunity to talk to other farmers about their adaptation practices and the subsequent environmental issues without it necessarily being an interview. This further led to a deeper understanding of the information I had already gathered and could better relate to it during the analysis.

4.4 Interview and power relations

Qualitative interview approach is highly interactive and creates a relationship between the interviewer and the interviewee. Cloke et al. (2004) point out that this research relationship will vary depending on the one being interviewed and this may result in different power relations. Hence, an interaction with a government official may be different (as the respondent can exert more influence during the interview) from that with a teenager. Also, how the interviewer is presented determines how informants make certain perceptions or view the interviewer. Therefore, appearance is very important during an interview as this also influences the relationship between the interviewer and the interviewee as well as the data generated.

During my interview with the two environmental officers I put on a formal dress to suit the purpose for the interview. My appearance was not only influenced by who was going to be interviewed but also where the interview was going to take place. Thus, I dressed casually for my

interview with the AEO since the interview was held in the house of my informant. With my interview with the farmers I put on a casual dress and paid much attention to how I appeared and portrayed myself. I did my best to blend with the locals as much as possible not just in the way I dress or how I interacted with them but also the language as I spoke in the local dialect.

In terms of power relation, during my interview with the EA, I realised the official exerted more power and authority. The officer decided beforehand how long the interview should last or how long I spent on each question. However, I tried to maintain some control over the interview by probing more into each answer provided in order to generate quality information.

4.5 Interview questions and sequencing

Questions posed during an interview are aimed at exploring what people feel or think about the issue, their attitudes towards the issue or their experiences with the issue. In order for the participant to provide the right answers or give a truthful account of the issue, it is essential that the interviewer frames the questions in a manner that allows the participant to understand exactly what is expected. Since there are different strategies to enquiry Cloke et al. (2004, p 127) state that:

“choosing an appropriate practice for asking questions should therefore be considered as part of a much wider research strategy, fully interconnected both with careful formulation of research questions and with a clear idea of how the data are to be interpreted.”

Patton (2002), on the other hand, distinguishes between different types of questions that an interviewer can ask during an interview and specify that the clarity of the questions determines how the informant is able to understand and respond appropriately. It is thus important that the researcher pays attention to the wording and the ordering of questions as well as the kind of language used to enable the interviewee follow up during the interview.

This research adopted an approach of questioning which was aimed at discovering in-depth people's perspective and attitude towards the issue under study. Since the ordering of the research questions is dependent on the researcher the study started by asking questions that provides background information about the informant. The purpose was to identify the different characteristics of each individual and prepare the informant for further questions. After the

background questions, further questions did not actually follow a clear order as I found myself going back and forth inquiring about the opinions, knowledge, experience and behavioural attributes of my informants. Knowledge and opinion questions required informants to talk about their experiences and also to provide their thoughts about the issue. The questions also covered behavioural attributes concerning the activities and future expectations of informants concerning the issue.

Questions covered a timeframe of the past, present and then the future. Individuals were asked to reflect on their past experiences concerning the issue and then I gradually moved towards obtaining information on the current situation. The purpose was to refresh the memories of my informants so they can make better judgement on the issue now. This was then followed up with questions that required the informant to talk about future expectations and attitudes. Thus, questions were in the past, present and future tense. With respect to language, it was simple and carefully worded. However, I soon realised that my ability to translate the English language to the local dialect to enable my informants to understand was very significant as the interview was in the local dialect. As a result, translating certain technical terms to the local dialect proved to be a little challenging. However, questions posed were carefully worded so that the informant could understand the question in order to not to lose meaning of what was being put across. Data obtained was thus not affected.

4.6 Data analysis

Once the primary data was obtained from the field they were transcribed and coded based on the themes and issues that emerged. The list of codes was organized using the structural approach. By structural approach, the data was coded under main and similar categories and further sub-categorized using the conceptual framework as a guideline (Skambraks 2014). For example, a main category used was extreme weather event and sub-category was drought or flood. This was to help bring out a better understanding of emerging and contrary issues. Data obtained were presented by directly quoting informants throughout the analyses to give a better reflection of real life issues from the informants' perspective. Conflicting opinions from various informants' have also been presented in the analyses to reflect the varying opinions of different categories of people (for example, either by gender or occupational background) on the issue during the field interview. This is to show that in real life events people may have different perspective about the

same issue. For the purpose of clarity and anonymity, informants have been given proxy names to aid in the analyses.

4.7 Field experience and challenges

Although every researcher anticipates some challenges on the field such as problems with audio recorder, time and place for interviewing informants and possible ways to address these challenges, sometimes how to address certain challenges may take a different turn when the researcher faces such realities on the ground. The researcher would one way or the other has to find some solutions to these challenges in order to ensure the continuation of the field work.

4.7.1 Time for the interview

One of the major challenges I faced during my stay on the field was the time for the interview. Majority of the interview with the farmers was held late afternoon mostly after 3pm. This was because it was the rainy season and most of the farmers left their various homes for the farm early morning and returned late afternoon. Therefore, it was difficult to get farmers for the interview during most part of the day. A few of the farmers who had been interviewed in the morning or early afternoon during my community observation were farmers who were either ill and had opted not to go to the farm or farmers who were extremely tired from the previous day's activities and had decided to rest for the day. It was during one of my morning community observations that I had the opportunity to interview a young male farmer who could not go to the farm due to ill health. I also took the opportunity to ask him to take me to the farm so I could make some observations concerning some of the information already gathered, which farmers had indicated were still being experienced on the farms. Luckily, the farmer agreed to take me to his farm to make these observations and this also gave me the opportunity to interview other farmers who were also on the farm.

Also, interviews with female farmers turned to be more hectic than that of the male farmers. As already stated, most of the interview was done during late afternoon when women who had returned from their farms went about their domestic activities mostly preparing supper. This resulted in either interviewing these female farmers while they were cooking or waiting for them to finish their domestic chores. Either way, there were negative consequences. Certain interviews which were held during the process of domestic duties resulted in limited attention

and several interruptions during the interview as well as background noise during the recordings. Likewise, waiting for female farmers to finish their domestic chores also delayed the interview which lasted late into the night amidst mosquitoes that are a major problem in the night during the rainy season. There were other times that the interview had to be rescheduled which were similarly around the same time the women were expected to go about their evening activities with the assurance of the interview taking place this time. These inconveniences further increased my expenses since I had to make several trips sometimes for such rescheduled interviews. Similarly, interviews with key informants in Wenchi (the AEO and EW) were also rescheduled a couple of times. This was due to the fact that the assembly man served as the intermediary between me and my key informants and therefore the time for the interview was not just one which could be decided only by my informants but also the assembly man who would provide me access to these people. Furthermore, changes in appointment were mostly not communicated early.

I must also add that during the week of my first interviews with the farmers the gatekeeper assisted by organizing the farmers at a specific location for the interview. Therefore, it was quite difficult for me to really exhaust time with each interviewee since the other farmers who were waiting to be interviewed would get impatient while some on the other hand would leave. This I had to handle by having two farmers at a time with one being interviewed while the other waited. The rest of the farmers were given different times to come for the interview or I had to be taken to their respective homes by the gatekeeper for the interview to take place. Data gathered was therefore reliable since I had ample time for the interview with informants.

4.7.2 Location for the interview

The location for the interview posed a certain challenge. During the initial stages of my interviewing I did not have control over the location of the interview since the gatekeeper determined where the interview could take place. The interview was thus held in an open space under a tree. The location was however close to a major street. Therefore, there was a lot of background noise during the recordings. I sometimes had to repeat questions as informants could not hear the questions especially with the passing of big vehicles. The interview thus sometimes lasted longer than it should.

Moreover, due to the fact that the interview took place in an open space, friends of the interviewees especially interrupted the interview mostly asking questions concerning what the interview was about and sometimes certain personal conversation between the interviewees and passersby. On the very first day of the field work, I actually had this first-time experience. There was one incident where the interviewee had to leave in the middle of the interview to talk to some friends concerning some money issues. This resulted in the interview keeping much longer than expected. I therefore had to give a recap of what had already been discussed to refresh the memory of the interviewee concerning what had been discussed earlier on. I then had to change the location for the interview by seeking the consent of the interviewees to let the interview take place in their respective homes to avoid such distractions.

Even though the change in location of the interview was able to rectify the problems encountered with the initial location to some extent I however realised that it was not just a matter of location but also an issue of human behaviour. One unfortunate and an unforgettable incident which cost me dearly occurred on the last day of my field work. This time, I interviewed a female farmer in her house while she had returned from the farm and was as usual getting supper ready. About not more than 10 minutes into the interview, the interviewee's son (who also a farmer) interrupted the interview with a conversation. Due to my previous experiences with people interrupting the interviewing while my recorder was still on, I therefore decided to pause the recorder. Well, after the end of the interview I tried to replay the recorded conversation (which I usually did after each interview) only to find out that I had not resumed the recording after the informants' conversation with her son. As a result, I had lost an interview of over an hour. The most unfortunate situation is that my informant provided me with relevant historical information which was quite different from what I had already gathered from my previous interviews. I was however fortunate to realise this soon enough to reflect on what had already been discussed and made a quick write up of what the female farmer had told me while it was still fresh in my mind. Furthermore, since I was accustomed to taking short notes during the interviews it helped to refresh my memory on what had been discussed. I must however admit that if the interview had been fully recorded; it would have improved the quality of data gathered.

4.7.3 The timing of the field work

The field work which took place during the rainy season also interrupted some of my scheduled interview with the farmers. This resulted in rescheduling of the interviews especially for the FGDs. One memorable incident was when there was a sudden change in weather during my journey to the research community for the FGD. Winds were soon followed by torrential rains and there was no doubt in my mind that the interview would be postponed. This was because the FGD was going to take place in an open space and also due to the fact that it was getting late and mostly people would prefer to stay indoors after the rain. It was an anxious period for me anytime there was a change in weather especially when I had a scheduled interview. The time of the field work also affected the number of people I was able to interview since most of the farmers were on the farms working during the day as earlier discussed and I could only interview just a few of the farmers after the day's work. Irrespective of this, I was able to gather the needed information much as possible to help me reach my research objective.

4.7.4 Language

During a research, it is important that the researcher is able to know the language and terms used by the people he or she will be studying or interacting with as it helps to build rapport, clarify questions and also facilitate understanding. Patton (2002, p 361) points out that:

“Clarity can be sharpened by understanding what language participants use among themselves in talking about a setting, activities or other aspects of life.”

In the first week of my interview with the farmers I found myself using words like weedicides and pesticides which I assumed were words that the farmers should be able to know as these chemicals (the weedicides and pesticides) are commonly used by farmers in their day to day farming activities. I did not factor in the fact that the farmers would have their own terminologies pertaining to their occupation and that I was also dealing with farmers who had different educational backgrounds and will therefore express themselves in their own language. As a result, using words like weedicides and pesticides left some of the farmers confused (especially those who had not attained education beyond basic education level). This therefore resulted in a negative response whenever I asked the farmers if they used these chemicals in their farming activities. After making enquiries concerning some of the terms used among the farmers in their

farming activities I got to know that the term used for the chemicals was “poison” since the chemicals kill weeds and pests. I therefore received positive responses for my questions afterwards when I asked whether “poison” was used on the farms. This facilitated understanding of questions and also enhanced the flow of information during the interview. It further improved the quality of information I was able to gather on the field. My first week on the field turned out to be a learning process.

4.8 Limitation of study

As part of individual characteristics of my informants, I had the intention of interviewing people with different educational background. However, I could not get the opportunity to interview someone who had been in the tertiary level of education. I only got to know through the gatekeeper that there was only one farmer within the community who had obtained tertiary education. Unfortunately, efforts to interview this farmer proved futile as the farmer was not around during my entire stay on the field. Therefore, I did not get any opinion concerning the issue from people within that category as I had initially intended. The information given by the AEO was good enough to fill the gap created by the lack of highly educated farmers.

4.9 Ethical consideration

Qualitative interview approaches entail that the researcher delves into the lives of people to know what they think and how they feel about issues. It may sometimes require that the individual reflects on past incidence to provide answers and this may expose the experience, knowledge or feelings of the participant. Cloke et al. (2004) further specify that questions asked during interviews may be painful, traumatic or confidential to participants since the questions may probe into the personal issues of the participant. Thus, interviews one way or the other affect the lives of the participant and it is therefore significant that every researcher cautiously anticipate some ethical issues pertaining to the study. Patton (2002) concludes that the researcher needs to work within an ethical framework when dealing with such ethical issues during the planning and designing of the research, the data collection and also during the analysis. Even though some of these ethical issues are mostly to seek the consent of the people, ensure confidentiality and anonymity to the people under study, there are some ethical issues which are worth considering depending on the sensitivity of research topic or the people under study.

During the interviews, one of the ethical dilemmas faced was disclosing the actual purpose of the field work. I realised that the informants (that is the farmers) thought I was researching for the government in order that they may receive aid for the various problems they were facing with their farming activities. I was as a result left contemplating whether I should even talk about why I was conducting the research as the excitement of some of the farmers died down when I disclosed that it was purely for academic purpose and had nothing to do with the government. However, through the informal conversation with some of the farmers earlier on revealed that they felt some researchers come to make enquiries with the intention of bringing aid which never came and this made them feel used. Thus, in order to avoid exploitation of my informants and ensure honesty to my informants, I informed them the actual reason behind the research and how their views were important contributions to the research.

During the interview it was imperative that I become sensitive to gender differences. As already indicated, I had to conduct a separate FGD with the men and women so that the women especially would be able to express themselves and share their opinions without any reservations.

Even though I noticed that my informants wanted me to promise them that there was going to be some aid of a kind after the interview, I dared not give them such indication even though that meant loss of interest or refusal to participate in the interview. It was quite a difficult situation for me since the farmers seemed to be tired and suffering from research fatigue. I therefore stressed on the purpose of the study and indicated that it was also my hope that through the findings the farmers may someday receive assistance should an organization be interested in my research findings.

4.10 Chapter summary

The chapter discussed the various methods used in collecting data for the research. These were semi-structured interviews and FGDs for farmers and in-depth interviews for key informants which best suited the purpose of the study. Selection of farmers was based on certain criteria such as age, education, farm size and ownership and experience in farming which helped achieve the research objective. Although, the interview was adequately prepared for, realities on the ground proved to be very challenging and this affected the data both positively and negatively. However, the outcome of information gathered for this research is reliable.

CHAPTER FIVE
RESULTS AND ANALYSIS
(SECTION ONE)

5.1 Introduction

This chapter presents and discusses the results of the study. It is mainly divided into two sections addressing each research objective. The first section addresses smallholders' adaptation practices to extreme weather events and climate change. The section also answers the research question one and two addressed in the theoretical framework. The second section answers the research question 3 addressing the impact of the various adaptation practices on the environment. Each section is thus organized according to the research objectives. With reference to the definition of smallholders established in the literature and for the purpose of this study, all agricultural households interviewed would be referred to as farmers since some of the informants had lands more than the standard 2 ha.

5.2 Smallholders' knowledge on weather variability and climate change

Farmers in Wenchi are well aware of climate change and have reported changes in climatic conditions over the last three decades. Farmers identified the changes in climatic conditions by comparing the current weather conditions to that of their childhood days. Farmers also identified the changes in climatic conditions to major events in their childhood such as Easter and Christmas. The changes in climatic conditions are mostly temperature and rainfall with rainfall being the climatic variable with the major reported change.

With respect to rainfall, there have been several and significant changes in its characteristics. Farmers specified rainfall to be the most significant climatic variable which has been subjected to major changes over the past few years. Farmers reported that total annual rainfall in the area has decreased over the years with a delay in the onset and reduction in the frequency of rainfall events. As recounted by farmers in the area, in the past the rainy season was mostly experienced some few months after Christmas or in the early months of a new year mostly beginning in March and April. This is however not the case in recent times as the rains usually come later in the month of May. The onset of rainfall is characterized by an uneven distribution across the area with reduction in quantity and reduced frequency within the year. As indicated by farmers, there has been a long stretch of rainfall received from one rainy day to

another within the same month which can be between two to three weeks. The evidence of climate change in the area is particularly attributed to the decline in the duration of the rainy season and an increasing dry season. The changes in rainfall characteristics imply a shift in rainfall pattern in the area and reduction in the number of rainy days as compared to the past. The farmers further indicated that the rains have been unpredictable as farmers used to be able to predict in the past. According to farmers in the area, they knew when to expect the rains however; the recent trends in weather variability are now making it difficult for them to rely on experiences and intuition to predict the rainfall. This finding is in line with the studies of IFAD (2015) and UNCTAD (2015) as discussed in the literature, specifying that smallholders can no longer rely on historical trends of weather events for their farming activities since the changes in climatic conditions are exceeding indigenous adaptation practices. The changes in climatic conditions in the study area are recounted by Naa, a 70 year old female farmer during a FGD that:

“In the 6th month of the year it used to rain a lot and in the 8th month the dry spell occurs (that is a short dry spell between the major and minor rainy season) but that has now changed. The dry spell can delay to the 10th month which is supposed to be a minor rainy season. So everything has changed.”

The above statement points out that the dry spell between the major and minor rainy season is becoming prolonged and the minor rainy season is becoming shorter indicating a shift in the rainfall regime. Thus, the changes in rainfall characteristics supports the analysis of Owusu and Waylen (2013b) indicating that there has been variations in the onset of both the rainy season and the short dry spell with the rainy season experiencing a reduction in the mean number of rainy days and total annual rainfall in the study area.

Regarding temperature, farmers in the study area pointed out an increase in temperature and amount of sunshine received over the years. The increase in temperature is attributed to the reduction in the amount and frequency of rainfall received. Farmers further pointed out that the area is experiencing lots of windy conditions in recent times as this was not the case in the past. Farmers are well aware of the risk they face as the current state of climatic conditions in the study area is summed up in the words of Abu, a 78 year old male farmer:

“In the past when it was cloudy the rains would fall but now the cloudy atmosphere is accompanied by lots of winds with little or no rains at all. The rains do not come when it is supposed to or as expected. The sun also shines a lot. It seems this place is turning into the northern regions.”

The association of climatic characteristics of the study area to that of the northern part of Ghana which experiences a single rainy season and high temperatures throughout the year indicate that the study area is slowly having a reduction in rainfall season. Also, as asserted by the farmers in the future the area might experience a uni-modal rainfall regime like that of the northern regions of Ghana should the current weather conditions persist as already indicated. This assertion is consistent with the observation of Owusu and Waylen (2013b) showing that the rainfall characteristics of Wenchi is increasingly becoming similar to that of the uni-modal zone of the northern part of Ghana than the south humid in the past due to an in-filling of the dry spell and the receding of the minor rainy season.

Farmers associated the changes in climatic conditions to both human-related and natural causes. One of the key phenomena acknowledged by the farmers is the change in vegetation cover due to deforestation as observed by Adjei-Nsiah and Kermah (2012). The reduction in forest cover is believed to be the major cause of the variabilities in weather conditions particularly reduction in rainfall. According to the farmers, the area experienced lots of rainfall when there was a dense vegetation cover in the past. However, farmers have come to witness most of the trees being cut down for various reasons and purposes such as farmers clearing the land for planting and farm expansion. The depletion in vegetation cover as reported by most farmers has also contributed to an increase in windy conditions in the area. Bush burning especially during the dry season is also another human-related cause for changes in climate in the study area as it has resulted in the reduction of vegetation cover. The current climatic condition was also attributed to religious and spiritual reasons. Other farmers believe that man has no control over rainfall or temperature and that God is the controller of the atmosphere and therefore the giver of rain. It was also blamed on the sins of men which have resulted in harsh climatic conditions as a form of punishment from God. Since it is evident that the area has experienced both major and minor changes in climatic conditions predominantly rainfall and temperature, it is imperative to assess how the changes in these climatic variables pose a threat to the livelihood of farmers in Wenchi.

5.3 Climate change impact on crop production and livelihood

“*The rain is the farmer.*” The words of Manu, a 70 year old male farmer.

Farmers in the study area have acknowledged that the changes in weather conditions such as the decline in rainfall and increased temperatures have generally had a negative impact on crop production over the years. The adverse effect of climate change on crop production has further led to other related impacts on the livelihood of farmers in the study area.

Agriculture in Wenchi is mostly rain-fed and farmers therefore rely on the annual bi-modal rainfall pattern for their farming activities. The declining rainfall and increasing temperature have affected *crop yield*. According to farmers interviewed, the inconsistent rainfall and increased incident of dry spells affect crop growth as they are unable to develop and mature well as expected. On the other hand, high temperatures also lead to rotting of seeds in the soil and burning of crops such as tomatoes, maize and cocoa. The high sunshine accompanied with low rainfall sometimes demands that the plants are completely cut down and replanted. Views from other farmers further indicated that on certain occasions, fruits fall off and plants are uprooted from their roots due to the occurrences of strong winds. The combined effect of insufficient water supply, high temperatures and poor soil nutrients in the area have resulted in the destruction of crops produced thus reducing total *crop quantity* during harvest.

Crop quality is also affected when climatic conditions are not favourable. According to farmers, the harsh weather conditions such as a sudden break in rainfall do not support proper plant growth especially when plants demand more rainfall in order to thrive. This tends to affect the quality of crops produced as crops may tend to be smaller in sizes with unappreciable colours due to insufficient ripening. Other farmers reported that high temperature likewise causes cracks in crops (for example tomatoes) which then become attractive to pests who may destroy the crops. The destruction caused by these obnoxious pests only further worsens matters for farmers. The reduction in food quality forces farmers to sell their produce at lower prices or discard the crops which cannot be sold on the market.

The delay in the onset of rainfall has affected the farming activities of farmers in the study area. It has resulted in *changes in farming activities* such as the period at which farmers are able to sow their seeds and consequently harvest the crops. According to farmers in the area, seeds were sowed in early March since farmers were expecting the rains soon afterwards and then by May crops would have attained maturity ready for harvesting. For instance, maize as

recounted by farmers was usually harvested as early as April. This is however not the case in recent times as farmers are now mostly able to sow their seeds in the latter part of April or early May due to the uncertainty in the onset and delay in rainfall. This information was further confirmed by the AEO in Wenchi. The current effect on farming activities as indicated by farmers in the study area is that there is *a shift in the planting (cropping) season* and the period at which farmers are able to harvest crops as compared to that of the past. Currently, farmers find it risky to cultivate a second crop under rain-fed agriculture during the minor season. This is because the season is becoming unreliable under climate change.

The variabilities in rainfall has also *increased the cost of farming* since any delay in rainfall leads to the sprouting of weeds on the land which had already been cleared in preparation for cultivation. As narrated by farmers, they would sometimes have to choose between cultivating the crops among the weeds and manually uprooting the weeds later when the crops are maturing in order to avoid competition of nutrients or clearing the land again before cultivation which may further increase cost. The former is however preferred by most farmers with reasons being that the additional clearing of the land even though increases cost can also result in the destruction of seeds as farmers would have to take the opportunity to sow seeds at the first indication of rains. It is also due to the fact that the unpredictability and breakages in rainfall may end up destroying the crops should there be a delay in time spent on clearing the land again instead of sowing the seeds.

As already discussed, the unfavourable climatic conditions which have resulted in the reduction in the quality and quantity of yields have led to a negative effect on the livelihood of farmers in the study area. The poor harvest has resulted in farmers incurring higher cost for their farming activities. It has also led to farmers receiving lower prices on the market for their produce. These situations, as narrated by farmers have in totality affected the income generated from their farming activities and the ability of farmers to sufficiently meet their household needs. Additionally, a key effect on farming activities as shared by various farmers is that they sometimes find it difficult to cultivate on a large scale especially the season after a bad farming season. This is because of the fear of losing investment due to the uncertainty in rainfall. As reported by farmers, the decline in crop production has also adversely affected *food security* among farmers since it has resulted in hunger in the area which was uncommon in the past. The reduction in crop yield has decreased the availability of surplus food sufficient for household

consumption after sale in order for farmers to earn some income. On the other hand, farmers pointed out that they are sometimes forced to keep crops for household consumption especially when harvest is extremely bad during that farming season thus reducing the availability of food supply on the market. Should the existing adverse impacts of climate change on farming activities persist the subsequent effect is that the current situation on food security in the area can worsen in the future. This finding shows that in low income and agriculture dependent economies, the increase in temperature, decline in rainfall and increase variabilities in rainfall reduce crop yield and threaten food security as observed by Deressa et al. (2011).

5.4 Smallholders' adaptation practices to weather variability and climate change

Farmers in Wenchi have adopted various adaptation practices to buffer themselves against the risk associated with the prevailing changes in climatic conditions in the area. Farmers have adopted several adaptation practices that help them to reduce their vulnerabilities to adverse weather events. The different adaptation practices can broadly be categorized into on-farm and non-farm adaptation practices. On-farm adaptation practices are those that take place on the household's own farm and are therefore farm related activities used by farmers to reduce climate associated risk. This includes water and crop management practices. This will therefore include both indigenous and modern adaptation practices. Non-farm adaptation practices on the other hand are those activities and income generated which take place outside the usual farming activities. This may therefore include wage labour activities such as provision of farm labour, renting of lands, migration and petty trading.

Farmers in Wenchi municipality have adapted to climate change for various reasons which is also dependent on the resource availability of a farmer. The various adaptation practices adopted is to reduce the effect of extreme weather events such as flood or drought and high temperatures or the decline in rainfall on farming activities. The adjustment in farming activities are generally aimed at improving and increasing crop quality and productivity, maximizing profit and securing income, food and livelihood.

5.4.1 On-farm adaptation practices

5.4.1.1 Indigenous adaptation practices

Farmers *diversify cropping and farming systems* in order to reduce risk and maintain production. The diversification of crops involves growing crops which are regarded to withstand certain weather conditions. For instance, farmers have diversified their cropping system from the cultivation of cocoa to cashew which is deemed to better withstand harsh weather conditions such as drought. According to the farmers, cocoa was the prominent cash crop cultivated in the study area. However, the harsh weather conditions due to the decline in rainfall pattern and drought in the early 1980s (EPA 2011) resulted in bushfires and caused a decline in cocoa production. These events encouraged farmers to shift into the cultivation of cashew. The diversification from cocoa to other crops in Wenchi in order for farmers to better adapt to the unfavourable climatic conditions in the area is confirmed in a study by Adjei-Nsiah and Kermah (2012). Other views were expressed indicating that farmers are trying to revive cocoa production in the area due to its economic value. However, the environmental challenges still remain. This further reveals that socio-economic factors (in this case the value of crops) interact with biophysical factors (such as rainfall) to influence farmers' decision in adopting various adaptation practices as shown in the conceptual framework. The adoption of climate-resilient crop varieties is also adopted by farmers in Southeast Asia (Lasco et al. 2011).

Farmers also adapt to the low rainfall conditions and high temperatures by engaging in *inter-cropping*. Farmers grow different types of crops on the same piece of land to reduce the risk of crop failure should the rains fail. As pointed out by the farmers, this involves growing both major crops mostly cash crops (such as cashew) and tubers and cereals (such as yam, cassava and maize); and minor crops usually vegetables (such as pepper, tomatoes, garden eggs and okro) on the same farm land. The views of other farmers again revealed that cocoa is also cultivated at a lower rate. As reported by farmers, different types of crops are cultivated due to the variations in their duration of maturity and development so that when one type of crop is destroyed the other type which is able to withstand harsh weather conditions may still remain. For instance, short term duration crops such as tomatoes and garden eggs are cultivated together with annual crops such as yam and cassava in order to support farming activities and help farmers gain income on a short term basis. Secondly, short duration crops such as pepper and tomatoes are cultivated together to reduce risk of crop failure since pepper is better able to

withstand extreme weather conditions than tomatoes. The cultivation of different crops which demand different soil nutrients may in this manner enhance the efficient use of soil nutrients. It is hence logical that farmers adopt this practice in order to reduce loss of crop production and offset cost. The adoption of inter-cropping farming system among farmers in Wenchi is also indicated in an earlier study by Adjei-Nsiah and Kermah (2012).

It was again observed that the minor crops were purposely for household consumption in the past however this is changing over the years. Currently, farmers can sell the minor crops when they are able to endure the harsh weather conditions and may therefore tend to be in excess supply. It was also noticed that the minor crops were in the past grown on smaller basis for household consumption but due to the changes in rainfall pattern and the increasing dry spells, the cultivation of the minor crops have now been intensified. Farmers stated that they are now growing the minor crops on a larger basis than what was being done in the past in order to obtain some produce when the production of major crops are low and especially if the rains should fail. Farmers are currently as a result depending on the cultivation of minor crops for two purposes; that is for household food consumption and security and as an additional source of income. This therefore shows that climate change is changing the farming practices of farmers in the Wenchi municipality. The benefits of inter-cropping as indicated in this study are also pointed out in a study by Ayivor et al. (2016) indicating that the system of farming helps farmers to spread risk of crop failure, ensure nutrient regulation and household food security.

Farmers practice *crop rotation* to improve crop production and enhance their resilience to the unfavourable weather conditions in the area. Different types of crops are grown sequentially to improve soil fertility and crop production. The use of different crops which demands different soil nutrients and also provide different nutrients (such as nitrogen fixing crops) into the soil hence helping to sustain such environmental resource. For instance, farmers reported that they are advised to grow short duration crops such as pepper, and tomatoes with perennial crop like cashew and not cassava. Interview with the AEO revealed that crops such as groundnuts and cowpeas are recommended to farmers to help improve the declining soil fertility and reduce the application of inorganic fertilizers. This was confirmed by the interviews with farmers in Nkonsia many of whom indicated that they are educated to cultivate nitrogen fixing crops such as groundnuts to enhance soil fertility. The challenge encountered with this adaptation practice is that crops which are recommended to farmers in order to enhance soil fertility are not often

adopted. This according to the farmers is because the nitrogen fixing crops recommended do not serve as a major food item for household consumption since the staple food crops in the area are maize, cassava and yam. Similarly, the leguminous crops frequently demand the application of agrochemicals which farmers have inadequate financial ability to purchase. Farmers subsequently take advantage to cultivate leguminous crops as and when they deem fit making the efforts by the AEOs partly effective. The importance of diversified cropping systems in increasing food sufficiency and income to smallholders as illustrated in this study has been attested to by Nhamo et al. (2014).

Mixed farming is well practised among farmers in the study area. Apart from the growing of crops, farmers disclosed that they usually keep livestock such as fowls and goats which are mostly reared at home. The animals are kept primarily for household consumption and to improve household nutrition during periods when food production has declined. Farmers during the individual interviews nonetheless indicated that the animals are also sold as an additional source of income when income from farming activities is low and also when animals are in excess. The additional income helps to sustain household needs since farmers are able to purchase other food items which they do not produce themselves. Aged farmers expressed their disinterest in engaging in mixed farming due to the difficulty in managing the animals especially goats as a result of old age. This result is supported by the findings of Egyir et al. (2014) showing that livestock production among farmers in the transition zone helps them to cope with low rainfall and drought, increase production, income and household food consumption.

Similarly, a key adaptation practice employed by farmers is the *reduction in farm size* in order to have better control over farming activities and reduce risk. The reduction in farm size or the amount of crops cultivated is due to the uncertainty in rainfall characteristics in the area. The practice helps farmers to better manage farm resources in order to reduce cost during the extreme weather events. This practice is also adopted by farmers in northern Ghana (Etwire et al. 2013). When Atsu, a 30 year old male farmer was asked his motive for choosing to reduce his farm size he explains that:

“Reducing the farm size under cultivation helps me not to invest so much (both financially and physically) into each type of crop sowed. It further allows me to concentrate and manage well the little portion of land under cultivation.”

Continuous cropping is also practiced among farmers in the study area. This indigenous practice has increased with intensity over time. Farmers explained that the practice is due to the scarcity of land in the area due to population increase which has led farmers to adopt less of shifting cultivation. In order for farmers to adapt to climate change and the associated socio-economic pressures, they over-cultivate on the same piece of land. This multiple cultivation is to ensure that farmers are able to maintain their production and ensure their livelihood sustenance amidst extreme weather events.

Farmers practice the application *organic manure* to enhance soil fertility and improve crop yield. The use of organic manure that is fowl faeces is practiced among a few farmers on an infrequent basis and unfortunately not a usual practice among most farmers. This is because there is no major animal husbandry in the area to encourage farmers to purchase animal manure as stated by farmers. This finding was also confirmed by the an interview with the EW indicating that, the unavailability of major animal farming on commercial basis is one key factor hindering farmers from effectively adopting the use of organic manure. Farmers also indicated that one would have to travel a long distance to other places in order to obtain the manure and this also comes with more cost. Even though farmers would have preferred to adopt the application of organic manure frequently since it is less expensive and environmentally friendly, limited availability has discouraged and restricted its use.

Farmers also resort to other indigenous practices such as pruning; weeding around plants to allow for better circulation of air especially during the dry season; mulching in order to retain soil moisture and reduce evaporation; moulding (as shown in figure 6); growing of tree crops such as cashew which can withstand dry climatic conditions; planting to coincide with the rainy season which may lead to an appreciable crop yield and making ponds (as shown in figure 3). The cultivation of tree crops such as cashew (as shown in figure 4) which have also been recommended by the AEO in the area is aimed at enhancing farmer's adaptive capacity and improving the vegetation cover and environmental conditions in the area while mitigating against the prevailing changes in climatic conditions. Farmers also further indicated that fallen leaves from plants (as also shown in figure 4) are also maintained to serve as form manure when the leaves decompose in order to improve soil quality. In addition, a 36 year old male farmer Danquah, revealed that farmers purposely grow certain crops to serve as shade to other crops which cannot withstand high temperature so as to avoid or reduce their destruction. For example,

the broad branches of plantain plants are used to serve as shade to cocoa plants during the early growing stages of the cocoa plant since it cannot withstand high temperature as displayed in figure 5.



Figure 3: A hand dug trench used to water crops during severe drought and for rearing fish during the rainy season.



Figure 4: Leaves from cashew plants left to cover the soil surface to conserve moisture. The decomposition of the leaves also enhances the soil fertility.



Figure 5: A plantain planted close to a cocoa plant to serve as shade to the cocoa plant.

The plantain also functions to conserve moisture and keep the soil cool as it shades the cocoa plant. This is to prevent the cocoa from being destroyed by sunshine as shown in figure 5. The farmer plants at least one plantain near a cocoa plant. The plantain plant is preferred because it has broad leaves when it develops which serves as shade, does not compete with the cocoa for nutrients and has water in its root which the cocoa plant can draw from during drought.



Figure 6: A traditional practice of mounding used to conserve soil moisture on a maize farm.

5.4.1.2 Modern adaptation practices

Farmers in the study area have embraced various forms of modern adaptation practices to reduce their vulnerabilities to the impacts of climate change. Beyond these adaptation practices serving primarily as a response to climate change effects, over the years they also serve the secondary purpose of improving crop productivity for farmers.

The application of *inorganic fertilizer* is practiced among most farmers in the study area. Even though in the past the use of fertilizer according to farmers was rare with farming activities in the area it has changed in recent years. Fertilizer use is considered to be a recent introduction to farming activities due to the increasing temperature, low rainfall and loss of soil fertility which negatively affect crop yield. Although farmers acknowledged that in the past the area could sometimes experience low rainfall, the situation was not so severe to result in (large) destruction of crops or crop failure. Farmers therefore barely did anything to adapt to the changes in rainfall. The recent application of fertilizer in the study area is hence aimed at improving and increasing crop productivity both in quality (in terms of size and colour) and quantity and in reducing climate related adverse effects. As indicated by the farmers, with the application of fertilizer, a little amount of rainfall quickly enhances and speeds up crop growth till the next rainfall day. Some of the various types of fertilizer used among the farmers are urea and ammonium. Agyemang, a 45 year old male farmer thus throws more light on the benefit accrued to a farmer who uses fertilizer to a non-user. He thus indicates that:

“My motive for using fertilizer is to increase crop production. The farmer who uses fertilizer on his one acre farmland will get more production than me, who does not use fertilizer on my four acre farm land.”

According to the AEO, fertilizer also provides the additional benefit of reducing pest attack since plants develop hard and bitter leaves which becomes unattractive to pests such as armyworm (*Spodoptera exempta*). Even though farmers indicated that fertilizer helps plants to grow quickly even with the little amount of rainfall, it was equally acknowledged that, a sudden and long break in the rain may also destroy the crops as it may lead to artificial ripping of crops without the crop attaining the needed maturity. Consequently, even with the application of fertilizer, the right amount of water is needed in order to obtain the needed crop productivity both in quality and quantity. This therefore, shows that rainfall is an important variable in the activities of

smallholders in Wenchi since their activities are almost entirely rain-fed (Owusu and Waylen 2013b).

Aside climate change, the application of fertilizer is also influenced by other biophysical factors such as poor soil quality (Egyir et al. 2014). Farmers claim that over the years, soils in the area have reduced in quality due to over cultivation. This has thus reduced crop production and the ability to harvest a particular plant multiple times before it perishes since the soil can no longer support crop development as it used to do in the past. Farmers who had been farming for less than 10 years further indicated that they had to use fertilizer right from the beginning of their farming activities due to the already poor soils obtained and the reduction in rainfall. The application of fertilizer in this case is furthermore aimed at improving soil nutrients in order to boost crop production and attain a good harvest. It is then safe to conclude that, the application of fertility may not be consistent across years and geographical location as its use is influenced by the weather conditions (such as rainfall) and soil quality at a particular period.

The need to increase food production due to population increase and the desire to increase income has also warranted the application of fertilizer with a growing intensity among farmers in the area. These socio-economic factors were also confirmed during the FGDs and interviews with key informants. The importance of the application of fertilizer in helping farmers to increase food productivity and improve income was also reported by Adjei, a 52 years old farmer during the male FGD that; “*without fertilizer farming is no longer profitable.*” Farmers however, added that although fertilizer in present times increases food production it is not as significant as it was in the past.

Farmers also apply *weedicides* to control different types of weeds especially resilient weeds which cannot be easily controlled manually. Some of these resilient weeds are locally known as “Adankomilk” (as shown in figure 8) and “Nyame bewu ansa na mewo” (which literally means God will die before I die). These weeds are known to be resilient due to their ability to quickly grow and multiply at a faster pace especially with a little amount of rainfall. The weeds are also deemed to rigorously compete with crops for water and nutrients and are therefore better controlled with weedicides since the chemical easily helps to get rid of the weeds. The application of weedicide further enables farmers to control weeds in a manner that helps to reduce or prevent bush fire. It also helps to reduce the cost of the farmer in hiring labour to weed on the farm since that is increasingly becoming costly.

Pesticide even though not frequently used mostly among female farmers is used to help reduce the pest population in the area especially during major farming seasons and to control emerging pest as a result of changes in climatic conditions and farm expansion. Farmers asserted that this is because; during the rainy season the large farming activities lead to the insurgence of different pests which are attracted by different crops. Farmers interviewed in Nkonsia further explained that, there has been an increase in pest population over the years as a result of changes in rainfall and temperature. Other views shared especially by the older farmers revealed that aside from there being the emergence of pest which comes as a result of the rainy season, the expansion of farming activities in the area has also contributed to the increase in pest population. Some of these pests are better controlled with pesticides due to their large population and destructive nature to crops.

It must however be well noted that, it is difficult to ascertain whether the adoption of weedicide and pesticides in the study area is part of modern agriculture or also induced by climate change. Even though farmers in the study area link the use of weedicides and pesticides to changes in climatic conditions, in other cases farmers link the application of these chemicals to be more of an agricultural innovation mainly influenced by socio-economic factors in order to assist farmers in their farming activities.

The application of both the weedicide and pesticide helps to reduce the labour and workload of farmers. According to farmers in the study area, agrochemicals make farm work easy by reducing the energy used in farming and the time spent on the farm as compared to the traditional way of going about farm work. Crop failure has also been reduced with the application of these chemicals. As indicated by farmers, without these agrochemicals (that is fertilizers, weedicides and pesticides) farming becomes almost impossible. This indicates that modern adaptation practices have therefore become significant in improving the farming activities of farmers and also buffering farmers against their vulnerabilities to climate change.

It was found out that chemicals are mostly applied to crops which are cultivated on commercial basis such as cocoa, maize and cassava in order to enhance yield to an appreciable level. Farmers pointed out that they did not however like to apply the chemicals to crops which were purposely grown for household consumption such as pepper, tomatoes and yam. This according to the farmers is due to the effects of the chemicals on the crops and human health. It is worth noting that some of the crops for household consumption may also serve as a

commercial crop to another. Thus, the application of the chemicals on crops is dependent on the purpose for which the crops are being cultivated and the motivation to also apply chemicals is to improve the yield of cash crops.

Farmers in Wenchi practice the use of improved crop varieties such as *hybrid seeds and early maturing varieties*. The practice among farmers is usually promoted by AEOs in Wenchi. Farmers disclosed that the seeds are sometimes provided to them for free while at other times they would have to purchase the seeds themselves. The challenge here lies in the high cost involved for farmers in purchasing the new varieties. The seeds are known for their benefits to withstand harsh environmental conditions and their ability to mature quickly.

It is important to note that the various forms of modern adaptation practices discussed above requires some financial investment which is a major challenge to farmers in the study area. As stated by the farmers, this is because they do not have access to adequate financial loans and are financially affected by lower prices offered for their farm produce coupled with the increasing cost of farming. The adoption of modern adaptation practices among smallholders in the transition zone to deal with low rainfall and droughts; weeds and pest; poor soil fertility and increase food production is also reported in the studies of Egyir et al. (2014) and Egyir et al. (2015).

5.4.2 Non-farm adaptation practices

Farmers diversify income by engaging in several non-farm adaptation practices to enhance their resilience to climate change and extreme weather events. According to some farmers interviewed in the study area, some of these non-farm practices were already practiced as a source of income before engaging in farming. The non-farm practices which were already practiced by farmers had to be intensified as an adaptation to enhance resilience to the low rainfall conditions since farmers could not mainly rely on farming as the only source of livelihood. Some of the non-farm practices were mostly skills gained through informal education such as tailoring. Other income generating activities such as the operation of provision store, driving taxi and motor cycles and working on other commercial farms to earn additional income were mostly employed by young male farmers. Women were found to engage in the selling of household items such as utensils. Another important non-farm adaptation practice used by farmers in the study area is the buying of cash crops and food items such as cashew, pear, yam and dry maize from farmers in

other farming communities and selling them in the big market towns like Techiman or Wenchi to earn some income. The various non-farm practices are rigorously engaged in during the dry season when farming activities are low. In addition, a farmer may sometimes substitute one activity for another income earning activities since these practices are also dependent on their viability and the prevailing economic situations.

Farmers explained that income earned from the various non-farm activities is used to support families and further boost farming activities such as hiring of labour and purchasing of farming tools. Non-farm adaptation practice is regarded as effective since farmers are able to earn income on a regular basis. Farmers are therefore able to meet their daily and immediate needs especially during the lean farming season. Income earned as indicated by farmers is also used to pay back loans obtained from the government to support farming activities. This indicates that the various non-farm activities are crucial in helping farmers improve both their farming activities and livelihood as income gained is invested into reducing climate associated risk.

Even though the non-farm adaptation activities accrue several benefits to farmers, they revealed that it also comes with certain challenges. For example, farmers who engage in driving taxi face problems with rising fuel prices and in inadequate patronage of services due to the fact that other people engaged in the same activity and the general poverty levels of people in the area. Similarly, farmers involved in the buying and selling of food items are also subjected to high transportation cost and prices of food purchased for sale. A 34 year old male farmer Gymafi, who is involved in the buying and selling of maize as a non-farm practice lamented on how changes in climatic conditions can also affect non-farm agricultural related practices. He hence explains that:

“One challenge which I face in relation to this adaptation practice is that due to the current changes in climatic conditions and especially during extreme weather events the quantity of maize crops available for buying and selling have reduced as compared to the past.”

The above situation therefore implies that the reduction in the availability of such food crops sometimes affects the price as it becomes expensive for the farmer to buy in large quantities or make any purchase. The increase in price does not only make it difficult to buy but also to sell to others to gain the needed profit. The various challenges according to the farmers tend to affect

the general profit accrued to them. Nevertheless, farmers consider non-farm adaptation practice as effective due to the regular income they generate. A study by Owusu et al. (2015) in the Akuapim North District of Ghana also shows how farmers adopt several non-farm practices in order to reduce the risk associated with the low rainfall conditions in the area.

It should equally be noted that some farmers in the study area did not have any form of non-farm adaptation practice. These farmers therefore solely depended on farming and other on-farm practices which they adopt to enhance their resilience to climate change. The farmers acknowledged that their inability to engage in non-farm activities largely exposes them to the various impacts of climate change on their farming activities especially during extreme events since these farmers do not have any other source of income to fall on. Farmers cited old age and inadequate start-up capital as the main reasons for not engaging in non-farm adaptation practice. It is hence logical to state that farmers' ability to adapt to climate change in the study area is also exacerbated by old age and (financial) resource constraints.

5.4.3 Communal adaptation practices

This adaptation practice can involve both on-farm and non-farm activities. Such adaptive practices occur when farmers form a group either with friends and immediate families or by informal associations formed by the type of crops cultivated. Friends and families mostly assist each other through physical support and not in monetary terms. According to farmers, this involves providing seeds, clearing of farm land, harvesting and transporting of farming materials, lending of farm tools and providing advice on how best to enhance farming activities in order to increase crop production and income. This form of assistance helps farmers to reduce the various costs that they may incur on their farming activities. Even though communal practices still exist the challenge is that farmers sometimes regard it as a waste of time and effort to engage in communal farming activities due to the infrequent rainfall being experienced in the study area. This has affected communal farming activities and threatened the long tradition of working together to help each other.

The associations formed by the type of crops cultivated include Maize Farmers Associations, Cashew Farmers Associations and Vegetable Growers Associations. The various associations also help farmers to acquire agrochemicals such as fertilizer and weedicides from the government as loans and then payments are later made after farmers have harvested their

crops. Farmers reported that harvested crops are also transported to the major market towns by drivers hired by the associations to prevent the produce from damaging due to poor market in the hinterlands. It is also to protect farmers from being cheated by middlemen who give farmers low prices for their produce. By doing so, farmers are able to get profit from their farming activities which help them to also secure their livelihoods.

Some of the associations during the time of the research were not so active while others had collapsed due to certain challenges faced by the associations. One of the key reasons pointed out by the farmers for the collapse of some of the associations was the inability of farmers to pay back loans received from the government due to poor harvests. The poor harvest was attributed to the unfavourable rainfall characteristics such as low and unpredictable rainfall which make farmers incur losses during harvest. Also, farmers paid dues to the association which served as a means of financial support should any farmer need it. The funds when needed were not received on time and could sometimes be obtained when farmers were entering the dry season and the money was of no importance to them. Another challenge acknowledged by farmers is the lack of commitment on the part of some members who did not pay their dues (probably due to poor financial status) and thus money paid by other farmers were used to pay back loans obtained from the government which was regarded as unfair. These challenges resulted in difficulties in running the association and the reluctance of farmers to fully participate in some of the associations.

5.5 Factors affecting smallholders' adaptation practices

“Currently, if you do not have money you cannot be a farmer.” The words of Abu, a 78 year old male farmer.

Literature has indicated that diverse groups of people across various geographical locations experience different impacts of climate change (Etwire et al. 2013, Ayivor et al. 2016). This therefore makes adaptation to climate change area specific dependent on local characteristics (Deressa et al. 2009, Deressa et al. 2011). Adaptation to the numerous manifestations of climate change is affected by different factors which may serve as barriers or effective means to adaptation. The factors which are typical to local conditions can be categorized into biophysical, socio-economic and political/institutional factors. These factors were found to influence farmers' decisions for the adoption of various adaptation practices in the study area. The biophysical

factors that influence farmers' adaptive choices are in general influenced by the geographical location of the farm. The socio-economic factors determining farmers' adaptation practices are also interrelated and therefore the explanation of one factor may overlap into another. The study will however focus on the major issues under each factor.

5.5.1 Biophysical/environmental factors affecting adaptation

Generally, the key biophysical factors affecting farmers' adaptive behaviour to climate change in the study area are the declining rainfall and increasing temperature. Other biophysical factors identified to equally influence farmers adaptive choices are usually determined by *the geographical location* of the farm. *The availability of water* was found to also influence the choice of adaptation practice adopted. Farmers who had lands close to mountainous areas with water running downwards to the farm were able to dig trench to collect water as pond. As indicated by Danquah, a 36 year old male farmer the pond is then used to water certain minor crops during severe harmattan periods. Fishes such as herrings were also reared in the pond for household consumption during the rainy season when there is enough water. This corroborates information from the EA indicating that during droughts farmers hand dig to a depth to collect water. When farmers have to stay on the farm for days without returning home, the pond is also used for domestic purposes such as drinking even though as reported by the farmer the water is not clean and may affect one's health. The farmer however indicated that drinking the water from the pond at certain times becomes a matter of necessity. On the other hand, the majority of farmers interviewed did not have access to running water on their farms and this affected their adaptive choice considering how significant water is to farmers. This is in line with the results of Uddin et al. (2014) specifying that lack of available water both for domestic and farming purposes poses serious challenges for famers' adaptive choice to climate change in Bangladesh.

The type of soil found on the land also determines the adaptive choices of farmers in the study area. Farmers who have good soils which could still support plant growth did not practice the application of agrochemicals such as weedicides and fertilizer on the land. During the FGDs, famers revealed that the good composition of the soil was also due to the fact that these farmers in the past chose to avoid the use of agrochemicals and were thus able to maintain the natural state of the land or reduce the rapid deterioration of the fertility of the soil. This according to the farmers helps to save money for other activities and further sustain the environment by

maintaining the fertility of the soil. On the other hand, farmers who had relatively good soil or poor soils mostly used fertilizer and less frequently organic manure to improve soil fertility. The application of fertilizer and organic manure as already discussed is aimed at increasing soil nutrient, improving plant growth and increasing productivity. Also, the type of soil influences the type of crop that a farmer can cultivate. Farmers reported that they thus cultivate different crops on different farm lands (especially those with multiple farm lands) because the crops thrive better there and the soil supports the growth of that particular crop. Nevertheless, the differences in soil characteristics in certain cases threatened crop production as farmers were also limited by age and financial abilities. A study conducted by Etwire et al. (2013) indicates that farmers in northern Ghana adopt various soil and plant health related adaptation practices to climate change due to soil fertility decline.

Different plant species found on various farms resulted in different adaptation practices in the area. Farmers who had weeds (or small plants) which were resilient and had the ability to grow quickly preferred the application of weedicides to control the weeds as already discussed. Farmers cited that even though costly, they considered this practice to be more effective than the manual method of uprooting with the hand or hoes and cutlasses. Similarly, farmers who also had certain plants considered to compete less (such as plantain plant) with other crops for water and nutrients were maintained and thus served as shade for the small plants while plants regarded to affect crop growth were cut down. See for example, Etwire et al. (2013) who mention that farmers' adaptation practices are influenced by their agro-ecological location such as the presence of resilient weeds which have led farmers to adopt soil and plant climate related practices to reduce risk.

5.5.2 Socio-economic factors affecting adaptation

Different household characteristics proved significant in determining the type of adaptation practice adopted by a farmer. *The gender status* of farmers was found to influence the adaptation choice in the study area. It was observed that the majority of the farmers both the males and females have many years' farming experience of about more than 20 years. Men were able to engage more in different adaptation practices than women. Women were found to engage less in practices which are physically demanding than that of their male counterparts. This has resulted in differing adaptation practices across genders even though practices (such as the use of

weedicides, fertilizer, or hiring of labour) may also be similar among both male and female farmers but with differing intensity which may also be further influenced by the financial status of the farmer.

According to most of the male farmers interviewed, the traditional practice of clearing a large area (on the same piece land) was thus more adopted among male farmers and less among female farmers. The female farmers interviewed further pointed out that, they do not have the physical strength to engage in manual weeding using hoes and cutlasses or the financial capacity to adequately hire the needed supplementary labour. Likewise, the modern practice of applying weedicide involves the use of heavy protective garments and equipment which also poses certain challenges of utilization to female farmers. Aku, a 57 year old female thus indicated that:

“I scarcely use weedicide or fertilizer because I am a woman and considering my age it is difficult for me to spray the chemicals on my crops. I sometimes hire labourers to help me however; I have to put in some financial considerations as this is also important.”

The various indigenous and modern adaptation practices discussed earlier have thus created some difficulties for female farmers in their farming activities. The women are therefore forced to reduce the size of farm land cultivated to better manage those lands. It has also limited women’s ability to rigorously engage in on-farm adaptation practices but engage more in non-farm practices such as petty trading to improve their resilience to changes in climatic conditions. Male farmers at the farm level are therefore able to adapt better to climate change than their female counterparts. On the other hand, it can also be said that male farmers are more vulnerable to climate change due to their high dependence on on-farm practices and income. This result hence supports the findings of Deressa et al. (2009) whose findings indicated that male-headed households in the Nile Basin of Ethiopia easily adapt to climate change due to their access to agricultural resources and options. This implies that programmes and initiatives concerning adaptation to climate change should be gender-based as discussed in the literature.

Similarly, *the age* of a farmer also proved important in determining the adaptation choice adopted. Young farmers mostly below the ages of 45 engaged more in the application of modern adaptation practices than their older counterparts. As expected, interviews with young farmers revealed that they were more eager in adopting new methods such as the application of hybrid seeds and different crop varieties to better adapt to the low rainfall conditions and improve production. On the other hand, the older farmers who have been farming for years were more

reserved in their adoption of especially modern adaptation practices and were mostly guided by their experience in farming. It is thus rational to conclude that, the adoption of new technologies reduces with age and experience in farming. This confirms studies by IFAD (2011) and Ali and Erenstein (2017) who indicate that young farmers are more likely to adopt new innovations and technologies in their farm management practices. The finding is also in line with that of Uddin et al. (2014) among farmers in Bangladesh.

Farmers who were considered to be in *a better financial position* had different adaptation choices than their less fortunate counterparts. As per the FGDs, the better-off farmers were able to hire labour to work on their farms and could also afford the purchase of fertilizers and other hybrid seeds to boost farm production. It was also identified that the better-off farmers were mostly those who also had well to do non-farm activities and were thus better able to invest into activities that help them reduce climate related risk. On the other hand, the less well-to-do farmers were sometimes labour constrained and rather engaged the services of friends and family members to work on their farms. Even though these farmers were occasionally able to apply fertilizer on their farms the quantity and type of fertilizer used was also determined by their financial capabilities. This finding is consistent with that of Etwire et al. (2013) showing that wealthy farmers are more likely to try new technologies and adapt better to changes in climatic conditions.

Studies by Hassan and Nhemachena (2008); Deressa et al. (2009) and Uddin et al. (2014) indicate that the *educational status* of a farmer is important in determining the adaptation practice of a farmer since it significantly increases the probability of adoption of improved technologies to reduce the impact of changes in climatic conditions. In Wenchi, the educational status of a farmer did not prove to be important in determining the adaptation choice of a farmer. This may be due to the fact that the majority of the farmers had only attained the junior level of education and were relatively semi-literate. This depicts the general pattern of low educational status in the rural areas of Ghana (Owusu et al. 2015). During the interview with farmers, it was found out that the ability of a farmer to adopt new and various climate risk adaptation practices within the study area was more influenced by experience especially among the older farmers. Furthermore, knowledge on innovative ways to adapt and improve agricultural production in the area was influenced by informal education from extension services to complement the insufficiency in farmers' formal education in the area (Muneer 2008) and sharing of knowledge

through farmer-to-farmer extension. On the other hand, the ability of a farmer to adopt a practice based on knowledge received from extension services were also limited by financial constraints. This also shows the inter-relationship between the various factors influencing farmers' adaptive choices as shown in the conceptual framework.

The *ownership of land* and *land size* influenced how farmers are able to adapt to climate change. The majority of the farmers in the study area who were interviewed owned their lands and were acquired mostly through inheritance and on rare occasions by purchase. Findings on the field showed variations of farm sizes owned between male and female farmers. Male farmers mostly had medium to large land size while the female farmers' mostly owned small farm sizes. Interview with farmers in Nkonsia indicated that those who owned their lands were not under pressure to explore different adaptation practices or intensify production. These farmers chose to reduce the number of adaptation practice (such as the reduction in the application of agrochemicals) when they incur losses in production the season before since they had no financial responsibilities to landlords. This is consistent with previous studies indicating that land tenants intensify production in order to fulfil financial obligations while adapting to variabilities in climatic conditions (Ayivor et al. 2016). It was also found out that even though the majority of the farmers had lands which were medium in sizes; these lands were usually fragmented and served different agricultural purposes depending on the quality of the soil. This shows the inter-relationship between the various factors (in this case biophysical factors such as the soil quality and socio-economic factors such as land fragmentation) influencing farmers' adaptation behaviour. The ability of a farmer to grow different crops on different farm lands enhanced their capacity to be able to increase productivity and reduce their vulnerability to climate change. This is also however possible with large land ownership.

Population change has indirectly had an influence on how farmers are able to adapt to changes in climatic conditions in the study area. Wenchi municipality has seen an *increase in population* over the last few years as reported by the older farmers interviewed and this has led to problems with *land tenure* and changes in farming practices. Farmers reported that the increase in population has resulted in the general reduction of arable land available for cultivation. The situation has thus put pressure on farmers to change their farming practices amidst the unpredictable climatic conditions and adopt different adaptation practices in order to better adapt to drought and low rainfall in the area. Traditional farming systems (such as shifting

cultivation) have also been reduced in order to meet the new environmental (such as low soil quality) and socio-economic (such as population increase) conditions in the area. According to farmers, shifting cultivation, as already discussed which was more frequently practiced among farmers in the past is now fading away and less practised among farmers in recent times. Farmers attributed this to the increase in population which has made the practice less feasible and further by other pressures such as the high cost of land due to the reduction in the availability of arable land for purchase. This situation has in consequence led farmers to adopt the practice of continuously cropping on the same piece of land which may be environmentally unsustainable. A 44 year old male farmer Dzifa, explained how the increase in population has led to changes in farming activities. He therefore notes that:

“The reduction in soil quality and increase in fertilizer application is due to the continuous cropping on the same piece of land which I will attribute to the increase in population. In the past, we used to practice shifting cultivation which allowed farmers to cultivate twice on a land and change to another for the land to rest and regain its fertility. Now it is difficult to engage in such a practice since the land is now scarce.”

Moreover, an informant explained that lands which may also seem to be available and could be used by farmers are located in dense forested areas which as confirmed by other farmers make farming difficult due to problems of access and transportation. The situation may further increase the cost of farming. For these reasons, indigenous adaptation practices such as crop rotation and inter-cropping cropping which help to optimize land use are also practiced to help farmers sustain production in the prevailing climatic conditions as discussed earlier. Similarly, modern adaptation practices such as the application of fertilizer, weedicides and the cultivation of early maturing varieties were adopted by farmers to improve soil fertility and boost crop production. The current situation has also led farmers to engage in agricultural intensification of available and already exhausted lands to maximize production. This finding corroborates the results of Nhamo et al. (2014) and Ayivor et al. (2016) showing how the increase in population and land tenure affect the farming systems and agricultural investments of farmers exposed to threats of climate change. Also, population pressure is reported by EPA (2011) to be a major contributing cause of unsustainable agricultural practices leading to land degradation in the ecological zones of Ghana.

Farmers' *access to market* was in the same way found to be a significant factor affecting farmer's adaptation practices to climate change and extreme weather events. In Wenchi, farmers' ability to access market was decisive in influencing the adaptive choice made as the farmer is compelled to make some economic considerations. Farmers explained that those who were unable to get market for their produce (due to low prices offered for produce or the inability to get middle men to purchase the crops to bigger towns for sale) during the previous harvest changed their choices of adaptation practice the following farming season. The inability of farmers to get market for their produce has resulted in loss of income which is mostly difficult to recover and reinvest during the next farming season. For this reason, farmers in the study area indicated that they change their farming practices by reducing the quantity of agrochemicals applied in order to reduce cost, reducing the farm size under cultivation and changing the type of crop cultivated such as growing more of less perishable staple food crops such as maize and cassava and short duration varieties such as tomatoes and pepper. This was important in reducing cost of farming and post-harvest loss.

5.5.3 Political/institutional factors affecting adaptation

A study by Deressa et al. (2009) shows that *access to credit* has a positive impact on the adoption of various adaptation options. However, the findings of Uddin et al. (2014) showed a different opinion as access to credit did not seem to significantly influence farmers' adaptation practices. In the study area, it was found out that the ability of a farmer to access credit was important in determining the adaptation decisions to climate change. It was noticed that farmers who had joined various groups and association were able to access loans and credit to purchase fertilizers and other farming inputs to boost their farming activities. On the other hand, farmers who were not in any association and were able to obtain credit individually indicated that the loans helped them purchase improved crop varieties and agrochemicals which otherwise would have been expensive and unaffordable for the average farmer. Farmers expressed that the challenge however was the interest paid on the loans received and problems with paying on schedule in a monthly instalment especially during a bad harvest. Ewurama, a 47 year old female farmer during the female FGD expressed her thoughts on the predicaments farmers sometimes have to face with payment when farmers access loans.

“Initially, when farmers took money we sometimes paid in a year but now the loans received demand that farmers pay every month. How can the farmer pay monthly instalments? Sometimes when one cultivates cassava due to low rainfall the crops do not grow well or at all. If it does not rain too then rodents eat the rest of the crops. So how can the farmer pay for such loans?”

For this reason, some farmers indicated that due to bad experiences in the past they preferred to manage their available financial resources. This finding is in line with the observation of Hassan and Nhemachena (2008) showing that financial resources available to farmers enhances their adaptive measures and capacity to acquire important input needed to better adapt to climate change. It is therefore important that farmers have access to sufficient and affordable credit services

Access to extension services play a significant role in influencing the type of adaptation practice adopted by a farmer. Findings from a number of studies (Nhemachena and Hassan 2007, Nhamo et al. 2014) have indicated that the existence of extension services in an area tend to have a beneficial impact on the taking up of innovative technologies since extension services aid in spreading information concerning climate change and adaptive choices at the farm level. Extension services are therefore fundamental sources of information to smallholders. For instance, the female FGD revealed that farmers in the study area are educated by agricultural extension officers on how best to adapt to climate change by providing them with agricultural information on the various ways to adapt. An interview with the AEO also revealed that education received by farmers through farmer field school (FFS), were on both indigenous and modern ways to adapt to climate change. Farmers were educated on how and when it is appropriate to apply fertilizer and weedicide in order to sustain high yields; selection of planting materials at certain periods to improve yield such as drought resistant seeds and hybrid varieties and ways to avoid or control bush fire especially during the dry season.

Secondly, through FFS farmers are educated on how to effectively control pest by teaching them on beneficial and non-beneficial pest. Information from both the AEO and farmers interviewed in Nkonsia further indicated that farmers are advised against deforestation and encouraged to cultivate tree crops such as cashew, mango, citrus and cocoa which provide environmental benefits of improving weather conditions, enhancing the soil fertility in the area through the decomposing of fallen leaves and reducing bushfire. Occasionally, farmers are provided with free hybrid seeds to boost production. Farmers are also educated on the

application of fowl manure to improve soil fertility. Thus, the ability of farmers to access extension officers exposes the farmer to various ways to adapt and their subsequent impact on farm productivity. This finding is in line with the results of Muneer (2008) indicating that farmers who have access to extension services are more likely to have further knowledge on climate change and gain from several improved practices and agricultural innovations.

During the field work, both the male and female FGDs with farmers revealed that access to extension services were met with some challenges. Not all farmers had equal access to information from agricultural extension services since extension officers were mostly in contact with farmers who had formed some association or cooperation. Therefore, most farmers are usually unaware of when extension officers visit the study area. For this reason, farmers pointed out that they relied on information from other farmers concerning various farm-level management practices. Farmer-to-farmer extension hence played a major role in the exchange and dissemination of knowledge in the study area (Deressa et al. 2011). Interview with the AEO corroborated the information from the farmers indicating that it is easier getting access to farmers through cooperative groups. The AEO further indicated that visits are announced but only a few of the farmers are present during such meetings since most of the farmers are usually concerned about farm work than meetings. Due to this, farmers are mostly encouraged to pay periodic visits to the MOFA office in Wenchi for any information and advice needed. This information was likewise confirmed by individual interview with farmers noting that visits to MOFA have been helpful in providing information on farm management practices.

Governmental policies and institutional support was significant in influencing farmers' adaptive choices. According to farmers, the introduction of modern practices such as the use of agrochemicals especially fertilizer by the government in the past led to their adoption in the area. During an individual interview with Esi, a 70 year old female farmer it was found out that in order to propagate the adoption of the technology agrochemicals were sometimes provided for free and at other times at a subsidized price so that farmers could patronize the chemicals. Currently, the promise of free seeds and fertilizer to farmers in the area is partially fulfilled. During the female FGD, Obaa, a 55 year old farmer reported that:

“Government officials came to write our names with an assurance to provide us with seeds such as groundnut and cashew for sowing but we have since not heard from them. The agricultural extension officers once provided one bag of fertilizer to share among ourselves, what will one bag of fertilizer do for us?”

The high prices of fertilizer on the other hand have led to farmers reducing their patronage of the chemical since it increases the cost of farming. Even though farmers in the area apply fertilizer they mostly do so at critical moments when rainfall is extremely low and threatens food production. Interview with the AEO revealed that the directorate of MOFA in Wenchi collaborates with both local and foreign NGOs and other institutions to help farmers adapt through various Integrated Food Crop Projects (for example on vegetables and cashew) geared towards improving soil quality and plant health and proper methods of controlling crop pests and diseases. Some of these projects involved coaching farmers on innovative and practical ways to adapt to climate change and sustain production. For example, farmers are given practical knowledge on the cultivation of tree crops without the application of fertilizer through budding of citrus and grafting of cashew and mango.

Farmers who had *membership* in farmer based organisations (FBOs) were found to adapt better as they had access to knowledge and farming inputs than those who did not join any form of organisation. As a result, these farmers were able to adopt new technologies such as the use of hybrid seeds and high yielding varieties. This is aligned with the studies of Ali and Erenstein (2017) showing that the membership statuses of farmers have positive influences on the number of adaptation practices adopted and innovation used. Further, Uddin et al. (2014) indicate that the adoption of various adaptation strategies is higher for farmers who join cooperatives than farmers who do not. It can therefore be said that farmers who have various forms of membership maybe food and income secured than those who do not. This adaptation practice is also adopted by smallholders in Bangladesh (Lasco et al. 2011).

SECTION TWO

ENVIRONMENTAL OUTCOME OF THE ADAPTATION PRACTICES

“The chemicals have on one hand come to help farmers increase productivity and on the other hand come to destroy our lands.” They are our helper and destroyer”. The words of Manu, a 70 year old male farmer.

5.6 Introduction

Although the various adaptation practices applied by farmers are aimed at yielding positive outcomes on farming activities and income these practices also come with their negative impacts. Studies indicate that not all adaptation practices are environmentally friendly as some may result in negative impacts (Pretty et al. 2011, Adimassu and Kessler 2016). The change in climatic condition, its subsequent negative effect on farming activities and the combination of socio-economic pressures have affected sustainable agricultural practices among farmers in the study area.

5.7 Impact of the adaptation practices on the environment

Findings on the field revealed that the various adaptation practices adopted among farmers in order to be resilient to climate change have resulted in the *degradation of the environment* in the study area. This *ecological change* is as a result of the impacts of both indigenous and modern adaptation practices and the inappropriate use of available natural resources.

Farmers in the study area acknowledged that one of the major ecological changes resulting from their adaptation practices is a *change in soil fertility*. Continuous cropping which is influenced by both climatic and socio-economic factors as already discussed has led to reduction in soil fertility. As already indicated by farmers, the practice of continuously cropping on the same land have altered soil quality. Dzifa, a 39 year old cashew farmer expressed his views on the cause and effect of the indigenous adaptation practice on the environment:

“I believe the reason why the land is losing its fertility is because the land is continuously being cultivated leaving no room for fallow period as we used to practice in the past when the population of this area was smaller than it is now.”

Similarly, the continuous application of fertilizer is reported by farmers to further reduce the fertility of the land. Even though the main purpose of fertilizer is to improve the fertility of the

soil and crop yield amidst the unfavourable climatic conditions; the continuous application of the chemical has resulted in changes in soil nutrients. Farmers stated the excessive use of the chemical to be the main cause leading to changes in the mineral composition of the land and subsequently a reduction in the soil fertility. Farmers moreover, believe that certain micro-organisms which help in keeping the rich content of the soil have all been destroyed further causing the soil to deteriorate. During the interview with key informants, the AEO agreed to the fact that the excessive use of fertilizer and over-cultivation as indicated by farmers to be the causes affecting the fertility of the soil. The AEO however added that low quality fertilizers used by farmers are also other causes which reduce the soil fertility in the long run. A study by Killebrew and Wolff (2010) confirms that continuous cropping and the application of inorganic fertilizers both affects the fertility of the soil as a result of nutrient mining and the rise of soil acidification through nutrient leaching respectively.

Another effect of the various adaptation practices on the environment is *change in the physical structure of the land*. Farmers who were interviewed indicated changes in the physical conditions on the land which they can easily see as compared to the changes in the soil fertility whose effect is manifested in the changes in crop production. One of the physical changes mentioned by most of the farmers interviewed is the rigidity of the land emanating from the application of weedicide. This environmental impact is reported by a 39 year old farmer Sammy, as mostly being at its peak during periods when there is no rainfall. During such periods the land quickly dries and hardens up when the sun shines compared to when farmers used to manually cut down the weeds and burn them. Similarly, Danquah, a 36 year old farmer stated that “*during the wet season the land becomes extremely soft to the extent that when one steps on the soil one’s feet begin to sink.*”

There has also been the *sprouting of bad resilient plants and weeds* which were not originally known to the study area. Farmers indicated that the application of weedicides especially has led to the growing of certain resilient weeds some of which are locally called Nyame bewu ansa na mewu” and “Adankomilko” as already discussed. Thus, original plants and weeds are being replaced by new ones. The use of weedicide even though in the same way is intended to control weeds has further resulted in a similar problem of producing resilient weeds which have the capacity to multiply quickly especially during the rainy season when the land becomes extremely soft. Farmers further revealed that sometimes they have no choice but to

increase the use of the chemical which they know also results in environmental multiple problems. Interview with the AEO however revealed a differing opinion on the issue. According to the AEO, the sprouting of the resilience weeds which was agreed to be new to the ecology of the area is not just due to the chemicals as the farmers mentioned but due to other reasons. The migration of herders from the northern to the southern part of Ghana in search for pastures for their herds led to the animals passing excretory which contained remnants of weeds consumed from the north when they moved around the area. The weeds then germinated and have later taken over the lands. Informants interviewed later acknowledged that there are certain weeds from the north, however these weeds are not the resilient ones caused by the application of agrochemicals. Hence, the change in plant ecology in the area is due to both the adaptation practices of farmers and other reasons.

Furthermore, the practice of cutting down certain trees which are deemed to compete with crops for nutrients and water especially during drought as already discussed (and also as shown in figure 7) have resulted *in a change the plant cover* in the area. Both the male and female FGDs revealed that the practice of cutting down trees (as shown in figure 7) have changed the plant ecology in the area. The older farmers interviewed indicated that plants such as teak and odum no longer exists in the area as they have all been cut down and none have been replanted to replace the lost ones. Plants which were hence originally known to the area have been slowly wiped out. Interviews with other informants further revealed that sugarcane has also been wiped out due to the use of weedicide during weed control which tends to destroy the plant (as it quickly dies off) since the chemical is too strong for the plant to withstand. Consequently, various forms of both indigenous and modern adaptation practices have led to the reduction and loss of certain plant species in the study area.



Figure 7: Some tree cut down on the farm to allow for farming activities.

From figure 7 above, the trees cut down on a farm land are considered by the farmer to compete with the cocoa plants for nutrients. The farmer also deems these trees of no benefit for the farming process. The logs are used as firewood or sold for income. The activity of the farmer clearly shows that he does not fully take into consideration the environmental consequences of his actions. Furthermore, the farmer even though fully aware that the reduction in forest cover in the area has contributed to the changes in rainfall pattern in the area has taken no action to correct this problem. This also indicates that a farmer being aware of the causes of climate change in the area is not enough but also institutional support in promoting actions that will enhance sustainable practices among farmers is needed.

Both extreme weather events (such as drought or torrential rainfall) and farm expansion which sometimes lead to the outbreak of pests and have resulted in the increase need for pesticides have in recent times led to the *upsurge of different and resilient pests*, especially in the peak seasons of farming as farmers hardly depend on natural means of pest control. In addition, the AEO specified that certain indigenous practices such as crop rotation may lead to the outbreak of different pest which belong to the same family and have the tendency to multiply over time. The increase in pest calls for an increase in the need for pesticides to properly control the pest and diseases due to their destructive nature. This situation may lead an environmental

problem of a cyclical incident of pest control and outbreak. Indigenous means of pest control may therefore seem to be the most appropriate.

In addition, certain adaptation practices have led to the *disappearance of some animal species*. Farmers indicated that animals such as snails which were easy to come by in the forest are now difficult to find. In the past, during the rainy season snails were abundant but currently they are no longer available and becoming scarce. Farmers attributed the current situation to the use of agrochemicals which have become poisonous to forested animals and others found along river banks as well as the cutting down of trees. Some farmers in the area believe that the various chemicals being used in farming have killed most of the animal species which were on the land and some of them migrating to other places. A 70 old female farmer Naa, reported during the female FDG that:

“In the past snails were easy to come by. I used to get a basket full during the rainy season and there was no need to rare or buy them. The food that I used not to buy I currently have to buy them since they are now scarce in the area.”

Even though this study focuses on the environmental impacts of the various adaptation practices on the environment, some of these practices can also have human health implications. For example, farmers expressed their concern about the agrochemicals especially weedicide and pesticides affecting one’s health from time to time such as blurring the sight when used over a period. Farmers also reported body itch and burning sensation of the skin when the body comes into contact with the chemicals. The discussion above shows that farmers in the study area are well aware of the negative impacts of their adaptation practices on the environment. It must however be well noted that some farmers during the interview indicated that they were not aware of the negative consequences of their practices at the start of engaging in the practice but rather became aware after experiencing the impact on their land some years later. The negative implications on the environment especially on the land were noticed after some years of adopting the practice. On the other hand, other farmers were already aware of the possible effects the chemicals could have on the land. As reported by Danquah, a 36 year old male farmer:

“I had heard people talk about the effect of the chemicals on their farms however, it was difficult for me to believe until I started using the chemical and soon realized that my land had started becoming hard too.”

In addition, Aku, a 57 year old female farmer declared that she has personally not experienced the environmental impact of agrochemicals on her farm since she uses the chemical on an infrequent basis due to the challenges posed by her gender and age as discussed in the preceding section. This further confirms that age and gender of a farmer in the study area determines how a farmer is able to adapt. Likewise, this information reveals that the reduced application of agrochemicals reduces the adverse environmental impacts as discussed in the literature.

5.8 Impact of the negative effect of the adaptation practice on farming activities and crop production

The application of agrochemicals was revealed to affect farming activities and crop production. The high quantity of agrochemicals *negatively affects the quality of crops produced*. For example, most farmers indicated that high quantity of fertilizer used in order to rapidly boost production during periods of low rainfall changes the taste of crops such as yam and cassava. The chemical tends to makes cassava hard, difficult to cook, bitter and sometimes reddish in colour. On some occasions, one may have to dispose off the cooked cassava since it may not be good for consumption. Most farmers admitted that disposing the food is meant to prevent one from getting diarrhoea if one should consume it. This is because the food easily goes bad hours after cooking which was not the case in the past when agrochemicals were not introduced to crops. Similarly, high amount of fertilizer affects the physical features of crops. For instance, a 30 year old male farmer, Atsu mentioned that too much fertilizer affects the smooth growth of yam as the chemical makes the crop have some hair-like appearances which should normally not be the case. The maximum yields can therefore be attained when nutrients to plants are obtained through a blend of mineral fertilizers and natural sources (IFAD 2013). Farmers also pointed out that the application of pesticides in the wrong quantity and time may tend to affect crops as the chemical can make crops poisonous. This was corroborated by information from the AEO that the inappropriate application of agrochemicals affects food crops.

The application of weedicide *affects plant health and development*. The chemicals (such fertilizer) sometimes make plants like cocoa die off quickly when the chemical is not applied at the right time. Plants for which the weedicides are not intended for (as mentioned in the preceding discussion) and which are not compatible with the chemical such as plantain and

cocoyam quickly die off when the plants come into contact with the chemical during weed control farmers pointed out. In the same way, weedicide also has the tendency of changing the physical structure of certain plants such as cocoyam (which develop weird bending shape) when they come into contact with the chemical. A 52 year old farmer, Kofi observed that when the cocoyam plant dies it is no longer able to germinate or regrow and even when the plant is able to survive it grows in a *cockered manner*. Similarly, when a 36 year old male farmer, Akwesi applied the weedicide on his maize farm he indicated that the plant soon dried up, changed into a yellowish colour and slowly got destroyed without it bearing fruit. This he lamented affected his total produce and income. Furthermore, the rigidity of the land as earlier discussed farmers mentioned affects the ability of crops to geminate and grow well.

The negative consequences of the various practices were also found to *negatively affect the farming activities* of farmers in the study area. According to farmers interviewed, the adverse consequences of the practices make farming difficult as more time and resources are used in clearing the land of the unwanted resilient weeds as shown in figure 8 (A). The rigidity of the land as a result of the application of weedicide makes working with axe and hoes far difficult when farmers resort to these indigenous practices. Also, the rigid land which sometimes delays the quick and smooth growth of plants (as sowed seeds sometimes die or do not properly mature) delays when farmers are able to harvest. The change in soil fertility also means that crops (for example cassava as mentioned by farmers) which were initially cultivated on the same land could no longer develop after some years of fertilizer application as the soil composition changes over time. Due to the environmental changes, farmers would as a result change the type of crop cultivated and place of cultivation in order to maintain production.

Even though Wenchi is located in the transition zone considered as the nation's "breadbasket" (Wrigley-Asante et al. 2017), the findings of this study in totality indicate that the negative impact of farmers' practices have *increased the cost of farming and may threaten food security in the area*. This is because certain crops locally known in the area are slowly disappearing and farmers are finding it difficult to cultivate these crops on the same soils on which they were initially being cultivated on. The female farmers in the area during the FGD mentioned cocoyam, mushrooms and sugarcane as some of the crops which are now scarce or wiping out in the study area. This information was also corroborated by other farmers during the individual interviews. Farmers in the study area therefore spend a lot of resources in combating

the negative impacts of both climate change and their adaptation practices on their farming activities in order to maintain food production and sustain their livelihood.



Figure 8: (A). A resilient plant locally known as "Adankomilk". This is one of the many plants which have taken over most farm lands due to the application of weedicides.



(B). Adankomilk growing at a faster pace among maize crops. This can affect plant growth as the weeds can compete with the maize crops for nutrients. The farmer on the other hand cannot apply weedicide to the weeds since the chemical would destroy the crops. Thus, the farmer has to let the weeds and crops grow together till the crops attain some level maturity.

5.9 Factors that influence unsustainable agricultural practices

"Farming is a business and in every business one has to make profit." The words of Duah, a 46 year old male farmer.

During the field work, it was discovered that certain factors influence unsustainable adaptation practices in the study area. These factors when properly addressed may promote sustainable practices among smallholders in Wenchi.

Inadequate education and ignorance among farmers have influenced farmers in indulging in unsustainable practices. It was observed during the interviews that some farmers were not fully aware of the environmental consequences of certain actions as showed in figure 7 and 9. Even though farmer-to-farmer extension was significant in spreading information in the

study area, it was not enough to help farmers prevent some actions and their subsequent environmental impacts. It has thus become important that farmers are educated by highly knowledgeable people such as extension officers on the possible adverse impacts of the various adaptation practices which they adopt. This may also involve integrating both indigenous and formal knowledge. As indicated by IFAD (2013) smallholders' access to information through modernization of extension services in the form of FFS and radios is essential in helping farmers have efficient source of information.



Figure 9: Empty chemical cans left near a trench on a farmland.

The actions of the farmer (from figure 9) may affect the water table when it rains and running water from the chemical cans seeps into the trench. It can likewise affect the health of farmers as the water from the trench is also used for domestic purposes during severe drought. Killebrew and Wolff (2010) thus specify that agrochemicals and actions (for example as shown in figure 9) can affect human health, harm animals and affect the availability of water for human use through runoff and leaching of chemicals into water bodies and soils respectively.

Poverty, from the results of the field work contributes to the perpetuation of unsustainable farming practices. Wolfenson (2013) have established that that there is a connection between rural poverty and sustainable agriculture. Additionally, EPA (2011) reports a strong relation between climate change and poverty levels in the agro-ecological zones of Ghana. Even though, some farmers were aware of the negative environmental consequences of some practices (such as continuous cropping, the use of cheap and unsustainable chemicals and the

removal of trees), farmers chose to continue with these practices as they were considered by the farmers to be effective in increasing yield amidst climate change. According to these farmers, they have no other option or the financial capital to invest in any other practice which may have less impact on the environment. For instance, a field observation and an interview with a farmer revealed that due his poor condition, the farmer chose to remove large quantities of trees from his land as he deemed those trees as a danger to his crops such as competing with the crops for sunlight and soil nutrients which he could not afford. The farmer's ability to rigorously engage in such an act was also exacerbated by the fact that he had no financial capital to engage in other non-farm activities. Therefore, the farmer's inability to rely on another income generating activity coupled with his poor livelihood condition together influenced him to take such drastic decisions which resulted in such an unsustainable practice with the desire to secure income in the changing climatic conditions.

Farmers also reported that if the use of modern practices in the midst of climate change make farm work easy and in general also sustain food production then it would be difficult for them to desist from such practices. For these reasons, most of the farmers in the area indicated that they cannot stop indulging in the adaptation practices such as the application of large quantities of agrochemicals (which may be cheap and low in quality) and the removal of forest lands even though they are aware of the environmental impacts. As indicated during an interview with the EA, farmers may not take into account the sustainability or the unintended consequences of their actions as the primary goal is to adapt. Farmers furthermore, mentioned scarcity of land (due to population increase which has increased continuous cropping) and soil infertility (as the land is already used to the chemical now) as factors also promoting the vibrant use of their practices. It was also found out that farmers' ability to have adequate access to formal credit and other sources of monetary resources was low as farmers interviewed had not obtained loans for many years due to factors already discussed. For some farmers, they have no choice but to continue their unsustainable practices in order to ensure the continuation of their livelihood activity. Thus, a 30 year old male farmer Atsu, expressed his helplessness towards the situation:

“Although I am aware of the environmental implications of the use of these chemicals, if I stop applying the chemicals farming basically becomes impossible considering the several factors affecting the activity now as plant growth would immensely be affected and farming becomes less profitable.”

Abu, a 78 year old farmer further expressed his thoughts about how poverty and ignorance could promote unsustainable practices:

“It takes someone who thinks about the environmental consequences on the land to limit the use of the chemicals. However, every farmer wants more money and this has increased the use of the chemicals since without the chemicals farmers cannot have a good harvest.”

The above statements means that for there to be sustainable management of the natural resource, poverty needs to be addressed among farmers by making financial resources available to them as their activities are driven by the profit maximization.

Inadequate deployment of extension officers was identified to be another factor responsible for farmers’ adoption of unsustainable agricultural practice in the study area. Even though farmers were educated on a variety of adaptation practices to reduce the negative impact of climate change as well as the environmental consequences, this was not enough. Interview with both the AEO and the EW revealed that the number of extension officers in the area was far from adequate. Therefore, few extension officers have the responsibility of covering a large area of farming households and this has posed significant challenges to the officers especially reaching those in the hinterlands. It was therefore clear that more extension officers are needed to visit farmers on a regular basis and allow for adequate monitoring as well. The quality of extension services is also important and therefore extension service should be made to suit local needs, build on farmers’ knowledge ...and incorporate sustainable approaches into the programmes of extension services to promote the training of environmentally knowledgeable officers (IFAD 2013). By so doing, extension officers can strengthen farmers’ capacity to overcome the challenges posed by climate change and the related environmental risk associated with their adaptation practices. Also, intensive external interventions by NGOs and other agencies can help promote climate smart adaptation practices among farmers.

5.10 Measures used by smallholders to tackle the environmental impact

Farmers in the study area being aware of how environmental degradation may affect their farming activities tend to make some efforts towards reducing the negative impact of their adaptation practice on the environment. For these farmers, if they do not do anything about the

current situation in their own way they may lose the very resources that provide them with their source of income. One way by which farmers tackle the negative environmental consequences is by reducing the quantity of fertilizer which is applied on the soil (*soil management*) from time to time. The EW however believes that farmers who reduce the quantity of agrochemicals used are mostly geared by protecting their economic interest since the chemicals are expensive and purposely not for the environmental effect. Farmers also practice land rotation (*land management*) by dividing their land into two and then cultivate half of the land while the other is left to fallow in order to later support cultivation.

Other measures also involve tree planting (*land management*) to reduce evaporation, maintain soil moisture and increase plant cover; reduction and change in the type of weedicide used to a type that has less effect on the land and crops (*soil and crop management*); application of weedicide at the right time that is during the rainy season and not the dry season to better reduce its effect on the land and to properly control weeds (*land management*); crop rotation and growing of nitrogen fixing crops (*crop and soil management*). By doing these, farmers hope to sustain the little of what is left of the environment. Farmers also on rare occasions engage in the application of fowl manure (*soil management*) to reverse the negative impact and improve soil nutrients. Interview with EW and the AEO revealed that farmers are advised on food safety which begins right from the farm and the environmental effects of the chemicals used. This includes talking to farmers on which agrochemical can be used on a particular soil, indigenous ways of maintaining the natural resources and going about farm work (such as the cultivation of leguminous crops) and aid in the regulation on the importation of agrochemicals at the national level. The problem however is that unsustainable agrochemicals still find their way into the local market.

Although some efforts are being made towards reducing the negative impacts of smallholders' practices on environmental resources, interview with the EA revealed that some of the impacts may have a long term environmental impact in terms of quality, quantity and the natural land scape. The impact can either be reversed or may lead to permanent losses such as the change in plant ecology as the findings of this study have discussed above. It is therefore paramount that more action is taken to prevent permanent damage of the natural environment as well as sustainably manage what is left of it.

5.11 Governmental and NGO support

Aside the measures used by farmers to combat the negative impact of their agricultural practices on the environment; farmers also indicated that support from the government and other NGOs would help them adapt better to climate change with less environmental consequences.

Governmental and NGO assistants were needed in the form of provision of hybrid seeds, provision of quality fertilizers; reduction in the prices of fertilizers so every farmer can afford and provision of various farming equipment to make farm work easy since they do not practice mechanized farming. Some farmers also shared their thoughts that fertilizer may not be as important to them as the government providing them with other forms of assistance such as helping farmers in the area get market for their produce. This according to the farmers is important since nothing can be done about the rain which is the major problem. However, getting market for farmers' produce during the lean season and especially during bumper harvest when the rains are favourable is better since farmers tend to face the challenge of looking for buyers for their produce and sometimes with the products going bad. Farmers cited that governmental assistance may further come in the form of the government setting up a price ceiling for agricultural produce so that farmers would not be cheated by middlemen especially during bumper harvest. This would help farmers in the study area earn enough money for their produce in order that they may not incur high cost for their farming activities and also help farmers from selling their produce at a cheap price.

Other supports are needed by increasing education received from AEOs, providing boreholes and artificial dams to collect water to assist farmers in their farming activities and for irrigational purposes so that farmers do not have to totally depend on the rain. Farmers also need loans to be provided with flexible conditions to aid them cope better. Younger farmers interviewed were however worried about their livelihood conditions during their old age as well as farming being less attractive to the upcoming youth. These farmers thus mentioned that farmers should be given a pension scheme in order to secure their livelihood in the future during old age and further attract young farmers into the sector.

5.12 Chapter Summary

This chapter sought to explore the prevalent climatic conditions in the study area. It also explored the adaptation practices adopted by farmers, the factors that influence their adaptive

practices and established the link between these factors in aiding farmers to successfully adapt or hinder farmers' adaptation to climate change. The environmental impacts of the various practices were discussed. From the discussion it can be inferred that low rainfall, poor soil fertility, financial endowments, access to information and gender are the main determinants influencing farmers' adaptive choices in the study area. Currently, farmers use both indigenous and modern practices to safeguard themselves against the risk associated with the prevailing climatic conditions in the area. Most farmers also tend to diversify their activities to improve income and sustain household food consumption. The environmental consequences of the adaptation practices are manifested in the form of reduction in the quality and quantity of environmental resources with multiple effects on farming activities. Even though smallholders try to make amends to reduce their impacts on the environment this is not enough since the factors accounting for unsustainable agricultural practices among farmers still persist.

CHAPTER SIX

DISCUSSION AND CONCLUSION

6.1 Discussion

It is evident that the climatic condition in the Wenchi municipality is changing. The observed changes in rainfall and temperature are considered as significant indicators of climate change in the area for the study in the form of high temperatures and reduced rainfall. Observed extreme events were persistent drought, long dry spells and heavy rainfall during the rainy season. For example, a previous study by Owusu and Waylen (2013b) suggests empirical evidence of changes in climatic conditions in the area especially variability in rainfall characteristics. Findings however indicated that farmers are more worried and affected by drier-conditions and torrential rains since they have implications on food production. The factors also responsible for the high temperatures and low rainfall in the area are human related causes such as deforestation which has resulted in a change in vegetation cover (Adjei-Nsiah and Kermah 2012).

Agriculture is a significant source of income to smallholders in Wenchi as it provides farmers with income and food. However, just like other rural communities being faced with challenges posed by climate change, the changes in climatic conditions in Wenchi have had significant impacts on the farming activities and livelihood of smallholders. Since irrigation agriculture is not a dominant practice it was important to assess the impact of changes in climatic conditions on the livelihood of the farmers as well as the practices being used to reduce such impacts. The impact include reduction in the quality and quantity of food production, changes in the farming activities such as change in the type of crop produced, delay in farming season and the general reduction in the income received by farmers. The impact of climate change in affecting food production, food security and income is discussed in the studies of Harvey et al. (2014) and Owusu et al. (2015). Apart from the high temperatures and low rainfall received, low soil fertility resulting from over cultivation has also been a significant factor accounting for the low agricultural production in the area (Egyir et al. 2014). This has affected food security at the household level and may have *implications for future food security in Ghana*.

In the following, reference is made to information from farmers in Nkonsia and not generalizing to the Wenchi municipality. The findings of this research might be relevant for most communities in the municipality but the conclusion of this research cannot come to that conclusion or corroborate. From the qualitative interview, smallholders have consequently

adopted both indigenous and modern adaptation practices to reduce the impacts of climate change on their farming activities in order to sustain their livelihood income activities as the literature review indicated (Morton 2007, Thornton 2011, Osei-Owusu et al. 2012, Egyir et al. 2015). The key indigenous adaptation practices adopted by farmers were inter-cropping, mixed farming, crop rotation, reduction in farm size, shift in planting dates, continuous cropping and the use of drought tolerant crops. Farmers have also shifted from growing annual crops to include crops that can be harvested on a monthly basis. Modern adaptation practices adopted by farmers include the use of fertilizer, weedicides and pesticides to reduce the gap in food productivity posed by changes in climatic conditions (Egyir et al. 2014). While a farmer engage in an on-farm practice, the farmer may at the same time engage in a non-farm activity. There is thus the combination of both on-farm and non-farm practices to generate income. Non-farm practices are rigorously employed in between farming seasons and are thus significant source of income to farmers. The ability of a farmer to engage in a non-farm practice is also dependent on the asset availability both human and most importantly financial capital. For instance, farmers who engaged in non-farm practices and were financially better-off could hire labour to work on their farms while they paid more attention to their non-farm activities and only came in when necessary.

Diversification from agriculture to non-agricultural activities has consequently gained importance among farmers as they seek to find other income to support their agricultural incomes. As part of their strategy to survive, farmers engage in other income earning activities such as selling of food items, provision stores, driving and providing of extra labour outside their farming activities in order to reduce risk posed by the variabilities in climatic conditions and also to sustain their livelihood. Findings indicated that even though women engaged in on-farm practices they resorted more to non-farm practices than their male counterparts showing that men and women have varying ways of responding to challenges associated with climate change (Wrigley-Asante et al. 2017). Most farmers preferred non-farm adaptation practices to on-farm since it ensures regular income, reduces farmers' dependence on a single source of income and hence reduces poverty levels among farmers. Even though other farmers regarded non-farm adaptation practices as effective due to their ability to help farmers obtain income on a regular basis, farmers equally acknowledged that on-farm practices are much preferred since they are effective (especially modern practices) and income earned from farming is much better than that

earned from non-farm activities should the rains be favourable. This means that the effectiveness and significance of the various adaptation practices engaged by a farmer is subject to and dependent on seasonal changes. Farmers also engage in communal adaptation by identifying themselves with clan members and friends to help each other by providing financial assistance, advice and physical strength to each other during various phases of the farming life cycle. However, this way of adapting had grown less importance due to the challenges involved.

One significant findings of the study was that the minor crops which were in the past served as household food consumption is now growing in importance due to farmers' effort to reduce the risk of variabilities in rainfall and drought on their livelihood. As a result, these minor crops now serve as an additional source of income which farmers now rely on their sale for household sustenance. It was also observed that the ability of farmers in the study area to successfully adapt to climate change and extreme weather events is influenced by biophysical, socio-economic and political factors (Smit and Pilifosova 2003, Smit and Wandel 2006, Feola et al. 2015) as discussed in the literature. These include farm specific location, availability of water; capacity of the farmer such as the available financial resource; age of the farmer, cooperative membership, educational status, access to extension services (Uddin et al. 2014), access to market, access to credits and loans, and governmental supports. These factors dictated the adaptive behaviour of farmers in the area in order to reduce climate associated risk and improve crop production. Among these factors the most important ones found to influence farmers' choice of adaptation to high temperatures and low rainfall in the area either through on-farm or non-farm practices were poor soil nutrients, resource constraints such as inadequate finances, knowledge, strength (or age of the farmer), gender and access to information from extension officers. Even though education received from extension officers are beneficial they are also costly to farmers both in monetary value and the type of crops farmers are to grow for their household consumption. For these reasons, knowledge on the multiple factors which facilitate or limit farmers' adaptive choice to climate change is important since it can aid local and national leaders to devote resources to these factors. Mechanized farming was revealed to be uncommon among farmers and this should be encouraged to allow farmers to better adapt to the changing climatic conditions in the area.

The adaptation practices either indigenous or modern adopted by farmers were accompanied by unintended environmental consequences. In addition, farmers' decision

concerning their adaptation practices did not come with environmental considerations since the priority was to increase food production and income. The negative environmental impacts of the adaptation practices in the study area are manifested in the form of reduction in the quality and quantity of environmental resources and conditions as discussed in the literature review (IAASTD 2009, Killebrew and Wolff 2010, Pretty et al. 2011). One of the key environmental impacts is the change and reduction of soil fertility due to continuous cropping of the land and the application of chemical fertilizers and weedicides which have affected soil nutrients as the chemicals change soil compositions and kill the microorganisms in the soils. The land has become rigid which is as a result of the combined effect of low rainfall, high sunshine and the application of agrochemicals. Weedicide use has also resulted in change in plant ecology as old plants are being wiped out and new ones continuously taking over the land. Similarly, tree cutting for farming and other purposes have reduced plant cover and this has also influenced the rainfall pattern in the area which may in the future worsen should the current situation persist. Thus, the negative impact of deforestation resulting from farmers' adaptation practices to climate change and extreme weather events have further led to variations in weather conditions creating a spiral situation. Such feedback loop may also worsen the situation for smallholders themselves. The various environmental impacts have consequently contributed to changes in both ecological and climatic conditions in the area. With the intention of being resilient to climate change the practices adopted by farmers also involve the dependence on natural resources which may lead to long term land degradation and environmental problems as posited in the conceptual framework. The impact of the adaptation practices does not only pose a threat to the environment but also to farmers as it has increased the cost of farming reducing farmers' profit as well as reducing food sufficiency among households. The findings of Misra (2017) in a similar study in Bangladesh show how various agricultural technologies negatively affect the environment and smallholder's livelihood as they result in increasing financial cost, reducing forest cover, lead to the disappearance of insects and other animal species due to pesticides poisoning, agrochemicals contaminating water bodies and affecting aquatic animals and the reduction in soil productivity.

Despite the fact that farmers are aware of the environmental consequences of their chosen practices especially the use of agrochemicals, they are preferred among most farmers as the chemicals help farmers to achieve a higher increase in production. Farmers therefore consider the use of modern practices as more effective than the indigenous ways of adapting but also

acknowledge that indigenous practices may be more environmentally friendly. However, farmers are equally aware of what the current negative impact of their practices may pose to their source of livelihood and are therefore taking steps to tackle the numerous environmental changes. This include various soil (Killebrew and Wolff 2010, Pretty et al. 2011); crop (Ajani et al. 2013) and land management practices (Ajayi et al. 2008, Reddy 2015) such as the application of agrochemicals in the appropriate quantity and time, land fallowing, crop rotation, cultivation of leguminous crops and tree planting. Through these sustainable agricultural management practices, farmers hope to regenerate already degraded lands as explained in the conceptual framework. Farmers' inability to sustainably manage environmental resources in their farming activities were influenced by the poverty conditions of farmers in the area (Wolfenson 2013), ignorance, inadequate information and access to extension services. Consequently, farmers' ability to adapt should be based on the idea that they should have the capacity to continually adapt to the changing biophysical and economic conditions surrounding them (Verchot et al. 2007).

In order to reverse or maintain the present environmental conditions there should be restrictions on unsustainable farming practices especially the new accepted method of farming. This will involve institutional roles in strengthening farmers' adaptive capacity through gender-based initiatives and programmes rigorously involving women as discussed in the literature. In Ghana this will involve collaborations between the ministry of agriculture and EPA to properly educate farmers and monitor their agricultural practices. New varieties which can stand shade can also be developed so that farmers do not cut down trees. The economic trend can also be changed by encouraging the production of tree crops such as mangoes, cashew, teak which have both economic value and is environmentally beneficial. For farmers in the study area to better adapt to climate change and extreme weather events assistance are needed in the form of provision of monetary resources, quality agrochemicals and hybrid seeds. Farmers also need irrigation systems to combat drought and pension schemes to secure their old age. Governmental and international support through research, improved information systems, education and extension services are needed to help farmers better adapt to climate change (Verchot et al. 2007) and the multiple stresses posed by the various biophysical, socio-economic and political factors.

6.2 Conclusion

Basing the conclusion of this research on the interviews and literature review, this study has shown that smallholders are adapting to climate change in various ways through local knowledge and new technologies. Based on the conceptual framework, the study illustrated how various factors affect farmer behaviour to the on-going adaptation process to climate change and the impact on food production and the environment. The usefulness of the conceptual framework also lies in showing the interlinkages between climate change, adaptation and the various biophysical, socio-economic and political factors. This further suggests that for smallholders to effectively adapt to climate change the various factors need to be considered. The major barriers affecting farmers' ability to effectively adapt to climate change were financial constraints, old age and gender, access to information and poor soil nutrients. This implies that there is no single means for farmers to successfully adapt to climate change.

Empirical findings revealed that even though smallholders themselves are making efforts to change some of their practices to help sustain the environment, these efforts are also accompanied by financial considerations. This brings us to another research question of the link between poverty and sustainable practices as farmers adapt to climate change in the study area. The negative environmental impact emanating from the various adaptation practices further demand that the government and other decision makers should strengthen policies concerning agricultural practices among farmers. It also calls for agricultural stakeholders to broadly promote sustainable practices among smallholders by tackling specifically the various factors that affect farmers' ability to successfully adapt through a multidisciplinary approach that suits local needs and changing socio-economic conditions. By so doing, smallholders would have the motivation to aim beyond maximizing profit and also be custodians of the environment as they still remain central to the provision of food and the sustenance of the ecosystem both in the short and long term.

APPENDICES

Appendix 1: List of informants

Key informants			
Participant	Gender	Organization	Type of interview
Environmentalists, national level (Accra)	M	EPA	In-depth interview
Environmentalists, municipality level (Wenchi)	M	EPA	In-depth interview
AEO	F	MOFA	In-depth interview

Individual interviews with farmers			
Participant	Gender	Age	Type of interview
Farmer 1	M	45	Semi-structured
Farmer 2	M	54	Semi-structured
Farmer 3	M	52	Semi-structured
Farmer 4	M	36	Semi-structured
Farmer 5	M	30	Semi-structured
Farmer 6	M	34	Semi-structured
Farmer 7	M	26	Semi-structured
Farmer 8	M	25	Semi-structured
Farmer 9	M	39	Semi-structured
Farmer 10	M	37	Semi-structured

Farmer 11	F	47	Semi-structured
Farmer 12	F	57	Semi-structured
Farmer 13	F	44	Semi-structured
Farmer 14	M	39	Semi-structured
Farmer 15	F	45	Semi-structured
Farmer 16	M	36	Semi-structured
Farmer 17	F	70	Semi-structured
Farmer 18	M	78	Semi-structured
Farmer 19	M	78	Semi-structured
Farmer 20	M	70	Semi-structured

Male focus group discussion

Participant	Age
Farmer 1	34
Farmer 2	32
Farmer 3	52
Farmer 4	55
Farmer 5	46
Farmer 6	62

Female focus group discussion

Farmer 1	40
Farmer 2	65
Farmer 3	47
Farmer 4	52
Farmer 5	55
Farmer 6	70
Farmer 7	54

Appendix 2:

Interview Guide

Section A: Community entry

- Go through traditional community formalities.
- Introduce myself and research objective.
- State ethical guidelines
- Negotiate terms for the interview such as the place and time for participants.

Section B: Interview guide for farmers

Part I: Background information on farmer-informant

- Age:
- Gender:
- Educational attainment (primary, junior high, secondary and tertiary):

- Farm size (small, medium and large plot):
- Crops cultivated (major and additional crops):
- Livestock:

Part II: Knowledge on climate change

1. What was the climatic condition at the onset or offset of major farming seasons during your teenage period?
2. How different is the climatic condition now? Please explain further.
3. What do you think has accounted for the present climatic condition?
4. What weather extremes do you experience?
5. Is there any information related to climate change which I have not asked? Please tell me more.

Part III: On-farm adaptation strategies

1. What are the impacts of extreme weather events on your farming activities?
2. What strategies did you use to cope with the changing weather conditions in the past?
3. What new strategies do you use to adapt to extreme weather events presently?
4. How long have you been adopting these strategies?
5. What decisions informs your choice of adaptation strategy?
6. How has the new adaptation strategy helped you to reduce your vulnerability to climate change?
7. Which of the two adaptation strategies do you consider to be most effective? Please explain.
8. Is there any information concerning your farming adaptation strategies which have not been covered? Please tell me more.

Part IV: Non-farm adaptation strategies

1. Which non-farming strategies do you engage to further build your capacity to adapt to climate change and extreme weather events?

2. How has the various non-farming adaptation strategies strengthened your resilience to adapt?
3. What challenges do you face in using these strategies to reduce your vulnerability to climate change and extreme weather events?
4. How different will you say are the benefits of the non-farming adaptation strategies from the farming adaptation strategies in building your resilience to adapt to climate change?
5. Which other information would you want to disclose concerning your non-farming adaptation strategies? Please tell me more.

Part V: Environmental impact of the changing farming practices

1. What are the impacts of the indigenous adaptation strategies on the environment? Please explain.
2. What are the environmental impacts of the new adaptation strategies?
3. How long have you noticed these environmental impacts?
4. How has the changes in environmental conditions due to these farming practices affected your resilience to climate change?
5. How do you take the environmental implications of your adaptation strategies into consideration?
6. What measures have you taken to deal with these environmental problems?
7. Will you stop practicing an adaptation strategy which negatively affects the environment even though it increases your food production? Please explain further.
8. What do you think should be done to aid you adapt better to climate change while reducing adverse environmental implication?
9. Is there any communal adaptation strategy which is adversely affecting the environment? Please explain.
10. Is there any communal adaptation strategy which is being beneficial to the environment? Please explain.
11. Is there any other knowledge on the environmental impacts of the various adaptation strategies which I have not asked? Please tell me more.

Section C: Focus group discussion with farmers

1. What has been your experience with climate change in this area? Please explain.
2. What indigenous strategies did you use to adapt to the changing weather conditions?
3. What new method do you use to adapt to extreme weather events?
4. What are the environmental impacts of the various adaptation strategies?
5. Is there any other information related to the environmental impacts which I have not asked? Please tell me more.

Appendix 3: Interview guide for key informants

Section C: Interview guide for agricultural extension officer

Thanks for your willingness to participate in this study. I am a student of University of Oslo in Norway. This study is being conducted for my master's thesis and I seek to understand from you how smallholders' adaptation practices to climate change and extreme weather events have affected the physical environment. I will therefore ask you some few questions concerning the adaptation practices, their impacts on environmental sustainability and measures being taken to address these impacts. Your participation in this study is fully voluntary and you may choose to withdraw at any time. All information will be held confidential. The interview will last for an hour. I will be recording and taking notes as well. Thank you.

Background information on informant

- Department:
 - Position:
1. Which adaptation strategies are being recommended to aid smallholders reduce their vulnerabilities to climate change and extreme weather events?
 2. What are the anticipated adverse impacts of these adaptation strategies on the environment?
 3. How will you assess the possible long term impacts of these adaptation strategies on the environment?

4. What measures have you taken to tackle the adverse impacts of these adaptation strategies on the environment?
5. Has these measures been successful? Please explain.
6. In your opinion, how effective are these measures in preventing or reducing a long term environmental impact?
7. Which non-governmental agencies have you partnership with to tackle the environmental problems associated with these adaptation strategies?
8. How can local adaptation practices be integrated into modern practices to better improve environmental conditions concerning smallholders' adaptation strategies?
9. Which other information would you want to disclose concerning the adaptation strategies and their environmental implications that has not been covered? Please tell me more.

Section E: Interview guide for environmentalist

Thanks for your willingness to participate in this study. I am a student of University of Oslo in Norway. This study is being conducted for my master's thesis and I seek to understand from you how smallholders' adaptation practices to climate change and extreme weather events have affected the physical environment. I will therefore ask you some few questions concerning the environmental sustainability of the adaptation strategies and the possible long term impact of the current strategies. Your participation in this study is fully voluntary and you may choose to withdraw at any time. All information will be held confidential. The interview will last for 45 minutes. I will be recording and taking notes as well. Thank you.

Background information on informant

Department:

Position:

1. How does smallholders' adaptation strategy negatively affect the sustainability of the environment?
2. Which of the adaptation strategies used by smallholders' has the potential of having a long term impact on the environment?
3. In your opinion, can the adverse impact on the environment be reversed? Please explain.

4. In your opinion, is the current negative environmental impact capable of prolonging into the future? Please explain further.
5. Which of the adaptation strategies should be promoted to enhance environmental sustainability while building farmers' resilience to climate change and extreme weather events?
6. Is there any other information related to the environmental impacts of the adaptation practices which I have not asked? Please I want to know more.

Thank you.

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