UNIVERSITY FOR DEVELOPMENT STUDIES

AGROFORESTRY AS AN ADAPTATION STRATEGY TO CLIMATE CHANGE IN THE KASSENA NANKANA WEST DISTRICT, UPPER EAST REGION, GHANA

BY

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DECLARATION

Student

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere:

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I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

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ABSTRACT

This thesis explored agroforestry as an adaptation strategy to climate change in the Kassena Nankana West District, Upper East Region. Climate change poses a serious threat to agricultural activities in agrarian economies, such as Ghana, which requires adaptation. Therefore, the main aim of this study was to assess how farming communities are using agroforestry to be able to adapt to the negative consequences of climate change. Specifically, the study assessed farmers' understanding of climate change and agroforestry as an adaptation strategy to climate change in the study area. Mixed methodology was adopted for this study involving the use questionnaires, focus group discussions, key informant interviews and observation to gather relevant data. The findings of the study revealed that farmers noticed changes in climate with adverse effects on agricultural activities. The study discovered that agroforestry practice is a resilient agricultural adaptation option for farming communities as it supported farmers to cope with climate change impacts, such as drought, floods, wind storms, food insecurity and contributed in improving productive potential of the soil which in turn increases crop production. However, agroforestry in dry lands is a challenging task and hence adoption was low. The challenges include inadequate rainfall, free grazing, perennial bushfires and limited access to lands by women farmers for agroforestry practice. The study concludes that agroforestry is a vibrant climate change adaptation strategy. Therefore, the study recommends that farmers should retain and plant more trees on crop lands and also encourage and supported knowledge sharing. In addition, the Ministry of Food and Agriculture in the study district should help farmers with fencing materials and small dams for watering the trees seedlings.

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DEDICATION

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ACRONYMS

AEA	Agriculture Extension Agents
AF	Agroforestry
FAO	Food and Agriculture Organization
FGDs	Focus Groups Discussions
GDP	Gross Domestic Product
GSS	Ghana Statistical Service
GLSS	Ghana Living Standard Survey
HA	Hectare
IPCC	Intergovernmental Panel on Climate Change
KNWD	Kassena Nankana West District
MDGs	Millennium Development Goals
MM	Millimeters
MOFA	Ministry of Food and Agriculture
MT	Metric Ton
NGO	Non-Governmental Organization
ORGIIS	Organization for Indigenous Initiative and Sustainability
UER	Upper East Region
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background to the Study

Agroforestry is briefly defined as integration of trees and crops on the same piece of farm land. The purpose of agroforestry is to produce food, wood and conservation of land resources at the same time. By so doing, agroforestry is expected to moderate potential damages of a constantly changing climate manifested in the agricultural sector. The agricultural adaptation strategies employed include agroforestry practices which the farming communities undertake to cope with climate change; agroforestry adjustments made in response to climate change; and, agroforestry processes to reduce harm or risk of harm resulting from the changing climate (Rao et al., 2007; Verchot et al., 2007; Kiptot and Franzel, 2011). Hence, there is the pressing need to assess the deliberate actions of tree planting and tending on farm lands geared towards avoidance and reduction of harm or risk of harm which may result from climate change.

Farmers' response to climate change is very crucial because the success of agriculture especially rain-fed agriculture depends on climatic conditions (Stige, et al., 2006; FAO, 2009). According to Sivakumar et al. (2005), climate in Africa is characterised by variable rainfall, accompanied by high temperatures with low agricultural productivity as a resultant effect. Agricultural productions in developing countries will not farewell under climate change, and the severity of the impact would be experienced by smallholder farmers (McCabe, 2013). In view of this, serious attention must be given to agroforestry which is capable of reducing temperatures and enhancing the growing of crops on farms (Sanchez, 2000; Kwesiga et al., 2003 cited in UNEP and ICRAF, 2006).

Agroforestry as an adaptation strategy could sustain agricultural production and enhance farmers' ability to improve livelihoods. This will minimize the impacts of climate change which include drought, variable rainfall and extreme temperatures (Syampungani et al., 2010).

Agroforestry development is yet an important strategy that can ameliorate climate change. According to Van Noordwijk et al. (2011), emission of greenhouse gases from agriculture, forestry and land-use change have exacerbated climate change. Robledo (2006) mentioned deforestation and burning of fossil fuels as additional anthropogenic causes of climate change. Agroforestry can play a dual role- mitigation and adaptation, which makes it one of the best responses to climate change. Nair (2009) noted that agroforestry has received international attention as an effective strategy for carbon sequestration and greenhouse mitigation. In addition, agroforestry as a forest-based system plays a significant role in conserving existing carbons, thereby limiting carbon emissions and also absorbing carbons that are released into the atmosphere (Schlamadinger et al., 2007 cited in Syampungani et al., 2010).

Using agroforestry can increase farmers' resilience and position them strategically to adapt to the impacts of a changing climate (Charles et al., 2013). The impacts of climate change are not hard to find especially in Africa. It has been noted that the consequences of climate change on agricultural sector are enormous, this pose a serious challenge to development efforts in general and poverty reduction in particular (Mawere, 2011 cited in Mawere et al., 2013). Rioux (2012) observed that climate change has resulted in the reduction of yields in food crop production in some parts of Africa and consequently, greater percentage of households survive on one or two meals a day. It is noted that

agroforestry has multi-functional purposes which makes it one of the most promising strategies for climate change adaptation. According to FAO (2010:9), "the use of trees and shrubs in agricultural systems help to tackle the triple challenge of securing food security, mitigation and reducing the vulnerability and increasing the adaptability of agricultural systems to climate change". Agroforestry is very useful because it generates quite substantial benefits on arable lands in diverse ways; trees in agricultural fields improve soil fertility through control of erosion, improve nitrogen content of the soil and increase organic matter of the soil (IPCC, 2001 cited in Rao et al., 2007).

In addition, developing countries suffer greatly from the negative effects of climate change because their economies are predominantly agrarian. Floods, drought, extreme weather patterns are among the impacts of climate change in the in the sub-region (Verchot et at., 2007; Badege et al., 2013). Recently, agroforestry has been hailed internationally as an effective sustainable agricultural land use approach because of its production and environmental benefits (Nair et al., 2009). According to Woodfine, (2009:63), "agroforestry systems bring hydrological benefits at field to watershed level, increasing precipitation infiltration, reducing overland flows, reducing peak and low flows and improving water quality -lower sediment content in rivers, streams and dams". Agroforestry transforms degraded lands into productive agricultural lands and improves productive capacities of soils (Rao et al., 2007).

Agroforestry practices by farmers will augment other climate change adaptation strategies employed in Ghana. Ghana is optimistic that effective adaptation to climate change will contribute towards the achievement of sustainable development and to a large extent, the attainment of the Millennium Development Goals (Agyemang and Antwi,

2013). Agroforestry development in Ghana is not new. The Government of Ghana realised the importance of agroforestry initiatives in the 1980s which led to the formulation of national agroforestry policy in 1986 which provided direction and facilitated the development of agroforestry in the country (Asare, 2004). The main aim of the policy was to encourage farmers to adopt agroforestry practices for sustainable land use (MOFA/AFU, 1986 cited in Asare, 2004). Therefore, it reduces the farmer's cost on chemical fertilizer to some extent.

Unfortunately, agroforestry adoption is not widespread and for that matter success stories are found in isolated areas in Ghana and among few adopters of agroforestry initiatives. It is not always the case that policies are implemented as they were intended and so the need to assess farmers' perspectives on agroforestry adoption and implementation especially when climate change has become a serious constraint to agricultural development. Although agroforestry is hailed at the international and national levels as an effective adaptation strategy with a positive impact on global warming and climate risk, its practice among farmers in Northern Ghana is not encouraging. Therefore, it is important to investigate the benefits of agroforestry that makes it one of the most effective agricultural adaptations to climate change and how it is practiced in the study district.

1.2 Problem Statement

Rainfall and temperature variations in northern Ghana have affected agricultural production substantially, which has led to reduction in household incomes and, more importantly, deterioration in household welfare. It is unlikely that changes in climatic conditions in the future will be favourable; the same can be said about its impact on

agriculture (Nkegbe and Kuunibe, 2014). According to Laube et al. (2011:753) "Climate change and land degradation result in decreasing yields and crop failures in Northern Ghana and have caused further impoverishment of Ghana's poorest region".

The sixth round of Ghana Living Standard Survey ranks the Upper East Region (UER) 2nd in Ghana in terms of poverty with 70.4% (GSS, 2014a). The region is prone to desertification and severe soil degradation due to inappropriate farming practices and high rate of poverty (USAID, 2011). The UER recorded a substantial reduction in rainfall accompanied by rising temperatures in recent years (Laube et al., 2011). The cumulative effects of poverty and land degradation have made people in the region vulnerable to the impacts of climate change.

Climate change has negatively affected the productive potential of the soil in the Kassena Nankana West District. The wind storms, recurrent drought and, sometimes, floods resulting from changes in the climate variables have contributed greatly to the loss of soil fertility in the district. According to Ofori-Sarpong (2001), the district is characterised by intermittent drought, soil erosion, low soil fertility, and overgrazing leading to poor crop yields. Apart from climate change, continuous cropping on the same piece of land also affects the ability of the soil to regain its lost nutrients. According to Garrity (2004:7), "Farmland in the developing world generally suffers from the continuous depletion of nutrients as farmers harvest without fertilizing adequately or fallowing the land. Small-scale farmers have removed large quantities of nutrients from their soils without using sufficient amounts of manure or fertilizer to replenish fertility". Cumulatively, changes in climatic conditions coupled with continuous farming practices on the same piece of land are the causal factors of the loss of soil nutrients.

Traditional coping mechanisms to the impacts of climate change in the district include mixed cropping, dry season gardening, non-farm activities and traditional agroforestry practices by some individual farmers which is quite relevant because agroforestry is considered as one of the most important sustainable land use practice for farming communities. However, bush burning, slash and burn farming methods, charcoal production activities in the district expose the district to further impacts of climate change. This calls for attention from all, especially farmers in the study district to tackle the problem before it becomes a crisis for all. Agroforestry is a versatile and resilient land use approach that can rehabilitate degraded lands for successful agricultural production. According to Carsan et al. (2014), agroforestry restores and enhances nutrients retention in the soil and reduce fertilizer application by 50%. In the words of McCabe (2013:4) "agroforestry merits special attention because of the diverse benefits it provides for smallholder farmers across the developing world".

Even though agroforestry holds enormous sustainable land use and environmental benefits; studies conducted in the study district did not explore the linkage between agroforestry and climate change. Therefore, there is the urgent need to assess how agroforestry contributes to addressing the observed impacts of climate change in the Kassena Nankana West District.

1.3 Research Questions

1.3.1 General Research Question

The study answered the question: How does agroforestry serve as an adaptation strategy to climate change?

1.3.2 Specific Research Questions

The following specific questions were answered:

- How do farmers understand climate change in the Kassena Nankana West District?
- How is agroforestry practiced in the Kassena Nankana West District?
- How do farmers perceive agroforestry as an adaptation strategy to climate change?
- How do farmers cope with challenges encountered in agroforestry?

1.4 Research Objectives

The aim of the study was to assess the use of agroforestry by farming communities as an adaptation strategy to climate change in the Kassena Nankana West District.

Specifically, the study:

- Explored farmers' knowledge on climate change.
- Investigated the various measures involved in agroforestry practices in the Kassena Nankana West District.
- Examined farmers' perspective on agroforestry as an adaptation to climate change.
- Assessed various challenges of agroforestry in the Kassena Nankana West District.

1.5 Significance of the Study

Previous studies have contributed significantly to a body of knowledge on climate change adaptation in the UER. However, these studies did not consider how agroforestry can help farmers adapt to the consequences of climate change in the study area. The literature

reviewed revealed that studies conducted in the Upper East Region considered climate variability and yields of major staple food crops (Amikuzuno and Donkoh, 2012), impact of climate change on agriculture and farmers coping strategies (Ofori-Sarpong, 2001) and smallholder adaptation to climate change (Laube et al., 2011). None of these studies examined the relationship between agroforestry and climate change within the region. Therefore, this study attempts to explore agroforestry as an adaptation strategy to climate change in the Kassena Nankana West District. The following are the specific significance of this study:

- The study made a contribution to enhance farmers', land users' and planners' understanding of the role of agroforestry for climate change adaptation.
- Equally important is the fact that findings of this study may lead to the consideration of agroforestry as one of the adaptation strategies to climate change in the study district and may encourage more farmers to adopt it.
- This research contributed to a body of knowledge on agricultural adaptation to climate change in the study area.
- Also, the results of this study could be a reference material for further research on agricultural adaptation to climate change in the future.
- Development agents and organisations could use the findings to make relevant decisions with regards to implementation of agroforestry in areas with similar spatial and physical characteristics.

1.6 Scope of the Study

In terms of geographical scope, the study is conducted in the Kassena Nankana West District of the UER. This study explored agroforestry as an adaptation strategy to climate

change in the study district. The study used archival records which date back to the year 1985 and current data on agroforestry and climate change. Agroforestry practices examined in this study include home gardens, farm woodlots, plantation and crop combinations, trees on farms lands and scattered trees on farms.

Other agroforestry practices that are not mentioned here are beyond the scope of this study. In terms of the time scope of the research; the research covered a period of two years from 2013 to 2015.

1.7 Organisation of the Study

The study is organized into six chapters. The first chapter covers the background, problem statement, research questions and objectives, significance of the study, scope of the study and the methodology which encompasses the design of the study, sources of data, study population and sample size, sampling techniques, methods of data collection and data analysis techniques.

The second chapter captures the profile of Kassena Nankana West District where the study was carried out. Chapter three is an in-depth review of relevant literature and the conceptual framework on agricultural adaptation to climate change. The following issues were covered: concept of climate change, impacts of climate change, vulnerability of climate change, agricultural adaptation to climate change, agroforestry as an adaptation strategy to climate change, agroforestry practices, benefits of agroforestry, challenges of agroforestry and agroforestry policies.

Chapter four focuses on data analysis and presentation of results on the four objectives of the study. In chapter five, a detailed discussion was done on the results. Chapter six which is the last chapter takes care of summary and conclusion of the thesis.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

Studies have been conducted on climate change and agroforestry in recent times and in the past. Some of the studies looked at climate change and agroforestry separately while others considered the two concepts simultaneously. This chapter reviewed relevant literature on the concept of climate change, the impacts of climate change, vulnerability of farmers to impacts of climate change, agricultural adaptation to climate change, and agroforestry as an adaptation strategy to climate change. In addition, literature on agroforestry practices, the benefits of agroforestry, challenges of agroforestry practices, agroforestry policies and Ghana national climate change policy were reviewed. The conceptual framework for the thesis is stated at the end of the literature review.

2.2 Climate Change

2.2.1 The Concept of Climate Change

The IPCC agreed definition states that "climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer)" (IPCC, 2008 cited in Woodfine, 2009:10).

Climate change refers to the variation in climatic condition which emanate from human activities that alters the atmospheric composition across the globe over considerable long periods of time (UNFCCC 1994 cited in Macchi et al., 2011). The publication of the first assessment of climate change by the Intergovernmental Panel on Climate Change (IPCC, 1990) has generated interest of the scientific community in understanding the

extent to which climate has changed and its ramifications on agricultural systems (Antle, 2009).

Empirical studies have shown that climate change is a world-wide phenomenon. Global temperature records since the 1850, show increase in global mean surface temperature from 0.42°C to 0.54°C above the 1961-1990 annual average (IPCC, 2007). It also ranks eleven of the last twelve years (1995-2006) among the 12 warmest years. According to Robledo (2006), the IPCC noted that unprecedented alteration in the climate system have occurred globally during the 20th century especially, during the last decades of the 20th century. These changes manifested in three key variables- variable rainfall patterns, increase in average temperatures and an increase in the intensity and frequency of extreme events. In the African continent, the Fourth Assessment Report of the IPCC discovered a warming trend since the 1960s and indicated that rainfall in West Africa has decline significantly. This decline has resulted in southward shift of the savannah zone which can impact negatively on grassland and woodland (USAID, 2011). Studies on climate change in Africa indicate spatial and temporal climatic variation across the entire continent (Nicholson, 2001; Le Barbe et al., 2002).

Moreover, Hulme et al. (2001) noted climate in Africa has exhibited some significant degrees of variation overtime and will continue to do so in the coming years. Some empirical studies suggest that Sahara and semi-arid parts of Southern Africa will record a rise in temperature of about 1.6° by 2050s while that of the equatorial African countries will be warming at a slightly slower rate of about 1.4°C (Hernes et al., 1995; Ringius et al.1996 cited in Hulme et al., 2001).

Le Barbe et al., (2002), observed fluctuations in the rainfall pattern in the sub-region where the starting of the raining season as well as the ending of the season has become increasingly unpredictable. There has been prolonged dry season while the wet season has become relatively shorter; this situation has affected hydrological systems negatively. However, it is imperative to acknowledge that the reality of climate change is being contested by some scholars who do not believe that climate change is occurring, Stern (2006:2) argued that "they are a small minority and their positions become weaker as the evidence accumulates." This means that generally, scholarly consensus on the reality of climate change is yet to emerge.

At the national level, the situation is not quite different. Spatial and temporal rainfall fluctuations have been well captured by rainfall models over the last 30 years which show decline in rainfall in the southern and northern zones of Ghana (Owusu and Klutse, 2013). According to Nkegbe and Kuunibe (2014), significant variations in rainfall and temperature patterns indicate the occurrence of a changing climate in Ghana. The study pointed out that this will lead to further changes in precipitation patterns and general weather conditions in Northern Ghana.

Some scholars have argued that farmers have acquired some level of knowledge and understanding about climate change. A survey conducted by Maddison (2007) revealed that farmers in Africa have some level of knowledge on climate change as farmers have witnessed changes in temperature and precipitation. Farmers' level of experience has a positive influence on their knowledge of climate change.

Ozor et al. (2012) discovered that majority of farmers are aware that droughts, floods, incidence of pest and disease as well as uncertainties of the onset of the raining season

are manifestations of climate change. This has been attributed to awareness creation through the print and electronic media as well as social and religious networks. This means dissemination of climate change information has received serious attention in the study area, but it may not be applicable somewhere else. Macchi et al. (2011) argued that availability of water which depends on rainfall play a major role in subsistence farming and so when rainfall becomes erratic and unpredictable, farming activities will be at risk. From farmers' perspective, rainfall was declining to the extent that it affected the quantity of water in the ground and the amount of drinking water for communities and livestock. In the light of the above, it is expedient to explore farmers understanding of climate change in the KNWD. Similarly, Bryan et al. (2010) found out that farming activities in Kenya were determined by variable rainfall, as such farmers' paid particular attention to the prevailing climatic conditions. The implication is that farmers' understanding of climate change is quiet essential as it guides agricultural production decisions at the farm level. Therefore, climate change must be a serious concern for all, especially when the change is detrimental to human health and agricultural development.

With regards to the causes of climate change, IPCC (2001) maintained that the concentration of greenhouse gases such as carbon dioxide and aerosols (microscopic airborne particles or droplets) are among the causal factors of the changes observed in climate. The IPCC argued strongly that climate change is largely influenced by human-induced emission of greenhouse gases especially in the 20th century. Salinger et al. (2000) observed that the main causes of climate change are a mixture of internal and external forces; the causal factors of a changing climate include volcanic eruptions, agricultural development and forestry operations, the activities of industrial processes, transportation

and the transformation of settlements into urban centres. These activities brought about emission of greenhouse gases that disturb atmospheric conditions.

It is evident that the dominant causes are all human activities that result in changes in the climatic conditions in geographical space and hence the need to tackle seriously human-induced climate change. In most of the studies on climate change, rainfall and temperature are the two elements that received attention from researchers, especially studies of climate change in relation to agricultural productions; arguably they are the two most important climate variables that determine to a large extent the success or failure of the agricultural system, particularly in Africa where agrarian economies are dominating.

2.2.2 Impacts of Climate Change

In terms of the impacts of climate change, Stern (2006) noted that consequences of climate change will be felt globally but disproportionately. The author goes on to state that the poorest countries will suffer severely from the adverse consequences of climate change due to their inability to respond appropriately to the shocks. The impacts of climate change are not hard to find, particularly in Africa where economies are most vulnerable to varying climate. Some studies revealed that climate change will have adverse effects on agricultural production and productivity in Africa (Challinor et al., 2007; Ozor et al., 2012). The destructive consequences of climate change include but not limited to the following: frequent occurrence of severe agricultural drought, floods, heat stress and other extreme weather events; these are the pathways through which the actual impacts are felt (Stern, 2006; Bryan et al., 2010; FAO, 2010 and Codjoe and Owusu, 2011).

Environmental resources such as soil and water upon which agricultural production depends are adversely affected by climate change which poses a serious threat to sustainable agricultural development especially in Africa (Carsan, et al., 2014). According to Verchot et al. (2007) farmers are unable to get returns on their investment during drought years and in the following years; the productive capacity of the farmer is worsened. This implies that drought has an immediate effects and aftermath effect on agricultural production. As a result, it may be extremely difficult for the farmer to recover from the impact of agricultural drought, hence adaptation deserves serious attention.

According to Szwed et al. (2010:1) "climate changes, and in particular increases in temperature and changes in rainfall have strong impacts on agriculture via weather extremes – droughts and heat waves. The crop yield depends particularly on water availability in the plant development phase." For instance, it is observed that the overall agricultural productivity loss in Africa as a result of climate change is estimated to be between 17% and 28% as compared to 3% to 16% for the world as a whole (Cline, 2007 cited in Badege, et al., 2013).

Ozor et al. (2012) maintained that agriculture contributes about 20-50% to gross domestic product in Africa and about 60% of the population in Africa are employed in the sector. However, the impacts of climate change have affected greatly food production in Africa and for that matter, the contribution of the agricultural sector to GDP.

The study found out that declining soil fertility and incidence of high weeds infestation are among the impacts of climate change in Southern Nigeria. Moreover, farmers in Kenya observed that animals feed has become very scarce due to climate change (Bryan et al., 2010). This study argues that climate change is not only a threat to food crop

production but also rearing of animals which is one of the major sources of livelihood for some people. It is clear that livelihoods that depend on variable rainfall and temperature are diminishing due to climate change and this trend if continues will make the poor poorer. This will make it difficult to achieve the goal of food security and poverty reduction in the continent. Therefore, it is evident that Africa will face the brunt of climate change.

Furthermore, Twumasi et al. (2011) observed that significant increase in temperature has negative bearing on forest cover; hence deforestation and vegetation loss are partly due to variable temperature. Irregularities in weather conditions pose serious threat to agriculture and predisposes developing countries to food insecurity especially those in semi-arid areas (Amikuzuno and Donkoh, 2012). A study by Codjoe and Owusu (2011) on climate change and food systems in Ghana; revealed that climate change has negative consequence on food crop production especially in rural settings. This situation has affected agricultural production in Ghana, to the extent that yields in maize production have declined considerably (Acquah and Kyei, 2012). This suggests that the rural farmer is vulnerable to the forces of the climate.

2.2.3 Vulnerability of Farmers to Impacts of Climate Change

According to the IPCC, vulnerability takes into account the degree to which a system is predisposed to and unable to thrive well in the face of adverse effects of climate change, including climate variability and extremes. It implies that the consequences of climate change are over and above the tolerant levels of the system (IPCC, 2007). There are other definitions of vulnerability but this study adopts the IPCC, 2007 definition due to its appropriateness. The vulnerability of the agricultural sector in Africa to the impacts of

climate change can be viewed in three dimensions: the capacity of institutions to respond to climate change, the sensitivity of crops to variable climates and the adaptive capacity of farmers (Challinor et al., 2007). This study noted the severity of the impacts depends on the extent to which places and systems are vulnerable to climatic changes.

Vulnerability is spatially variable; it is argued that Africa is the most vulnerable continent to the consequences of a changing climate. Similarly, agricultural has been seen as one of the human activities that is most vulnerable to changing climatic conditions, particularly tropical subsistence farmers because the needed resource base for effective adaptation are far from being enough and resources are also very sensitive to climate change (Verchot et al., 2007).

Badege et al., (2013) pointed out that food insecurity, population growth and other unfavourable socioeconomic factors make farm families in developing countries more vulnerable to the consequences of climate change. The continuous loss of forest cover and environmental degradation worsen vulnerability of farmers in developing countries to the impacts of a changed climate. Natural resources such as plants and animals are sensitive to climate change and extreme weather conditions and hence agricultural crops find it difficult to thrive well under stressed climatic conditions (USAID, 2011). Majority of Ghanaians rely on rain-fed agriculture, this makes the sector susceptible to the shocks of climate change (Breisinger et al., 2008 cited in Pinto et al., 2012) , eventually, climate change will hinder progress in the agricultural sector and reduce its contribution to economic growth in Ghana (Yaro, 2010 cited in Pinto et al., 2012). For example, the European Centre Hamburg Model (ECHAM5) projected a high rate of decline in yields of rain-fed groundnuts cultivation (Pinto et al., 2012).

2.2.4 Agricultural Adaptation to Climate Change

It has been established that farmers as well as the agricultural sector have suffered from the consequences of climate change unevenly due to varying degrees of vulnerability globally. Consequently, agricultural adaptation has been identified as one of the prudent strategies in responding to climate change (Verchot et al., 2007). Adaptation to climate change has to do with significant modifications in farming practices in response to a changed climate. It also refers to changes in coping strategies to observe or expected climatic conditions in order to minimize their effects or take advantage of the changes (Smit et al., 2000 cited in Wall and Smith, 2005). Wall and Smit (2005:1) concluded that "agricultural activity has always included adaptation to a number of diverse stresses and opportunities–elements that continue influencing developments in the agri-food sector. Climate and weather conditions are a good example of factors that require on-going adaptation." Farmers have demonstrated their willingness and ability to adapt to some variation in the environment, therefore when the right conditions are in place at the national and local levels, farmers will be able to adapt to changes in climatic conditions (Challinor et al., 2007). Therefore, governments should put in place the right measures that will propel farmers to embrace adaptation practices that are suitable to enhance agricultural development.

There are several forms of adaptations that are practiced at different levels and by different agents of development -farmers, agribusiness, industrial organizations and governments (Bryan et al., 2000 cited in Wall and Smit, 2005). In addition, Antle (2009) argued that there are various forms of adaptation in the various countries which include farmers' decision on what variety of crops to cultivate, the chemicals to be applied and

the various farming strategies to be adopted in the light of climate change at the farm level. Fankhauser et al. (1999) identified and analyzed optimal adaptation strategies to climate change and pointed out that research is among the most important steps that can contribute to effective adaptation and that research should concentrate on the development of crops that can withstand harsh weather condition overtime and also reduce the uncertainties of climate change to promote effective adaptation. The study indicated the urgent need of strengthening institutions so that research results get to the appropriate actors for implementation. The authors noted that it is not enough to employ reactive adaptation measures, but suggested that reactive adaptation policies should be the basis for formulation of anticipatory ones.

In Africa, farmers are making conscious efforts to cope with the impacts of climate change. Studies conducted by Maddison (2007) and Bryan et al. (2010) indicate that farmers are planting several varieties of crops as well as altering planting dates to be able to adapt to the impacts of climate change. Planting trees, decreasing the number of livestock, changing, or supplementing livestock feeds, changing fertilizer application, and soil water conservation practices are the other adaptation strategies (Bryan et al., 2010). These strategies may be applicable in the study area so this study will investigate how farmers using these strategies to be able to adapt to the impacts of climate change.

More to the point, Ozor et al. (2012) showed that the most intensively used adaptation practice was increased weeding. Other significant strategies adopted by farmers include changing the timing of land preparation activities, multiple cropping, processing crops to minimize post-harvest losses, increased use of farm inputs such as manures and seeds, crop replacement, as earlier ones wither away due to unfavourable weather conditions,

changing the planting dates, mixed farming, use of resistant varieties, changing the timing of harvesting dates and mulching. According to Yaro (2013), farmers in Ghana adapt to a changed climate using local hardy varieties, cultivate new improved varieties, farming around water bodies to take advantage of soil moisture and grow multi-crops on the same piece of land. These interventions suggest that farmers have some basic understanding of climate change and the actions that are required to be able to survive its impacts.

2.3 Agroforestry

2.3.1 Definitions of Agroforestry

Agroforestry has been defined as a resilient land use practice where farmers make deliberate efforts to retain trees and plant other woody perennials in association with crops as well as livestock in agricultural fields to benefit from the resultant ecological and economic interactions (MacDicken and Vergara, 1990 cited in Darkoh, 2003). In addition, Charles et al. (2013) defined agroforestry as the planting of exotic tree species with crops and/or animals on agricultural fields in addition to naturally occurring trees on croplands.

The study has adopted this definition of agroforestry because it encompasses in-situ and ex-situ trees as well as crops which are relevant to the study. This shows that farmers may intentionally retain some tree species during the first time land is being prepared and also introduce new species because farmers know the benefits of doing so. If the resultant ecological and economic interaction will be beneficial, then tree and other component combination must be compatible, hence it is relevant for farmers to know the appropriate combination in order to derive maximum benefits from agroforestry. From the definitions

above, the three most important components of agroforestry are the trees, crops and animals and for a system to qualify as agroforestry, the tree component must be combined with at least one of the other components.

2.3.2 Classification of Agroforestry Systems

Young (1989) categorized agroforestry systems into the following broad classifications: mainly agrosylvicultural (trees with crops), mainly or partly sylvopastoral (trees with pastures and livestock), and agroforestry with tree component predominance. Mainly agrosylvicultural comprises shifting cultivation, improved tree fallow, taungya, trees on cropland, plantation crop combinations, multistorey tree gardens, hedgerow intercropping (barrier hedges, alley cropping), boundary planting, trees on erosion-control structures, as well as windbreaks and shelterbelts.

Mainly sylvopastoral covers trees on rangeland or pastures, plantation crops with pastures, live fences, and fodder banks. Woodlots with multipurpose management, reclamation forestry leading to multiple uses constitute tree component predominance category. According to Nair (1993), agroforestry systems have three main components namely; woody perennials, herbaceous plants (agricultural crops) and animals that are manage by farmers and other land users.

2.3.3 Agroforestry Practices

Agroforestry is practised in different forms in different geographical areas. Farmers in tropical countries are engaged in the following agroforestry practices: home gardens, alley cropping, improved fallows, intercropped trees for shade and fodder production, and trees planted in hedgerows and along fence lines. Farmers' choice of any of these practices is largely determined by local needs and existing opportunities for adaptation

(Long and Nair, 1999). Badege et al., (2013) discovered that rotational wood lot, alley crop, fodder banks, windbreak, live fence, improve fallows, boundary planting, riparian forest buffers, silvopasture as well as forest farming are suitable for climate change adaptation in Kenya and Ethiopia.

2.3.3.1 Scattered Trees on Farm Lands (Parklands)

Agidie et al. (2013) studied agroforestry practices among farmers in the Upper Blue Nile in Ethiopia and discovered that intentional retention and tending of scattered trees on agricultural landscape is one of the traditional agroforestry systems in practice. *Croton macrostachys, Acacia abyssinica and Cordia Africana* are among the trees found on farm lands. Farmers integrate cereals such as finger millet barley, bread wheat and maize because such crops have good yield when combined with the trees mentioned above. Similarly, Gebrehiwot (2004) and Jamala et al. (2013) found out that the deliberate retaining of preferred trees on agricultural landscape is one of the commonest practices of agroforestry by majority of farmers in Ethiopia and Southern Nigeria respectively.

In view of the above, the number of trees that are retained in terms of spacing depends on the native trees species or seedling on site and farmers decision on the number of trees needed for various purposes. Comparatively, this may be cheaper than tree planting because beneficiary farmers will not incur any cost in purchasing seedlings and the difficulty associated with seedling survival would have been catered for. Once this is said to be the commonest practice, it will be imperative to find out how farmers are practicing it and how it is helping farmers to adapt to the consequences of climate change in the Kassena Nankana West District of the Upper East Region of Ghana.

2.3.3.2 Home Garden

This type of agroforestry practice involves the cultivation of vegetables, shrubs, medicinal trees as well as fodder and sometimes retention of naturally occurring trees on a relatively small piece of land that are close to people's houses. Farmers engage in this practice on the same piece of land for an extended period of time, benefits derived from home gardens are enormous (Oluka-Akileng, et al., 2000). Home garden help farmers to have easy access to fruits and vegetables all year round which is considered supplement to the food of farming households. It is also an important source of income to the farming especially during the dry season. According Badege et al. (2013), this practice may have come about due to population increase making it difficult to access large parcels of lands so people resort this as some form of adaptation. Wood perennials, crops and animals are integrated in this system in order take advantage of the interaction among them. However, home garden exist with or without animals (Nair, 1993). In the study district, animals are not kept in the garden, but in the kraal at home or somewhere around the home. Nevertheless, the farmer who manages the system facilitates the interaction where fodder and crops residue are used to feed the animal, while animal droppings are used to fertilize the vegetables and the crops.

2.3.3.3 Woodlot

It is a process whereby preferred trees species are planted usually on large tracks of lands, farmers can plant single or a combination of tree species on the same piece of land. It is noted that wood lot is another form of fallow because wood lot plantations are usually located in marginal lands (Oluka-Akileng et al., 2000). The authors go on to say that Kalitunsi (*Eucalyptus species)* and *Nsambya (Markhamia lutea)* are the preferred species

used in the establishment of wood lot plantations because the demand for their products which include timber and fuel wood is quite substantial. Management practices associated wood lot development includes thinning, weeding and pruning to ensure success.

2.3.3.4 Trees on Farm Land

It is a tree growing strategy where farmers plant trees in addition to the naturally occurring tree species retained on farm lands. This is a deliberate attempt by the farmer to increase tree population on agricultural fields in order to maximize the benefits of agroforestry. By so doing, the farmer has access to fruits, food, and income and enjoys shade provided by the trees. In the long run, it helps improve soil nutrients which will in turn boost agricultural production. It also moderate harsh environmental conditions of the local area (Alao and Shuaibu, 2013).

2.3.3.5 Plantation and Crop Combination

It refers to an integrated multistory mixture of tree crops, such as coconut, cacao, coffee, and rubber, with other tree crops, shade trees, and/or herbaceous crops (Long and Nair, 1999).

2.3.4 Tree Management Practices

Farmers undertake certain key activities to ensure the survival of trees on farms and also to promote effective functioning of the other components (crops and animals). Nair (1993) argued that tree management operations are numerous with diverse effects and that the magnitude of interactive effects in agroforestry systems depends on a number of factors. These include characteristics of species, planting densities of species and the spatial arrangements of trees and the nature of interaction- whether competitive or

complementary. The main aim of management operations is to maximize the desire outcome which is to improve production on one side and to minimize the negative effect resulting from competition on the other side. Management operations adopted by agroforestry farmers encompass rotation of animals, mulching, application of farm manure and fertilization.

Other tree management practices include coppicing- cutting trees at about knee height, pruning- selective removal of tree branches to reduce shade, lopping -cutting of portions of branches from the base of a stem. This is done to obtain fodder and firewood usually carried out by farmers to ensure that agroforestry systems thrive well and generates the needed benefits (Nair, 1993; Agidie et al., 2013). The practices reduce the amount of area that will be covered by shade from the trees and create enough space for farmers to plant other crops on the same piece land. Hence, the yields of crops that are not shade tolerant will improve. According to Gebrehiwot, (2004), some farmers are well aware that tree and seedling management is paramount for the desired result to be achieved.

2.3.5 Benefits of Agroforestry

2.3.5.1 Socioeconomic Benefits

Integration of trees with crops on agricultural landscape comes with some socioeconomic benefits to land users. Agroforestry has income generating potential which helps farmers to earn income by selling products such as fuel wood, timber, honey, fruits and even herbs (Gebrehiwot, 2004; Thorlakson and Neufeldt, 2012). According to Kiptot and Franzel (2011), incorporation of trees and shrubs on crop lands is a low cost strategy that replenishes the fertility of soils for women farmers who find it difficult to acquire fertilizer and a sustainable source of firewood for households. Other benefits includes

enhancement of farmers capacity, the capacity to control poverty, ensure food security, empowerment of female farmers and other under privilege rural dwellers, reduce deforestation and pressure on forest, improve production capacity of soil and increase farmers accessibility to medicinal trees (Tewari, 2008 cited in Kwakwa and Wiafe, 2014).

2.3.5.2 Biological Benefits

Agroforestry practices yield enormous benefits to bio-physical and bio-chemical processes that will go a long way to improve and rehabilitate nutrient poor soils which will be advantageous to cultivation of food crops (Nair, 1993 cited in Jamala et al.,2013). Agroforestry systems will improve agricultural fields in diverse ways by contributing to soil erosion prevention, organic matter renewal and retention of soil nutrients. In addition, agroforestry minimize soil nutrients leaching losses, ameliorate soil degradation, facilitation pollination on farms and also improve the soil recycling potentials (Darkoh, 2003). The author added that this will improve biodiversity in semi-arid lands in Africa.

According to Carsan et al. (2014) Agroforestry practices have multiplicity of agro-ecological benefits which have the potential of sustaining agricultural intensification in Africa without compromising yields. Kiptot and Franzel (2011) stated that the practice contributes significantly in improving the fertility of soils by generating and replacing soil nutrients for agricultural production and hence can be used to combat soil degradation. Agroforestry practices are also useful in controlling weeds on farms and increasing the yield of maize. Trees on agricultural landscapes especially leguminous trees play a significant role in nitrogen fixing to improve the nutrients levels of the soil

couple with other natural processes that aid decomposition of biomass to fertilize the soil (Badege et al., 2013).

2.3.5.3 Environmental/Ecological Benefits

Trees on farm lands play a number of crucial roles that are helpful to environmental health and the wellbeing of human beings. Place et al. (2012) noted that agroforestry creates some environmental benefits such as sustainability of biodiversity, watershed protection and carbon sequestration. Similarly, trees on agricultural fields create serene environment for human habitation and provide shade for some other living organisms, serve as wind breaks, help retain the fertility of the soil and influence the climatic condition of a particular geographical area (Verheij, 2004 cited in Kwaku and Wiafe, 2014).

Jose (2009) observed that agroforestry contributes to improving the quality of water in agricultural landscape, removing carbons from the atmosphere, conserves variety of life forms, enriches soil nutrients and reduces poverty levels of farming families. These benefits cannot be enjoyed by the farmer alone, due to positive externalities; the benefits are also enjoyed by the larger society.

2.3.6 Agroforestry as an Adaptation Strategy to Climate Change

Scholars have argued that farmers, especially in rural communities are turning to agroforestry in recent times as a means to adapt to the consequences of climate change. Agroforestry helps in regulating soil water and altering microclimate to minimize the effects of extreme weather conditions on crop cultivation to enhance agricultural production among poor smallholder farmers (Pramova et al., 2012; Ozor et al., 2012).

Agroforestry is one of the proactive measures that can empower farmers to be able to absorb the shocks from variable rainfall and temperature. Research shows that trees on farms have the capacity to protect crops from climate extreme conditions and will at least help farmers to maintain production (Pramova et al., 2012). Agroforestry systems are particular helpful as the deep roots of trees can draw underground water to enhance soil moisture during agricultural drought period, roots plays a key in improving soil porosity and help quite significantly in checking soil erosion (Verchot et al., 2007).

Planting of trees on agricultural lands is considered to be a good land-use practice that enhances farmers' access to improved livelihoods. This practice makes it possible for farmers to cultivate food crops, fodder and incorporate trees on crop lands simultaneously for adaptation purposes which help farmers to meet fodder, timber, poles and fruit needs (Darkoh, 2003). In Africa, nitrogen-fixing trees boost agricultural production even in drought years as trees play diverse roles in improving moisture and nutrient content of the soil (Garrity et al., 2010 cited in Pramova et al., 2012). Therefore, it can be argued that agroforestry systems are more resilient to drought than non-agroforestry farming systems.

One of the adaptation potentials of agroforestry has to do with its ability to improve food crop production. Syampungani et al. (2010) studied the potential of using agroforestry as a win-win solution to climate change and concluded that agroforestry can help farmers who have suffered from drought, floods and variable rainfall to sustain their production and have access to livelihoods. Likewise, Verchot et al. (2007) discovered that agroforestry systems are dynamic as they can maintain agricultural production in both wetter and drier years because trees have the ability to pump excess water from the soil and reduce runoff during wetter periods and in the drought periods, deep root systems of

trees are able to explore larger soil volume for water and nutrients. Therefore, agroforestry systems are more resistant to harsh weather conditions than any of the other farming practices, making it a viable climate change adaptation strategy for rural farmers.

Agroforestry as an adaptation to climate change have been embraced by some farmers in Ghana. Danquah et al. (2013) pointed out that some farmers in the Brong Ahafo Region have gained some level of understanding about climate change and environmental management practices in recent times due to the activities of environmental NGOs, as such farmers are willing to plant or retain trees on their farms to be able to cope with the challenges posed by climate change.

2.3.7 Challenges of Agroforestry

Agroforestry would have been more successful with great impact in society but this is not the case due to the challenges. Inappropriate land tenure arrangement as well as inadequate capacity of farmers with regards to tree planting and tending will a have cumulative negative effect on agroforestry practice.

A case-study conducted by Rioux (2012) categorized the challenges of agroforestry into three: land tenure system, land use and management, capacity and knowledge. The study noted that the land tenure system which is mainly clan-owned renting system makes it difficult for farmers to have access to large tracks of lands for agroforestry purposes and even the fact that land is rented can discourage people from planting trees on it. In terms of land use and management, the use of slash and burning as a strategy for land preparation is also a constraint to successful practice of agroforestry.

Some agroforestry farmers noted that inadequate rainfall to support tree growing, the length of time trees take to mature and lack of financial resources are among the serious challenges encountered (Kwakwa and Wiafe, 2014). Unfavourable land-tenure practices, coupled with population pressures that relegate agroforestry practices to degraded lands, subsistence needs that prevent extended periods of tree growth, and insufficient technical information or technology dissemination impede successful practices and development of agroforestry (Long and Nair, 1999).

The inability of the farmer to have access to certain production factors may hinder progress in agroforestry practice. Agidie et al. (2013) noted that inadequate availability of seedlings, free animal grazing and pest were serious challenges encountered by farmers in Ethiopia. Tom-Dery et al. (2014) carried out a study to find out the problems in afforestation of rural areas of Northern Ghana which noted that lack of access to seedling; seedling care; protection and maintenance of trees after planting, labour requirement for tree planting were among the challenges encountered by farmers. However, these studies failed to point out how farmers are dealing with these constraints, how these challenges have demotivated other farmers from practicing agroforestry in the study sites.

2.3.8 Agroforestry Policy

Policies play significant role in interventions by governments and other development organizations. Usually, the intentions of government on development are spelt out in policy which will be translated into action to attain the needed development. Place et al. (2012) concluded that policies are crucial in the determination of agroforestry adoption and practices among countries. In countries where there are favourable polices, the rate of

adoption and practice of agroforestry are higher than those where policies are absent or not implemented.

Research findings indicate that implementation of agroforestry projects have been hindered by the absence of appropriate policies, therefore, the importance of policy issues in agroforestry development cannot be overemphasized (Nair, 1993). Place et al. (2012) outlined three policy areas that are quite important and deserve attention for agroforestry practices to thrive; these include land tenure system that allows private individuals to own land and for that matter trees on the land; the development of an effective agroforestry information dissemination strategy; and, also the recognition of agroforestry as a viable venture by agricultural institutions and national agricultural programmes. The study further pointed out that agroforestry generates some benefits that are enjoyed by the general public.

From the literature, Ghana has National Agroforestry Policy that was developed about three decades ago with the main objective of promoting the adoption and practice of agroforestry among farmers in the country. The policy was mainstreamed into National Agricultural Policies to facilitate implementation (Asare, 2004). In recent years, the Government of Ghana has observed that land degradation is one of the serious environmental problems facing the country; as a result, one of the policy objectives of the Ghana Forest and Wildlife Policy is to promote rehabilitation and restoration of degraded lands. The government sought to do these through "information dissemination about the contribution of forest plantations to reverse land degradation, restore forest cover and improve rural livelihood and food security through agroforestry schemes" (Ministry of Land and Natural Resources, 2012:23). In addition, farm forestry practices will be

encouraged which encompasses managing trees on farms, boundary planting and other agroforestry systems. It is therefore pertinent to find out how well this important policy has been implemented in the Upper East Region, especially among rural farmers in the Kassena Nankana West District.

2.4 Ghana National Climate Change Policy

The Government of Ghana considers climate change as a serious threat to national development because of its impacts on key sectors of the economy. The impacts of climate change are felt in the health sector, water resources and more particularly on the agriculture sector which relies heavily on climatic conditions to thrive. Based on these considerations, the Government of Ghana came out with national climate change climate policy (MESTI, 2013). The national climate change policy is to provide strategic direction and coordinate issues of climate change in Ghana. One of the objectives of the policy is to ensure effective adaptation in the following thematic areas: energy and infrastructure, natural resources management, agriculture and food security and disaster preparedness and response.

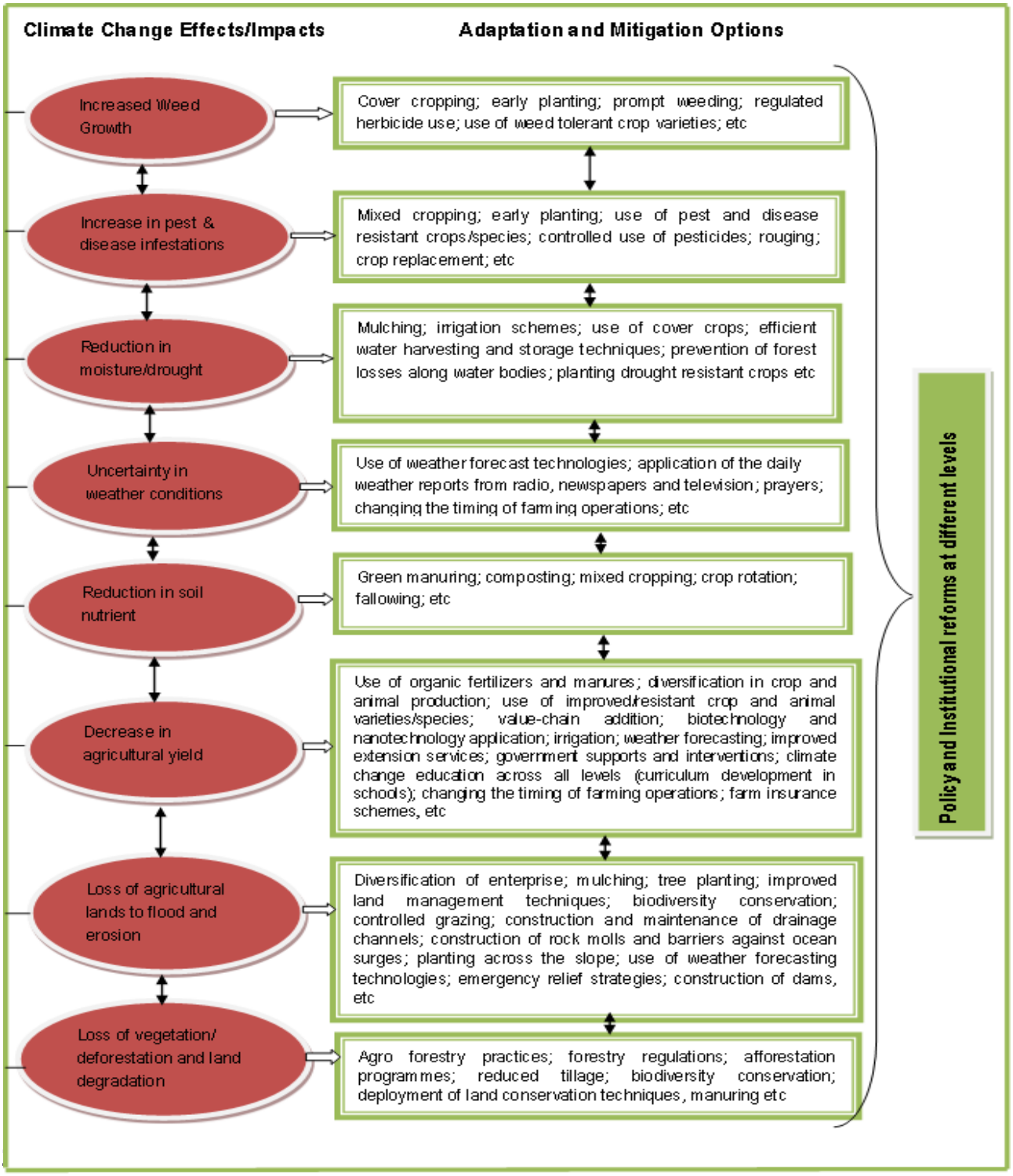
In order to ensure effective adaptation, the policy placed premium on community-based adaptation and ecosystem-based adaptation measures. Community-based Adaptation (CBA) has been defined as, "a community-led process, based on communities' priorities, needs, knowledge and capacities, which should empower people to plan for and cope with the impacts of climate change." (Reid et al. 2009 cited in MESTI, 2013:3). On the other hand, Ecosystem-based Adaptation (EBA**)** is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. These are commendable strategies; however, the problem is

usual found in the implementation process where there is a gap between what is planned and what is implemented. The policy proposed afforestation and other adaptation measures to climate change. Unfortunately, the effort of the nation in implementing afforestation programmes have been somewhat disappointing, SADA afforestation is a good example. The policy is however silent about agroforestry which is relatively successful compared to afforestation.

2.5 Conceptual Framework

The conceptual framework of this study is based on a framework for agricultural adaptation to climate change as postulated by Ozor et al. (2012). The conceptual framework clearly captures impacts of climate change on the agricultural sector as well as the measures that can be employed to be able to address the consequences. Climate change impacts on the agriculture sector include drought, floods, land degradation and reduction in crop yields, increased weed and pest (FAO, 2007 cited in Woodfine, 2009; Ozor et al., 2012; Thorlakson and Neufeldt, 2012). The adaptation measures include the use of cover crops, mixed cropping, improved varieties, altering planting dates and agroforestry practices (Ozor et al., 2012). This conceptual framework was considered most appropriate and relevant for this study because it highlights agroforestry as one of the response options to climate change, this addresses the core objective of this study was to assess the use of agroforestry by farming communities as an adaptation strategy to climate change in the Kassena Nankana West District of the Upper East Region. It was imperative to investigate whether the content of the conceptual framework actually reflects the situation in the study district.

Figure 2.1: Conceptual framework on agricultural adaptation climate change



Source: Ozor et al. (2012)

The conceptual framework identifies the effects/impacts of climate change and responses which include adaptation measures making most appropriate for this study.

2.6 Conclusion

The review indicates that scholars have done a lot on climate change and agroforestry but can still be added. The literature suggest that policy makers, the scientific community and the general public have had some level of understanding of climate change and its impacts and that conscious efforts are being made to respond to the consequences globally. The conceptual framework of the study shows clearly some impacts of climate change and adaptation measures. The review pointed out that some farmers understand the concept of climate change to some extent due to certain actions by governments, development organizations and farmers own experiences over the years.

Furthermore, the literature revealed that agroforestry has been recognized internationally as a winning land use strategy with numerous biological, environmental and socioeconomic benefits for land users and the society at large. It has also been established that agroforestry practices vary widely from one country to another because conditions that support agroforestry and provide direction for its practices are uneven across countries.

However, the literature is silent on how farmers can successfully practice agroforestry in areas where farmers use slash and burn as a method of land preparation couple with bush burning during the dry seasons and which specific tree species will be suitable in some particular settings. In addition, little is known about the challenges farmers encountered in agroforestry development especially in Ghana, with particular reference to the dry environment of Upper East Region and how farmers are dealing with such challenges. It is therefore relevant to assess how farmers view agroforestry as an adaptation strategy to climate change in the Upper East Region.

CHAPTER THREE

THE STUDY AREA AND METHODOLOGY

3.1 Background

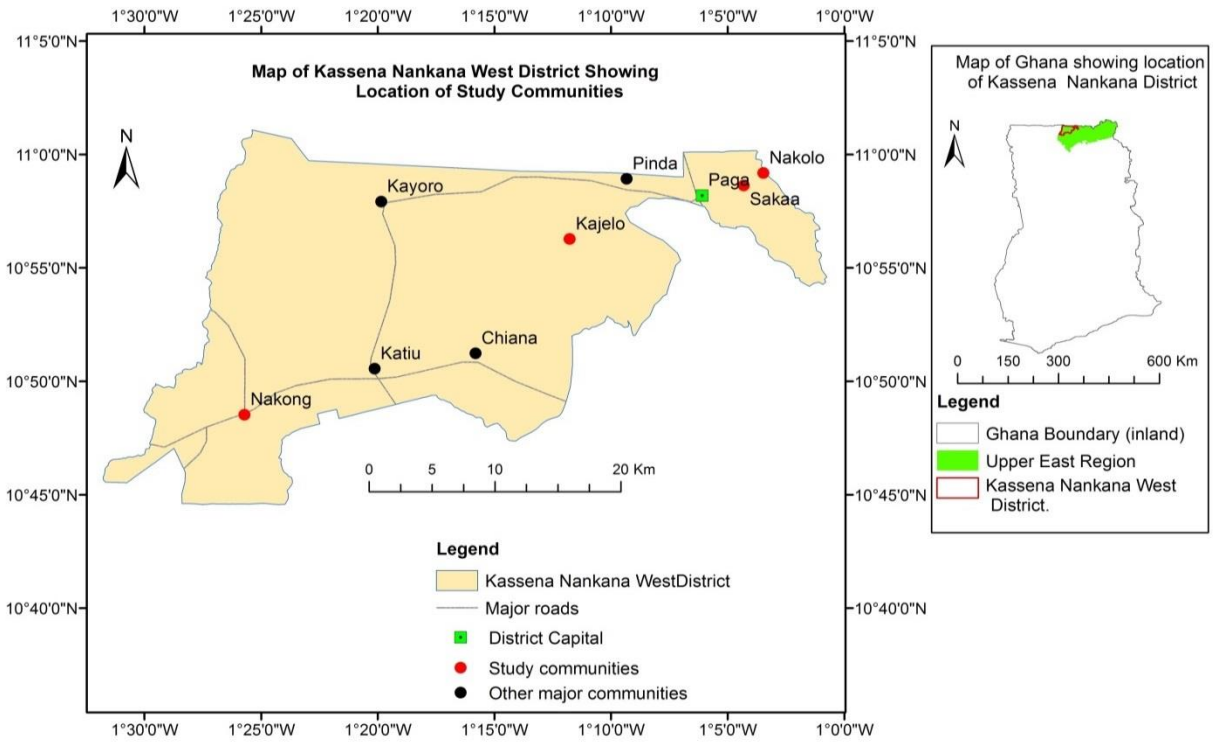
The Kassena-Nankana West District is one of the thirteen districts in the Upper East Region of Ghana. It was carved out of the Kassena Nankana Municipal in 2007 and inaugurated on Friday, 29th February 2008. The Local Government Instrument which established the district is Legislative Instrument (L.I) 1855. The paramount aim of creating this Assembly was to bring the business of governance to the doorsteps of the ordinary Ghanaian. It is located approximately between latitude 10.97° North and longitude 01.10° West. The district has a total land area of approximately 1,004 sq. km.

The Kassena-Nankana West District shares boundaries with Burkina Faso to the north, Bongo District to the north-east, Bolgatanga Municipal to east, Kassena Nankana Municipal to the south and Bulsa District to south-west (GSS, 2014b).

3.1 Relief and Drainage

The district is underlain mainly by Birrimian and Granitic rock formation. The relief of the district is generally low lying and undulating with isolated hills rising up to 300 meters above sea level in the western part of the district. Notable among these hills are Fie (9280 metres above sea level), Busono (350 metres), and Zambao (360 metres). The district is mainly drained by the Sissili River and its tributaries. There are however some few dug-outs and ponds which are used for livestock rearing, crop production and domestic purposes (GSS, 2014b).

Figure: 3. 1 Map of the Study Area



Source: Adapted from Ghana population census (GSS, 2014b)

3.2 Climate

The Kassena-Nankana West District falls within the interior continental climatic zone of the country characterized by pronounced dry and wet seasons. The two seasons are influenced by two air masses. First is the warm, dusty and dry harmattan air mass which blows in the north easterly direction across the whole district from the Sahara desert.

During its period of influence (late November – early March) rainfall is entirely absent, vapour pressure is very low (less than 10mb) and relative humidity rarely exceeds 20.0% during the day but may rise to 60.0% during the nights and early mornings (GSS, 2014b).

Temperatures are usually modest at this time of the year by tropical standards (26°C – 28°C). May to October is the wet season. During this period, the whole of West African sub-region including Kassena-Nankana West District is under the influence of a deep tropical maritime air mass. This air mass together with rising convention currents provides the district with rains. The total rainfall averages 950 mm per annum. The above phenomenon adversely affects the water table and reduces underground water. Water harvesting is probably a viable option in the district (GSS, 2014b).

3.3 Vegetation

The vegetation is mainly of Sahel Savannah type consisting of open savannah with fire swept grassland separating deciduous trees among which may be seen a few broad-leafed and fire-leached tree species. Some of the most densely vegetated parts of this district can be found along river basins and forest reserves. Examples are the Sissili and Asibelika basins. Most of these trees in the forested areas shed their leaves during the dry season. The human activities over the years have also affected the original vegetation considerably. Common trees which are also of economic importance include Dawadawa, Sheanut, Baobab, Nim and Mango. The low vegetation cover of the area hampers sufficient rainfall thereby reducing underground water supply (GSS, 2014b).

3.4 Soil

Two main soil types can be found in the district. These soil types are the Savannah Ochrosols and the ground water laterite. The northern and eastern parts of the district are covered by the Savannah Ochrosols, while the rest of the district is characterized by ground water laterite. The Savannah Ochrosols are porous, well drained, loamy, mild acidity and interspersed with patches of black or dark grey clay soils. This soil type is

suitable for cultivation of cereals and legumes. The ground water laterites are developed over shale and granite. Due to the underlying rock type, they become water logged during the rainy season and dry up during the dry season, thus causing cemented layers of iron-stone which make cultivation difficult. This would probably have contributed significantly to food insecurity in the district (GSS, 2014b).

3.5 Population

Age and sex composition of a given population constitute important population characteristics in any demographic analysis, and as a result usually receive attention. The district has a total population of 70,667 representing 6.8 percent of the population of UER. With an area of 872.8 square kilometres, the district has a population density of 81 persons per square kilometre. The proportion of the female population (50.8%) in the district is slightly higher than that of males (49.2%).

The rural population is 60,792, about six times that of urban (9,875). Also, out of the total population of the district, females constitute the majority (50.83%) and the remaining 49.17 percent are males. The percentage of males in the rural area is greater than those in the urban. However, the situation is the reverse for female population by locality. About 52.7 percent of the female population in the district lives in urban areas while 50.5 lived in the rural area (GSS, 2014b).

3.6 Households in Agriculture

Major agricultural activities engaged in by households in the district are crop farming and livestock rearing. Households engaged in agriculture constitute 90.7 percent of total households in the district and non-agricultural households account for only 9.3 percent. The figures suggest the economy of the district is predominantly agrarian. Of the

households engaged in agriculture, majority (98.2%) are into crop farming, followed by those into livestock rearing (78.0%). Only a small proportion of the households engaged in agriculture do tree planting (0.9%) and fish farming (aquaculture) (0.1%).

In urban areas, households engaged in agriculture are 75.0 percent and 93.4 percent in rural areas. Crop farming is done by most households (95.4%) in the urban areas and in rural areas (98.6%), followed by those into livestock rearing accounting for 67.0 percent of households in urban areas and 79.6 percent of rural households. A small proportion of households in urban (2.0%) and rural (0.8%) are involved in tree growing. For fish farming, very few households are into it in both urban and rural areas (0.1% each). Except for fish farming, the rural proportion in all other areas of agricultural households is greater than those of urban areas, indicating that agriculture is predominantly rural in KNWD (GSS, 2014b).

3.7 Types of Farming Activities

Crop farming and livestock rearing are the main agricultural activities in the district. Livestock rearing was the second commonest agricultural activity after crop farming. Fish farming and tree growing are uncommon activity in agricultural households. The low proportions of fish farming recorded in both urban and rural areas is probably because many households are unaware of fish farming or have not taken interest in the activity.

Among the traditional livestock (sheep, goats, cattle and pig), most people rear goats (30.7% of keepers) followed by chicken (23.5% of keepers) and sheep (20.4% of keepers). Although most livestock keepers kept goats, the average animal per goat keeper

is the same as that for cattle, 9 animals each, but less than that for pigs (11 animals per keeper) (GSS, 2014b).

3.8 Methodology

This study adopted mixed methodology to explore agroforestry as an adaptation strategy to climate change in the Kassena Nankana West District of the Upper East Region. Mixed method refers to a research strategy in which the investigator employs methods that make it possible to collect both quantitative and qualitative data either sequentially or simultaneously (Creswell, 2003).

In this study, quantitative and qualitative data were gathered sequentially, the researcher started with the quantitative data collection in which questionnaires were administered to a total of 75 study respondents. During the questionnaire administration, respondents with in-depth knowledge on the topic were identified and selected to participate in focus group discussions. Thereafter, focus group discussions and key informant interviews were conducted to obtain the qualitative data on certain pertinent issues in the study. The focus group discussions were helpful in obtaining in-depth and detailed information and explanations from the study respondents.

3.8.1 Research Design

Case study approach was employed in this research to assess and explain farmers' perspectives on agroforestry as an adaptation strategy to climate change in the Kassena Nankana West District of the Upper East Region. It is argued that research questions contribute significantly in the determination of the research design. According to Onwuegbuzie and Leech (2006:475) "research questions in mixed methods studies are important because they, in large part, dictate the type of research design used, the sample

size and sampling scheme employed, and the type of instruments administered as well as the data analysis techniques (i.e., statistical or qualitative) used".

Yin (2009) proposed that case study is appropriate when the study seeks to answer "how" or "why" empirical research questions and when the study is focused on understanding and explaining contemporary phenomenon within its real-life context. Therefore, the case study design is considered relevant and necessary in this study.

In addition, this approach creates room for the use of several methods to collect data from respondents in natural settings (Bhattacherjee, 2012). The varied methods ensure method triangulation which was crucial in order to minimize biases in data collection and ensure validity and reliability. The study considered the case study approach as the most appropriate strategy of collecting, documenting and analysing relevant data and reporting the research findings on agroforestry as an adaptation to climate change within the study area. The study further saw this design as appropriate for providing clear understanding of the issues being studied in the UER.

However, the case study is not without weaknesses. One major criticism leveled against the case study approach is that it does not allow generalization of the research findings beyond what pertains in the study area.

3.8.2 Sources of Data

Data for this study was gathered from both primary and secondary sources.

3.8.2.1 Primary Data

Primary data was gathered from farmers who are actively involved in agroforestry practices, since the study is more farmer-centred. Similarly, primary data were also obtained from key informants in the Kassena Nankana West District-representative of the

Director of MOFA, District Agricultural Extension Officer at Nakong, District Planning Officer, the Manager of Ghana Metrological Agency and Programmes Coordinator of ORGIIS-GHANA. Data from these sources revealed people's perceptions, opinions and experiences regarding agroforestry as an adaptation strategy to climate change.

3.8.1.2 Secondary Data

Secondary data were obtained from relevant documents of State institutions such as MOFA, the Kassena Nankana West District Assembly, ORGIIS-GHANA and Ghana Meteorological Agency. Similarly, journal articles, books and other relevant publications were the useful sources of secondary data. The institutions provided existing information about agricultural activities as well as climate change issues.

3.8.3 Study Population and Sample Size

Farmers who practice agroforestry and key informants in the Kassena Nankana West District constituted the study population. The study targeted farmers practicing agroforestry because they have in-depth knowledge agroforestry development. A total number of 75 farmers from four farming communities who are actively practicing agroforestry participated in the study.

3.8.4 Sampling Techniques and Procedures

It is practically impossible to contact all the potential communities and respondents in this study and hence the need for sampling. With regards to the study communities, four communities were purposively chosen not just because of their direct involvement in agroforestry, but also the level of success in the practice was an important factor in the determination of their inclusion in the study. Some efforts have been made by some

communities in the past as far as agroforestry is concerned with quite disappointing results, so it was prudent to investigate why a few of such communities succeeded.

From observation and also information gathered from MOFA and ORGII-GHANA, an NGO in KNWD, Kajelo, Nakolo, Nakong and Sakaa have some good results with regards to agroforestry practices. Therefore, the researcher purposively selected those communities to explore in detail the reasons behind their relative success in agroforestry where some communities failed woefully. Arguably, semi-arid areas are considered to be difficult terrain for successful tree growing, if others have succeeded, what did they do differently?

3.8.4.1 Selection of Respondents

The researcher anticipated at the beginning of the research that a baseline data on agroforestry practices, particularly farmer population involved in the practice, would be available at the MOFA office in KNWD. Unfortunately, MOFA is only assisting farmers to plant trees under the "Sustainable Land and Water Management Project" at the river Sisili catchment area at Nakong. MOFA has no records regarding agroforestry practice in the remaining three communities. Records on agroforestry in Nakong showed that farmers were in groups of not less than five members per group which comprises both males and females. Under the said project, it was the responsibility of the group to look for a parcel of land between 3-5 acres so that MOFA can support them with seedlings, technical expertise and donkey carts for watering the trees. Therefore, the researcher deemed it fit to purposively select the leader of each group to respond to the questions. Where the leader was not available, the secretary was contacted. These persons were considered the repository of knowledge as far as the activities of the groups were

concerned. Sixteen farmers representing 21% of respondent were selected from a total of 16 groups to participate in the study.

Apart from that, the researcher conducted a census to identify all successful agroforestry farmers. Using the census method, a total of 49 farmers were contacted due to their active involvement in agroforestry practice. Out of the 49, 23 (31%) came from Nakolo, 19 (25%) from Sakaa and 17 (23%) from Kajelo giving grand total of 75 farmers. The census was conducted because baseline data on the numbers practicing agroforestry was not available.

Selection of key informants, purposive sampling strategy was employed to identify key informants include one Agricultural Extension Officer, one representative of MOFA Director's office, the Kassena Nankana West District Planning Officer, the Manager of Ghana Meteorological Agency at Navrongo, and the Programmes Coordinator of ORGIIS-GHANA. Purposive sampling strategy is employed because it helped the researcher to find respondents who have in-depth knowledge on the topic to provide relevant answers to the research questions.

3.8.6 Techniques of Data Collection

Techniques that featured prominently in this study include structured interviews, focus group discussion, key informant interviews and observation.

Structured interview was one of the appropriate data collection methods employed in this study. In structured interviews, the questions are pre-determined by the investigator covering various issues to be studied. Both open-ended and close-ended questions are permissible when using this technique for data collection (Kusi, 2012). In this study, the researcher designed a questionnaire containing both open-ended and close-ended

questions at the initial stage. The questionnaires were administered to ten respondents during the pre-testing phase of the research. Based on the responses obtained from the open-ended questions, all the open-ended questions were converted to close-ended. The pre-testing made it possible for researcher to restate some questions that were not clear to the respondents and eliminated repeated questions.

Focus group discussions (FGD) were used to gather data from most experienced farmers from four communities (1female and 1male FGD each). A focus group membership numbered between 6 and 12; this range of membership is considered to be manageable for a fruitful discussion. The focus group discussion created an appropriate platform for discussants to discuss the issue thoroughly and so some of the important issues in the questionnaire were discussed in detail which enabled the study to generate in-depth qualitative data. An interview guide was used to facilitate the discussions, responses were tape recorded and transcribed. The study also obtained qualitative data through the use of key informant interviews.

Observation helped the researcher to assess the evidence on the ground through field visits. For instance, how farmers incorporate trees on their farms lands as well as the various trees were observed. Observation guide was used to obtained relevant data from the study area.

3.8.7 Methods of Data Analysis

Data obtained from the field and secondary sources were processed and analysed to make meaning out of it. Stata, a statistical programme was used to analyse quantitative data generated through the questionnaire administration. The researcher did a correlation analysis on rainfall and production levels of major crops in the study communities.

Content analysis was done on the qualitative data. Microsoft Excel was used to construct tables, charts and graph because Microsoft excel can construct good graphs. The quantitative and qualitative data were integrated by merging them in the discussion.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION

4.1 Introduction

This chapter deals with data analysis and the presentation of results. The chapter covers demographic characteristics of the study respondents, rainfall and temperature data from the Ghana Meteorological Agency, farmers' knowledge on climate change, agroforestry practices, agricultural adaptation, agroforestry as an adaptation strategy to climate change and coping strategies to the challenges of agroforestry. The data are presented in graphs, charts and tables.

4.2 Demographic Characteristics of Respondents

The study found it prudent to look out for the sex and age of respondents as well as their educational status which will make it possible to relate findings with the background of study respondents in the KNWD.

4.2.1 Sex of Respondents

Farming activities in the study district are undertaken by households which comprise both males and females. The study revealed that 71% of agroforestry farmers are males while 29% are females making agroforestry practice a male dominant one in the study area (Table 4.1). The male dominance is linked to land tenure arrangement in the study district which favours men. According to the traditional land ownership arrangement, women may have limited access to land for farming purposes but the same cannot be said about ownership. However, husbands can give portions of lands to their wives to own and hence such women do plant trees on their farms. Also, some of the female farmers are

widows suggesting that they have taken over the practice after the death of their husbands. This is an indication that land tenure arrangements in the study do not make provision for women and hence their participation in agroforestry is restricted. However, the 29% of women's involvement in the practice show that when women have equal access to land as their male counterpart, their participation in agroforestry practice will increase.

Table 4.1: showing sex of respondents

Sex	Frequency	Percentage
Male	53	71
Female	22	29
Total	**75**	**100**

Source: Author (2015)

4.2.2 Educational Levels of Respondents

The study interviewed farmers regarding their educational status in order to know whether any correlation existed between respondents' educational backgrounds and the adoption of agroforestry practices. Table 4.2 shows educational levels of study respondents, majority of the farmers (56%) have no formal education, while 15%, 13%, 12%, and 4% have primary, JHS, SHS and tertiary levels of education respectively. Among farmers who have gone through formal education, the majority ended at the primary school. This finding implies that in rural areas of the district, illiteracy levels are especially high among farming communities. This suggests that farmers rely largely on indigenous knowledge gain from parents and other farmer colleagues as well as

experience accumulated over the years. Nevertheless, the opinions of both illiterates and educated farmers have been well captured in the study showing that agroforestry can be embraced by any one regardless of their educational achievements.

Table 4.2: Educational status of respondents

Education status	Frequency	Percentages
No education	42	56
Primary	11	15
JHS	10	13
SHS	9	12
Tertiary	3	4
Total	**75**	**100**

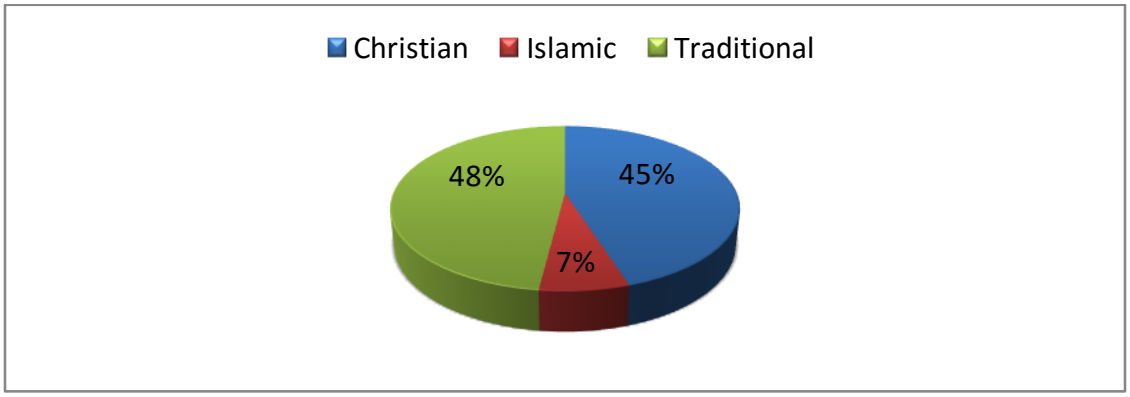
Source: Author (2015)

4.2.3 Religious Background of Study Respondents

Religion is an inherent component of the culture of a people and does influence human behaviour and relationships. Therefore, the study deemed it necessary to find out the religious inclination of study respondents. The respondents in the study communities were made up of three religious groups (Figure 4.1). From the results, about 48% of farmers belong to the traditional religion, 45% were Christians, and 7% belong to the Islamic religion. This means that in the four communities, majority of agroforestry farmers belong to the traditional religion followed by Christian religion. Therefore, traditional gathering as well as the church meetings could be used as good platforms for farmers to share information and useful lessons on climate change and agroforestry in the

study communities in order to enhance adoption and sustainability of agroforestry practices within the district.

Figure 4.1: Religious background of the respondents



Source: Author (2015)

4.2.4 Age Structure of Agroforestry Farmers

Given the time scope of the research, 30 year period, it was important to concentrate on farmers who are matured in age and could have relevant experience on climate change and agroforestry practices covering the time scope of the study. Therefore, the study considered farmers who are forty years and above because they will have enough experience that span thirty years. The individual interviews revealed that farmers belong to different age groups. From the (Table 4.3), majority of farmers (41%) fell within (40-49) age group, followed by 27% in the (50-59) age bracket, the rest 20%, 11% and 1% were within the (60-69), (70-79) and 80+ age brackets respectively. This indicates that majority of respondents are within the economically active age group which is from (18-64) (GSS, 2014). It means that the farmers still have enough room to expand agroforestry practices when they receive the needed assistance and also pass on this knowledge to others in the district. Also, 70 and above age group's involvement in agroforestry is an

indication that the practice is not a recent issue meaning that some knowledge has been accumulated.

Table 4.3: Age structure of agroforestry farmers

Age	Frequency	Percentages
40-49	31	41
50-59	20	27
60-69	15	20
70-79	8	11
80+	1	1
Total	**75**	**100**

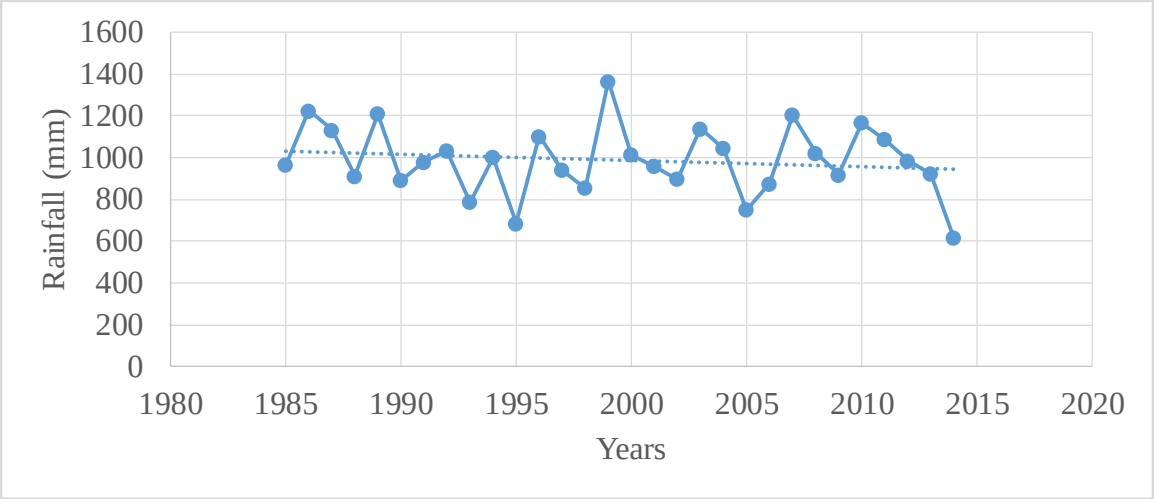
Source: author (2015)

4.3 Trends in Rainfall, Temperature and Food Crop Production

Statistical records show that annual rainfall values have not been the same for the last three decades; hence rainfall and temperature keep changing over time. It is clear from figure 4.2 that rainfall over the past three decades has not been stable. It shows some level of irregularity in total rainfall overtime, years such 1986, 1989, 1996, 1999, 2003, 2007 and 2010 recorded high rainfall figures which can be associated with some floods situations, especially the one in 2007.

On the other hand, years with low total rainfall figures include, 1994, 1995, 1998, 2005 and 2014, from the graph 2014 recorded the lowest total rainfall within the 30 year period. Regardless of these annual fluctuations, the trend shows continuous decrease in total rainfall overtime as revealed by the trend line.

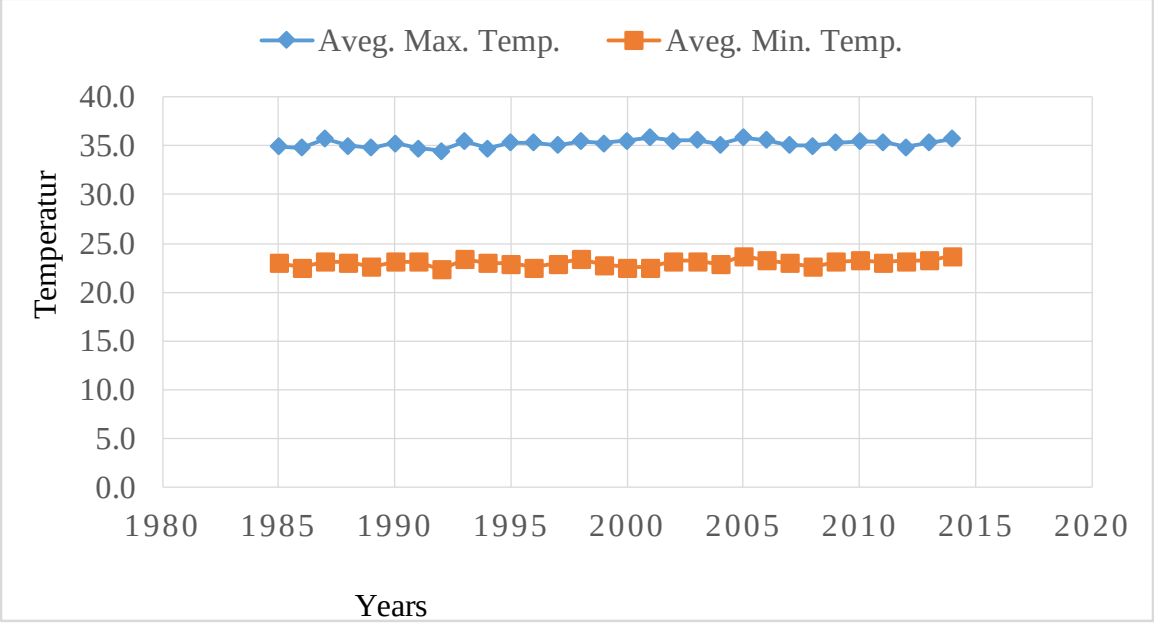
Figure 4.2: Total annual rainfall changes in the last three decades



Source: Ghana meteorological Agency-Navrongo, 2015

Temperature records in Figure 4.3 show fluctuations in both minimum and maximum temperature within the period 1985 – 2014.

Figure 4.3: Trend in Average temperature (^{o}C) from 1985 - 2014

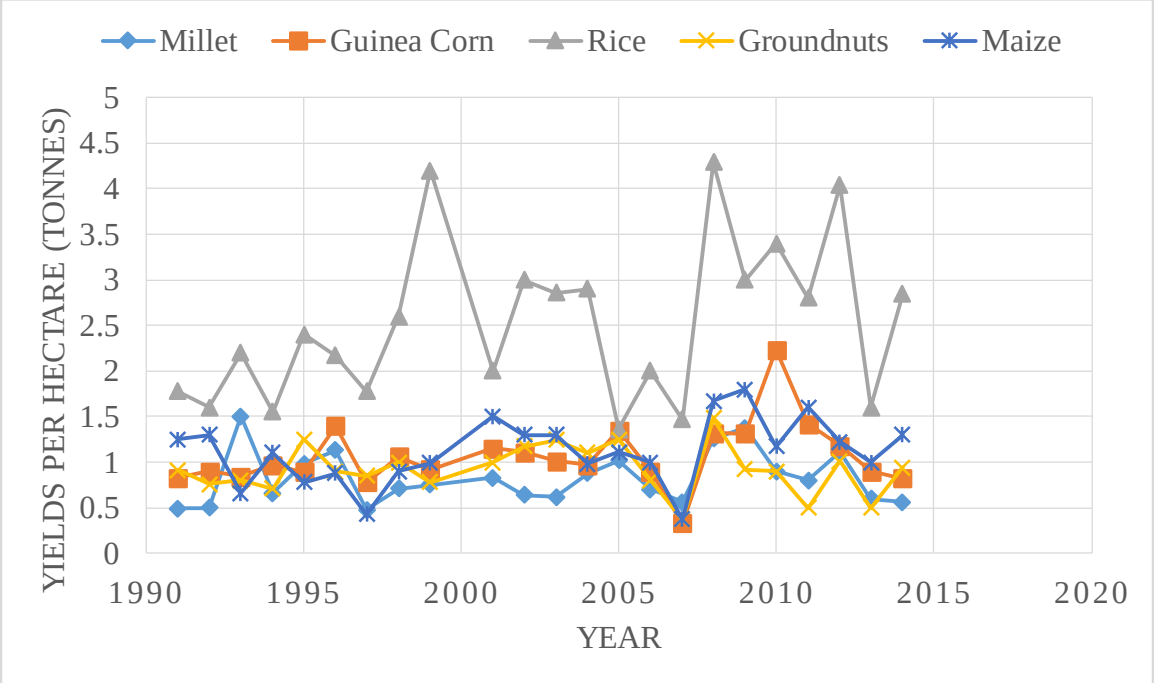


Source: Ghana Meteorological Agency-Navrongo, 2015

4.3.1 Crop Production (Tonnes) in the Study Area for the Past 23 Years (1991-2014)

Statistical records were obtained from the office of MOFA at Navrongo covering the past 23 years. There is no data on crop production for the year 2000, the current Officer in charge took over in 2005 and hence could not explain why it was so. The researcher collected this data from Navrongo because such records were non-existent at Paga. However, this data covers food crop production for both Kassena Nankana West District and Kassena Nankana Municipal. The data give a trend of production of five major crops. The crops include millet, maize, rice, groundnuts and guinea corn (Figure 4.4).

Figure 4.4: Trend of crop production (tonnes) in the study area



Source: MOFA-Navrongo, 2015

The graph shows continuous fluctuations in the production levels of all the five crops for the past two decades (Figure 4.4). It is evident from the graph that rice production has been comparatively good even though it has been varying between 1-5 tons per hectare.

The coefficient of determination suggests that rainfall only accounted for 8.7% of the variability in rice production. It meant that other factors such as soil fertility and continuous availability of adequate moisture might have worked in favour of rice. For instance, rice is cultivated in valleys and waterlog areas making it possible for rice to have adequate water requirement for its growth. Again, the rains also wash down soil nutrients from upland to the valleys to fertilize the area to promote high production of rice.

Maize is the next crop that is doing well in the study area followed by guinea corn; groundnut appeared to be the worst performing crop in the area. All the crops with the exception of rice hit the lowest point in 2007, showing that the flood in that year might have caused it.

4.3.2 Correlation Analysis between Total Rainfall and the Production of Five Major Crops

Correlation analysis of rainfall and crop production was considered necessary because study respondents claimed that reduction in rainfall has affected negatively the productions of food crops.

Table 4.4: Results of Pearson Correlation between total annual rainfall (mm) and crop yields (T/Ha) from 1991 - 2014

Description		Crop yields (T/Ha)				
		Millet	Guinea Corn	Rice	Groundnuts	Maize
Rainfall (mm)	Pearson Correlation	-0.141	0.150	0.296	-0.306	0.000
	Sig. (1-tailed)	0.260	0.248	0.085	0.078	0.500
	R^2	0.020	0.022	0.087	0.094	0.00000002482
	N	23	23	23	23	23

Source: Author (2015)

The results of a correlation analysis between total annual rainfall (mm) and millet yields per hectare (tonnes) from 1991- 2014 gives a Pearson correlation coefficient of -0.141 and with no significant relationship (Table 4.4). Similarly, correlation analysis between total annual rainfall (mm) and groundnuts yields gives a Pearson correlation coefficient of -0.306. Pearson correlation coefficient of -0.141 for millet and -0.306 for groundnut implies that as total annual rainfall (mm) increases, yields per hectare (tonnes) of the two crops are likely to fall accordingly. Furthermore, an analysis of coefficient of determination (R^2) revealed that rainfall only accounted for 2% of the variability in millet yields and 9.4% for that of groundnuts (see Table 4.4). This suggests that other variables like access to credit, access to fertilizer, soil fertility, temperature, pest and diseases and

post-harvest losses which influence millet production in KNWD account for 98% and 90.6% of the variability in millet and groundnut yield per hectare (tonnes) respectively.

However, the results of a correlation analysis between total annual rainfall (mm) and guinea corn as well as rice yields per hectare (tonnes) show Pearson correlation coefficients of 0.150 and 0.296 respectively with no significant relationship (Table 4.4). This means that as total rainfall in the study area increase, there will be a corresponding increase in the production of guinea corn and rice. In addition, analysis of coefficient of determination (R^2) indicates that total rainfall is only responsible for 2.2% and 8.7% of the variability in the yields of guinea corn and rice respectively. Other important production related issues may be accountable for the remaining percentages.

Finally, from Table 4.4, the correlation analysis showed that there exists no relation between rainfall and yields of maize per hectare (tonnes) given a Pearson Correlation coefficient of 0.000 (round to three decimal places). This implies that, yields of maize per hectare (tonnes) do not necessarily vary as total annual rainfall varies. An R^2 of 0.00000002482 means that the extent to which annual variation in yields of maize is caused by total amount of rainfall (mm) is insignificant.

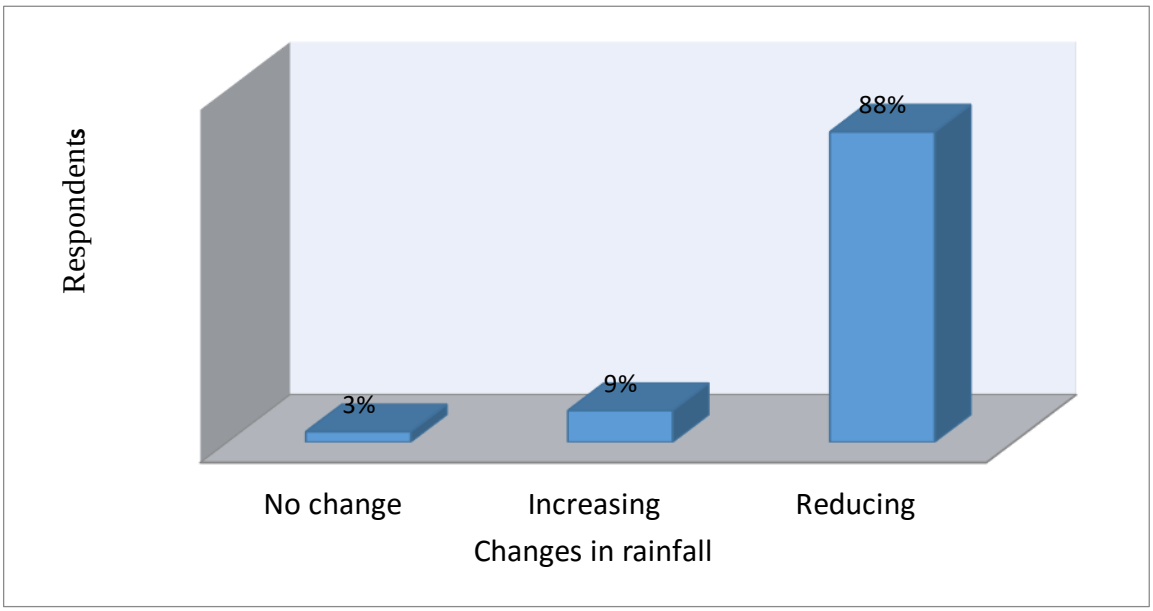
4.4 Farmers Understanding of Climate Change

4.4.1 Changes in Rainfall in the Study District

This study set out to interview farmers regarding their understanding of the concept of climate change in the KNWD. The results obtained on climate change, its impacts and causes are presented in the Figures 4.5. Majority of farmers (88%) noticed that rainfall has reduced over the years, 9% of farmers thought rainfall is rather increasing and not

reducing while 3% of farmers said they have not notice any changes in rainfall patterns for the last three decades. This information represents farmers own experiences due to their continuous engagement in farming practices.

Figure 4.5: Variable rainfall in the study district

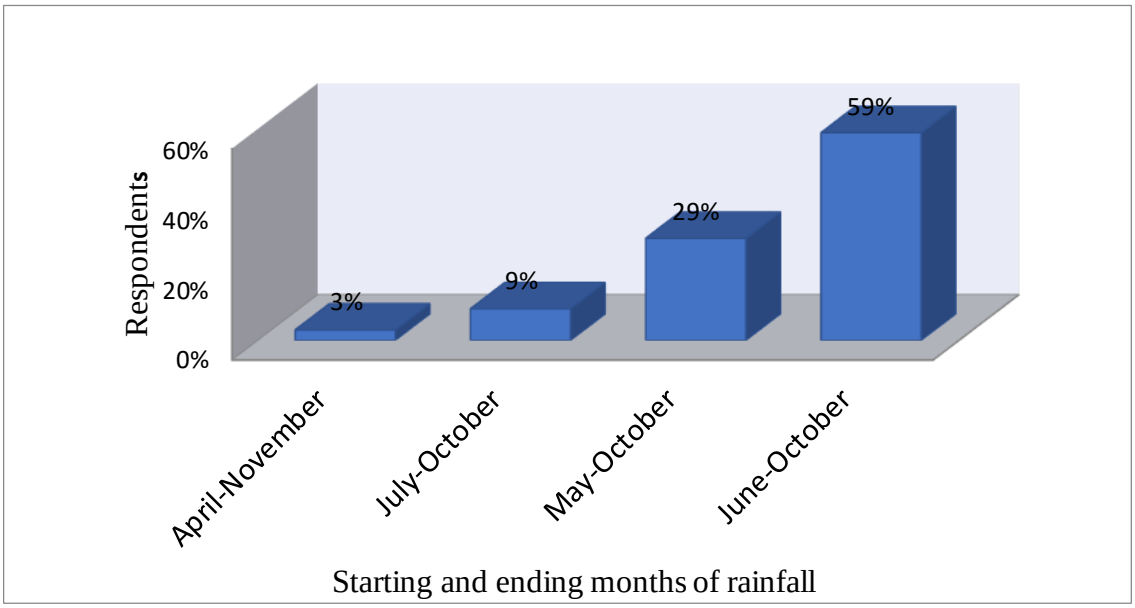


Source: Author (2015)

4.4.2 The Starting and Ending Months of Rainfall

Not only did farmers notice changes in the amounts of rainfall over the study period but farmers have also noticed that the months of rainfall have been altered over the years. In Figure 4.6, 59 percent of farmers reported that as a result of climate change, rainfall now starts in June and end in October, 29% said rainfall for the farming season starts in May and ends in October, 9% believed that rainfall starts in July and by October they do not receive rains. Lastly, a small number of farmers constituting 3% think that they receive the first rain for the farming season in April and the last rain in the years was received in November.

Figure 4.6: The starting and ending months of rainfall

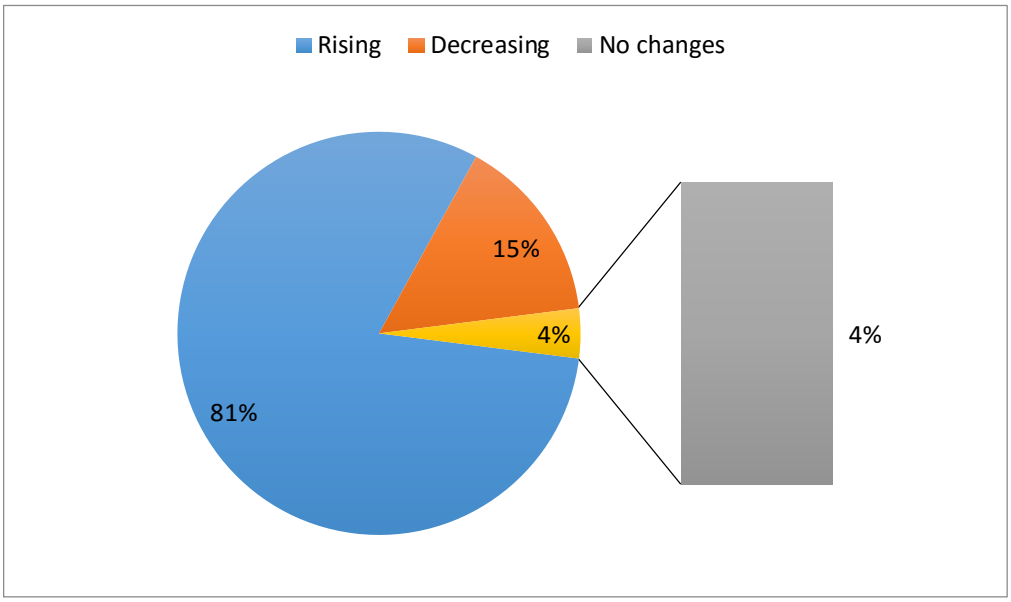


Source: Author (2015)

4.4.3 Changes in Temperature in the Study Area

Majority of farmers (81%) realized that temperature continues to rise in terms of its severity and its duration is also becoming much longer than in the past (Figure 4.7). Fifteen percent of respondents maintained that temperature was reducing while 4% of farmers did not see any change. Farmers mentioned that once the rains are reducing, temperature must rise because it is only rains that can bring down the temperature. From farmers' perspective, there is an inverse relation between rainfall and temperature, an increase in rainfall will lead to a reduction in temperature and vise-versa.

Figure 4.7: Variable temperature in the study area



Source: Author (2015)

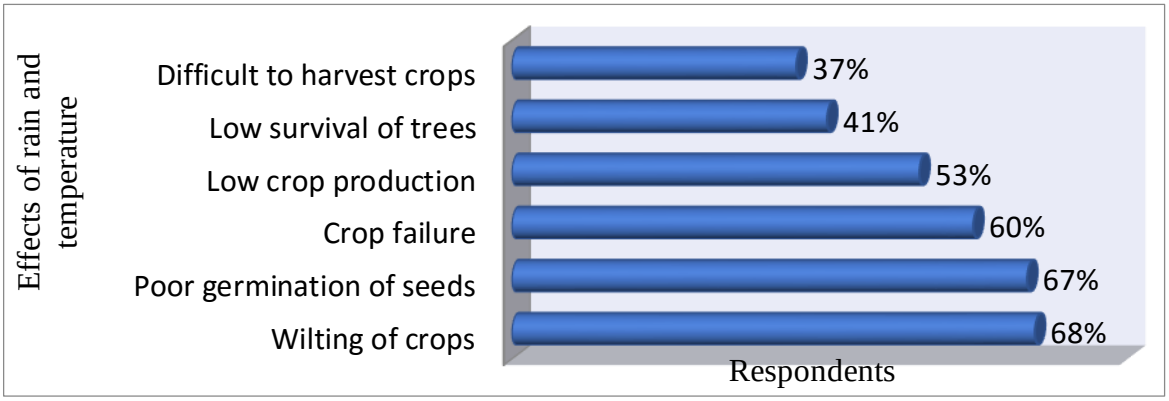
4.4.4 Effects of Variable Rainfall and Temperature on Crops

From Figure 4.8, households interviewed for this study have experienced a variety of variable rainfall and temperature effects in the last 30 years. Majority of farmers (68%) indicated that wilting of crops is of one the numerous impacts of climate change in the study communities; this was followed closely by poor germination of seeds of which 67% of farmers agreed that seeds do not germinate well. Other impacts include crop failure, low crop production, low survival of trees, and difficulty in harvesting crops, these were represented by 60%, 53%, 41% and 37% respectively.

Crops need some optimum water availability that will last their entire gestation period for them to mature well. When crops suffer from water shortage before the maturity time, crop failure will be the end result. During a focus group discussion, farmers stated that maize and groundnuts are the crops that normally fail due to inadequate water

availability. Consequently, poor germination of seeds, wilting of crops and crop failures has contributed greatly to low food crop production in the farming communities where the study was conducted.

Figure 4.8: Effects of variable rainfall and temperature on crops

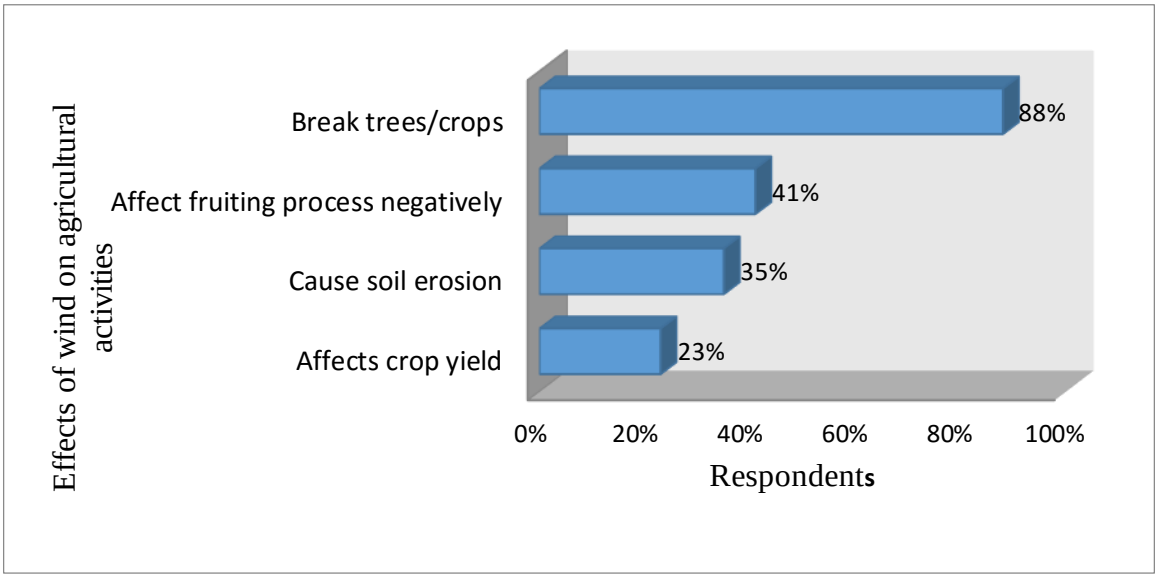


Source: Author (2015)

4.4.5 Effects of Changes in Wind on Agricultural Activities

The study interviewed farmers regarding changes in wind in the study communities. Farmers observed that the speed of the wind was increasing to the extent that farmers have experienced wind storms in the study area. They argued that in the past, wind storms were experienced at some specific periods of time, for instance the harmattan winds occurred around November to January. However, the occurrence of wind storms within the last 30 years has become a frequent phenomenon in the study district with adverse impacts on crops, trees and property. Specifically, majority of farmers (88%) reported that wind storms break down crops and trees, 41 percent of farmers said wind storms affect fruiting process negatively as it blow away the flowers on trees as well as crops. Moreover, 35% of farmers realized that wind storms cause erosion while 23% of farmers believed that wind storms are responsible for low crop production (Figure 4.9).

Figure 4.9: Effects of changes in wind on agricultural activities



Source: Author (2015)

4.4.6 Climate Change Impacts Experienced by Households in the KNWD

Within the last 30 years, farmers observed some impacts of climate change in the study communities (Table 4.5), 100% of farmers believed that wind storms is one of the impacts of climate change. With regards to drought, overwhelming 98% of farmers reported the occurrence of drought in the study area and linked it to climate change. They realized that rainfall is becoming poor in terms of its amounts and distribution. Farmers said that loss of soil fertility also affected farming activities, 83% of farmers were in support of this claim. Other impacts of climate change are erratic rainfall pattern, incidence of pest and disease and floods representing 65%, 34% and 30% respectively.

Table 4.5: Climate change impacts experienced by households in the KNWD

Variables	Frequency	Percentage
Wind storms	75	100
Drought	74	98
Loss of soil fertility	62	83
Erratic rainfall	49	65
Incidence of pest and diseases	25	34
Floods	22	30

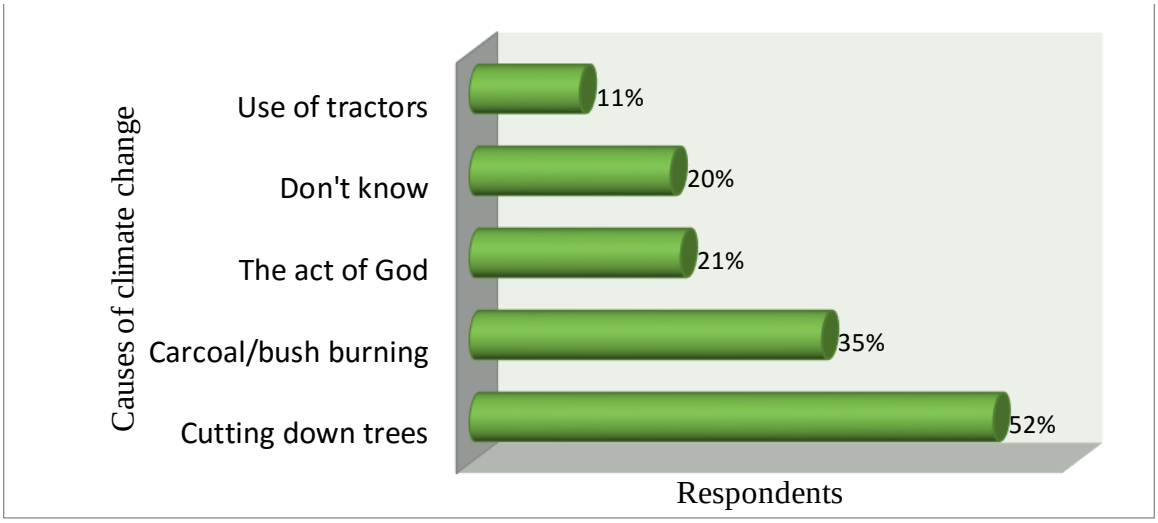
Source: Author (2015)

4.4.7 Causes of Climate Change

Farmers were interview to seek their opinion on the causes of the observed changes in climate. The responses were varied which include felling of trees, use of tractors for farming activities, charcoal production and bush burning among others (fig. 4.10). About half of the farmers (52%) indicated that cutting down of trees for various purposes caused variable rainfall and for that matter climate change. This suggest that majority of farmers are aware of some of the causes of climate change in the study district. A farmer at Sakaa had this to say "*I know we do not receive adequate rainfall in the North as compared to the south because they have more trees*". Beyond that 35 percent of respondents also attribute climate change to charcoal production and bush burning in the farming communities, 21% of farmers reported that climate has changed because God is angry with the evil activities of human beings. Twenty percent of respondents stated that they do not know what has caused the change in climate over the period; one of them said "*for*

me, I think that water has finished in the sky" this indeed indicate that some of the farmers only felt the impacts but do not know the cause of climate change, while the 11% percent of farmers attribute the change to use of heavy farm implements such as tractors and combined harvesters.

Figure 4.9: Farmers knowledge on the causes of climate change



Source: Author (2015)

4.5 Agroforestry Practices in the Kassena Nankana West District

4.5.1 Types of Agroforestry Practices

Farmers were interviewed in order to identify AF practices they have adopted (Table 4.6). Scattered trees (parklands) constituted the most dominant agroforestry practices in the study area. The study discovered that 100 percent of farmers have reserved naturally occurring trees on farm lands for variety of reasons. Scattered trees found on farm land include Shea, dawadawa, neem, baobab, ebony and whitethorn among others. With regards to the intentional planting and tending of trees, home garden is the dominant one,

48% of farmers have planted trees, crops and vegetables in their gardens. Another important agroforestry practice found in the study communities is trees on farm lands, 31 percent of farmers plant trees in addition to those they have retained on the same land management unit. It simply refers to the intentional integration of in-situ and ex-situ trees on farm lands in local communities where this study was conducted. Twenty one percent of the respondents are practicing plantation and crop combination in the District. Last but not least, 19% of farmers are doing farm woodlot in the Kassena Nankana west District.

Table 4.6: Types of agroforestry practices

Types of agroforestry practices	Frequency	Percentages
Scattered trees (parklands)	75	100
Home garden	36	48
Trees on farm land	23	31
Plantation and crop combination	16	21
Woodlot	14	19

Source: Author (2015)

The researcher went on field visits for observation and took pictures of the types of agroforestry practices adopted by farmers in the study communities. Plate 1 depicts scattered trees intercropped with sesame Kajelo. Most of the trees found on the farmland in (plate 1) are Shea trees.

Plate 4.1: Scattered Trees (Parklands) at Kajelo

Source: Field Survey, 2015

Home garden was another agroforestry practice that was observed during the field visits (Plate 2). Some farmers plant mango trees, neem as well as pawpaw trees in their home gardens at Nakolo.

Plate 4.2: Home Garden at Nakolo

Source: Field Survey, 2015

Farmers at Nakolo also do mango plantations for commercial purpose (Plate 3).

Plate 4.3: Mango Plantation at Nakolo

Source: Field Survey, 2015

Plate 4.4: Intercropping at Nakong

Source: Field Survey, 2015

Some farmers also adopted woodlot in the study District. Plate 5 is a farm woodlot at Sakaa community.

Plate 4.5: Farm woodlot at Sakaa

Source: Sakaa, 2015

4.5.2 Sex and Agroforestry Practices

Cross tabulation was considered necessary so to determine the relationship between sex of respondents and the uptake of agroforestry practices (Table 4.7). Cross tabulation on sex and agroforestry practices indicates that 49% of male farmers have adopted home garden as a practice, 30% for trees on farm lands, 21% of respondents are doing woodlot and 15% are engaged in plantation and crop combination (Table 4.7). This means that majority of male farmers in the study district have adopted home garden while plantation and crop combination is being practiced by the least number of male farmers. On the other hand, 48% of female farmers are practicing home garden, 33%, 29% and 14% are practicing trees on farm lands, plantation and crop combination and woodlot respectively. Majority of female farmers have equally adopted home garden while woodlot has received the least adoption. It is evidently clear that majority of both male and female farmers have adopted home garden in the KNWD which may be linked to its multiple livelihood benefits to households. Home garden in the district is a reliable source of fresh

vegetables, food, fodder, fuel wood and income all year round which help to reduce the impact of low crop production during the rainy season.

Table 4.7: Respondents' sex and agroforestry practices

Agroforestry practices	Sex			
	Male		Female	
	Freq.	%	Freq.	%
Home garden	26	49	10	48
Woodlot	11	21	3	14
Trees on farm lands	16	30	7	33
Plantation and crop combination	9	15	6	29

Source: Author (2015)

4.5.3 Age and Agroforestry Practices

A cross tabulation on respondents' age and agroforestry was done in order to determine the various practices that have been adopted by different age groups. From table 4.8; 45% of farmers within 40-49 age group are doing home garden, the rest of the farmers 29%, 26% and 19% are practicing trees on farm lands, plantation and woodlot in that order. For respondents within the 50-59 age brackets, majority of them (50%) are doing home garden, 35% of farmers have adopted trees on farm lands, 25% of farmers are practicing plantation/crop combination while 20% practice woodlot. Farmers in the 60-69 age group are practicing home garden (40%), trees on farm lands (33%), woodlot (20%) and plantation/crop combination (20%). Sixty three percent of respondents in 70-79 age group have adopted home garden while 25% and 12% are involved in trees on farm lands

and woodlot practices respectively. Finally, the study found that there is only one respondent who practiced home garden in the 80+ age category. From the results, home garden is the oldest agroforestry practice, while plantation and crop combination appears to be the recent one. Also, in all the age groups, majority of respondents are practicing home garden while the least number of respondents have adopted woodlot.

Table 4.8: Farmers' age and agroforestry practices

Agroforestry practices	**Age**									
	40-49		50-59		60-69		70-79		80+	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Home garden	14	45	10	50	6	40	5	63	1	100
Woodlot	6	19	4	20	3	20	1	12	0	0
Trees on farm lands	9	29	7	35	5	33	2	25	0	0
Plantation/crop combination	8	26	5	25	3	20	0	0	0	0

Source: Author (2015)

4.5.4 Some Trees Species in the Study Communities

Farmers in the study have variety of tree species on their farms in the communities. The local, English and botanical names of the tree species are presented in (Table 4.9).

Table 4.9: Some trees species in the communities

Local Name	English Name	Planted or natural	Botanical Name
Kanzono	Whitethorn	Natural	*Acacia albida*
Songo	Shea	Both	*Vitellaria paradoxa*
Mangwo	Mango	Planted	Mangifera indica
Atea	Cashew	Planted	Anacadium occidentale
Tio	Baobab	Natural	*Adansonia digitata*
Feilatio	Neem	Both	Azadiracta indica
Sungu	Dawadawa	Both	Parkia clapatoniana
	Eucalyptus	Planted	Ecucalyptus camaldulensis
	Cacia	Planted	Cassia semea
	Albesia	Planted	Albezia lebbeck
Tiki	Teak	Planted	Tectona grandis
Pino	Mahogany	Both	Khaya senegalensis
Gungu	Kapok	Patural	*Ceiba pentandra*

Source: Author, 2015

4.5.5 Importance of Some Selected Trees

In focus group discussions, farmers mentioned some important agroforestry trees on farms and explained the socioeconomic and ecological benefits of such trees in the study area (Table 4.10).

Table 4.10: Importance of Some Selected Tree Species in the Study Area

Trees	Socioeconomic importance	Ecological/production importance
Whitethorn	-Source of fuel wood Thorny parts makes it a good fencing material for planted trees Bark and roots are medicinal The fruits are sold to generate income	Shed its leaves during raining season to fertilize the soil Absence of shade during farming season promote the growth of crops Increase soil fertility drastically Fruits and leaves are good source of fodder
Shea	Increase household income Constructional material Fencing material Source of material for carving mortar and farm implements Extract butter for household use	Leaves add to soil nutrients Improve vegetation cover Moderate micro-climate
Dawadawa	Dawadawa is key ingredient for preparing soup Income generation Bark of tree for medicine Cover of the fruits are used to sprinkle on local houses	Leaves are used as fodder Falling leaves decay to improve organic matter of the soil Soil cover

	Branches used as fuel wood for households	
Baobab	Leaves for preparing soup Seeds for oil and soup Powder is eaten raw and also drinks and cakes Both seeds and powder at sold to earn income for households The trunk provide shelter for animals all parts of the tree have medicinal properties	the tree is fire resistant and can survive severe droughts, It is free from any serious pests and diseases It provides shade and protects the soil against erosion.

Source: Author (2015)

4.5.6 Agroforestry Management Practices

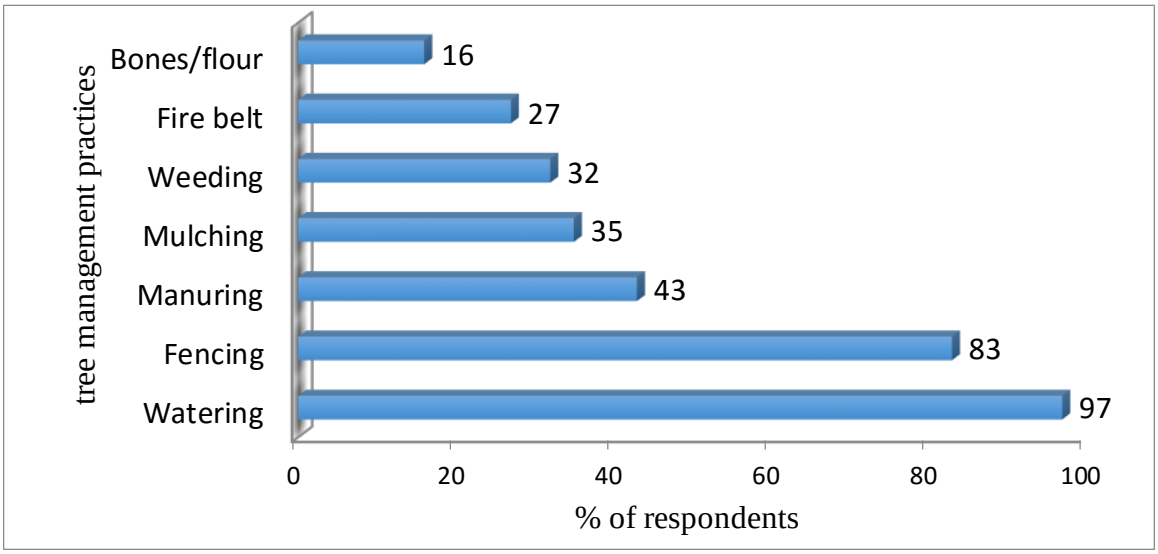
Agroforestry management practice is an integrated one that entails activities that are intentionally carried out to ensure tree survival, how crops and trees are managed to bring about increase in productions and how animals are fed. Farmers undertake a number of actions to be able to succeed in agroforestry practices in the KNWD.

4.5.6.1 Tree Management Practices

Farmers reported that a number of tree management practices are adopted (Figure 4.11). Overwhelming majority of agroforestry farmers (97%) argued that watering of seedlings and young trees is the most important tree management activities in the district. They reported that trees need water to enhance their survival. Fencing was ranked as the second most important tree management activity which ensures the security of the tree. Eighty three percent of farmers strongly support this view and make conscious efforts to look for fencing material and ensure that trees are properly fenced. Quite apart from that, 43% of farmers noted that application of manure is quite essential in the initial stages of agroforestry development, this provide the soil nutrient requirement for the seedlings and young trees to grow fast.

Other equally important tree management practices adopted by farmers in the study communities includes mulching (35%), weeding (32%), construction of fire belt (27%) and application of bones/flour (16%). Farmers put bones/flour around the seedlings during transplanting to prevent termites from attacking the seedlings. Respondents explained that bone/flour attract ants which overpower the termites. The management activities undertaken by farmers are indication that farmers do not only know what to do but they actually do what is required so that efforts in tree planting will not be in vain. In addition, tree management activities can be seen as important strategies that help farmers to deal with the challenges associated with agroforestry.

Figure 4.10: Tree Management Practices



Source: Author (2015)

4.5.6.2 Fencing Material

From table 4.11, majority of farmers constituting 60% were using tree branches for fencing trees, indicating that presence of trees in those communities contribute to the success of agroforestry. Thirty five percent respondents rely on the use of barbed wire as fencing material for the seedlings. From observation, all the farmers in Nakong were using barbed wire which was received from MOFA to fence the trees (Plate6).

In addition, some farmers in Sakaa and Nakolo were also using barbed wire received from ADRA for fencing. Lastly, 19% resorted to cutting of young trees to be able to fence their trees (plate 7). By implication, more trees are being destroyed in order to plant trees whose survival is not guaranteed. This is also an indication that some tree species are not considered valuable by farmers. In a response to why farmers were cutting such trees to fence the planted ones, a farmer at Kajelo said "*these are undesirable tree species*"

Table 4.11: Materials used for fencing of trees seedlings

Fencing material	Frequency	Percentages
Tree branches	43	60
Use barbed wire	25	35
Cut young trees	14	19

Source: Author (2015)

Barbed wire together with tree branches and young trees are used to fence tree seedlings. The tree branches and young trees that are erected as poles to support the fencing are replace after sometime due to decomposition.

Plate 4.6: Using barbed wire as fencing material Nakong

Source: Field Survey, 2015

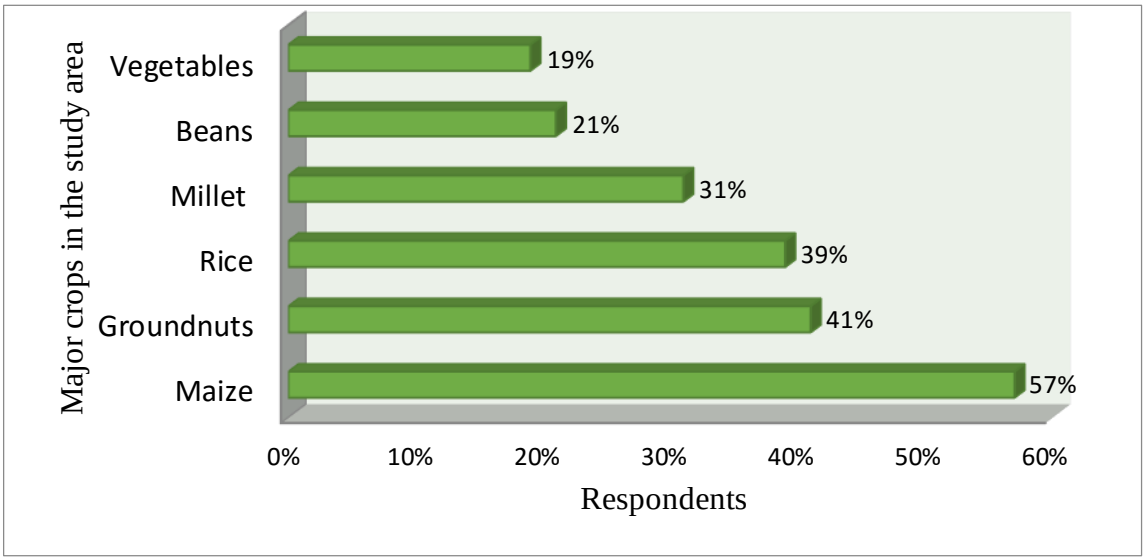
Plate 4.7: Using thorny species for fencing

Source: Field Survey, 2015

4.5.6.3 Major Crops in the Study Communities

Farmers in the KNWD cultivate a variety of crops for household consumption and for commercial purposes. The study investigated the kinds of crops that are cultivated together with the trees (Figure 4.12). From the results 57% of farmers reported that maize is intercropped with the trees on agricultural fields, 41% of farmers combined groundnuts with trees, combination of rice and trees was reported by 39% of farmers, while 31%, 21% and 19% are growing millet, beans and vegetables respectively on their fields. Respondents reported that these crops do well when combined with trees.

Figure 4.11: Major Crops in the Study Communities

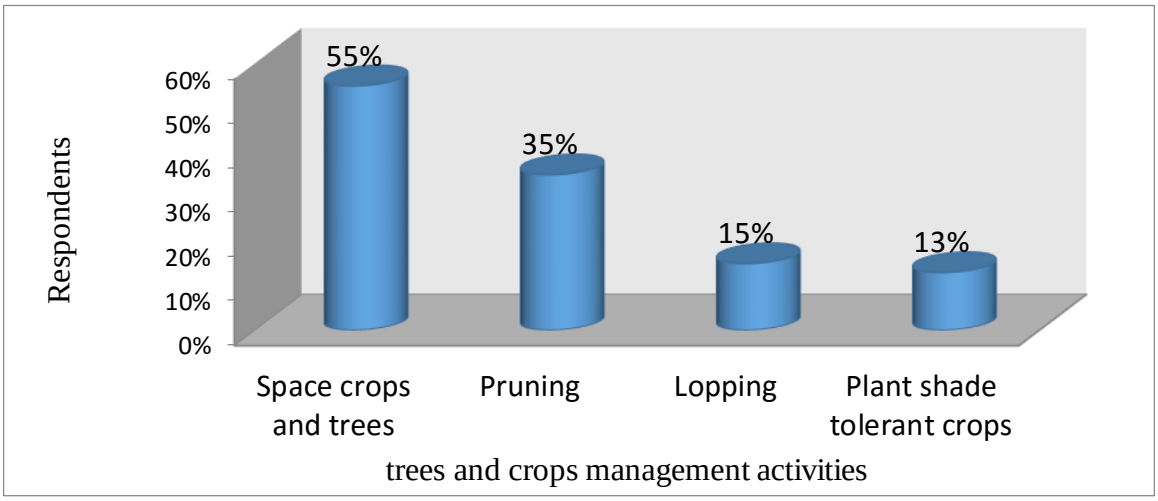


Source: Author (2015)

4.5.6.4 Tree and Crop Management Activities

Farmers in the study communities reported how they manage the tree and crop components to reduce negative competition and ensure good crop production during the farming season (4.13). The majority of farmers (55%) stated that spacing of the crops and trees is a prudent way of reducing the impact of shade on the crops, 35% of farmers were of the view that pruning at the beginning of the farming season is quite beneficial to the crops. In addition, lopping is another way of enhancing crops growth in agroforestry 15%, while 13% are planting shade tolerant crops

Figure 4.12: Tree and crop management practices

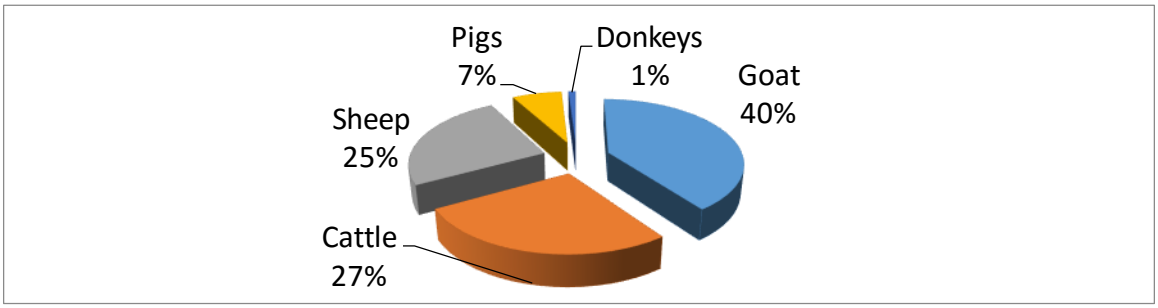


Source: Author (2015)

4.5.7 Animal Species in the Study Communities

Animal rearing is yet another important component of agroforestry, hence farmers were asked to indicate the dominant animal species in their households and five animal species were reported by farmers as the dominant species (figure 4.14). Among the dominant species, goats were the most dominant animal species reared by 40% of farmers, 27% of farmers interviewed rear cattle, 25% of the study respondents own sheep, 7% and 1% of farmers rear pigs and donkeys respectively

Figure 4.13: Dominant Domestic Animal Species

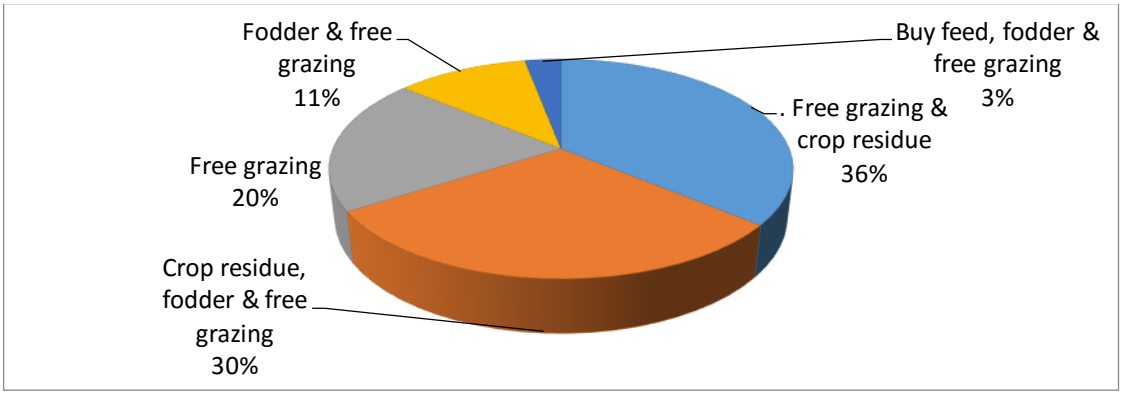


Source: Author (2015)

4.5.8 Source of Animal Feed

With regards to how the animals were fed, 36% of farmers said crop residue was used to supplement free grazing as a feeding option, the second important feeding combination was crop residue, fodder and free grazing which was adopted by 30% of the farmers, 20% of farmers revealed that free grazing was the only means of feeding the animals (Figure. 4.17). Eleven percent of farmers also relied on fodder and free grazing as a feeding source for the animals and the minority group of farmers (3%) mentioned that they use fodder, free grazing and sometimes buy feed for the animals.

Figure 4.14: Sources of feed for the animals



Source: Author (2015)

4.5.9 Benefits of Agroforestry Practices in the Study Area

Practicing agroforestry comes with some benefit to the farmer and farm families. Benefits enjoyed by farmers in the study communities are presented in Table 4.12. Overwhelming 93% of farmers noted that income generation through the sale of tree products such as fruits and poles is one of the benefits of agroforestry. Out of the 93% of farmers who mentioned income as a benefit, 78% of them ranked it as the most important, 21% ranked it as important and just 1% think that it is least important. 65 percent mentioned that trees

on farm provide shade for them and their animals especially during dry season when temperatures are usually high (Table 4.10).

Table 4.12: Benefits of Agroforestry Practices in the Study Area

			Ranking of the importance		
AF Benefits	**Freq.**	**%**	**Least important**	**Important**	**Most important**
Income	70	93 (1st)	1	21	78
Shade	49	65 (2nd)	9	65	26
Construction material	36	48 (3rd)	29	50	21
Fuel wood	32	43 (4th)	3	68	29
Medicine	29	39 (5th)	19	52	29
Fodder	12	16 (6th)	25	50	25

Source: Author (2015)

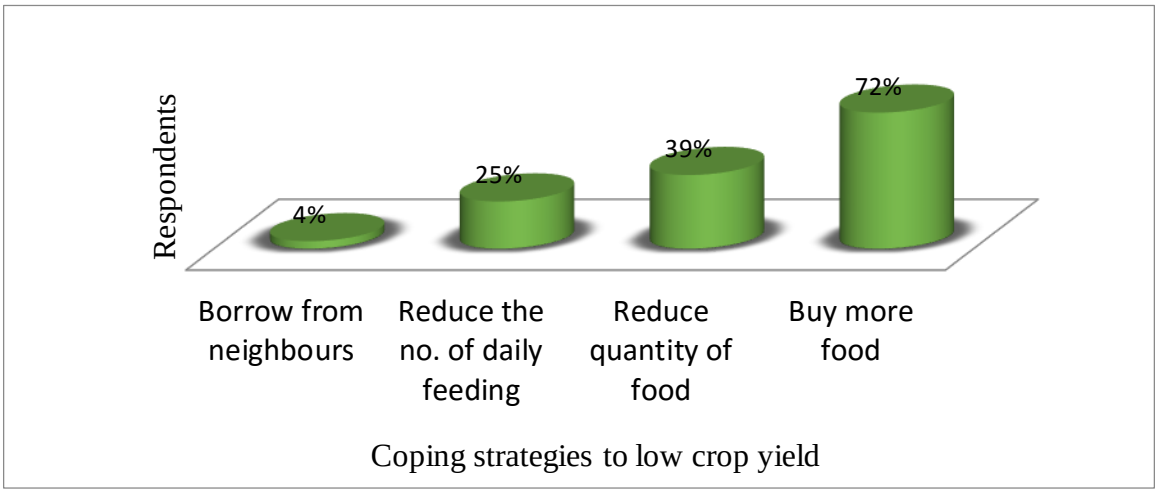
4.6 Agricultural Adaptation Strategies to Climate Change in the District

Farmers were interviewed on measures put in place to minimize the impact of climate change on agricultural activities in the study area. Farmers reported that they have taken some steps to be able to adapt to the consequences of climate change. Majority of farmers have altered the planting dates of food crops, 93% of farmers are now planting their crops late. In addition, 74 percent of respondents are cultivating improved varieties as an adaptation strategy while 51% and 50% of respondents have resorted to mixed cropping and dry season farming to be able to make a living.

4.6.1 Coping Strategies in Periods of Low Crop Production

Figure 4.16 shows the strategies farmers adopted during periods of low crop production due to climate change. 72 percent of farmers usually buy more food when crops production is low to enable them cope till the next harvesting season, 39% of the respondents reduced the quantity of food served during such periods. Likewise, 25% of farmers decided to reduce the number of daily meals while 4% of farmers reported that they borrow food from their neighbours with the promise to pay back in the next farming season.

Figure 4.15: Coping strategies adopted by farmers in times of low crop yields



Source: Author (2015)

4.6.2 General Agricultural Adaptation Strategies

Results from focus group discussions and key informant interviews brought to light variety of agricultural adaptation strategies farmers adopted to be able to deal with the adverse effects of a changing climate in the KNWD. Table 4.13 captures the general strategies that play crucial role in agricultural adaptation to climate change.

Table 4.13: Agricultural adaptation strategies in each of the four communities

Adaptation strategy	Description of the strategy
Application of manure/ fertilizer	Farmers in district apply manure obtained from animal droppings. Farmers said "*application of manure is a very old traditional practice, but we no longer have more animals so some farmers buy the manure from the Fulani herdsmen in the neighbourhood*". Chemical fertilizer is used to augment the manure for an improve crop yield.
Multiple weeding	Farmers weeding several times to prevent weeds from taking most of the soil nutrients and impede the growth and yield of the crop
Crop replacement	Irregular rainfall and poor distribution of it negatively affect the germination of seeds. Even some of the germinated seeds still die off because there is not adequate moisture content in the soil compelling farmers to replace those that died.
Agroforestry	Agroforestry refers to deliberate retention and planting of trees on agricultural landscape to improve crop production.
Crop rotation	Crop rotation is a popular adaptation strategy in the study communities. Farmers reported that crop rotation is good because it improves crop.
Plant drought resistant crops	There was a serious argument among discussants on this strategy; some argued that there is no crop that can resist the kind of drought

	experienced in recent times while others were of the view that some crops can thrive during drought situation. In the end, they all agreed that there are some crops such as millet and rice that can survive the drought that will kill other crops.
Application of weedicide	The use of weedicide helps farmers who can afford the chemicals to control weeds on their farms.
Composting	According to the discussants composting is done in the cattle kraal where farmers normally dump crop residue and straws. The compost is then applied on farms at the beginning of the farming season.
Construction of dams	Farmers in the study communities rely on small irrigation dams for dry season farming to complement the wet season produce.
Use of bones/flour	The study respondents used bones and flour to deal with termites which kill the seedlings and young trees. According to them, the bones and the flour will attract ants that will overpower the termites.
Sprinkling of cow dung/neem extract	Farmers also sprinkle cow dung/neem extract to control pests and diseases that attack the trees.
Dry season gardening	Small dams in the area help farmers to do gardens in the dry season. Some farmers dig wells on their own for the same purpose.
Selling fuel wood	Women cut fuel wood for sale to be able to make a living.
Hunting/fishing	Some male farmers also hunt for animals and engage in fishing as an adaptation strategy.

Source: Author, 2015

4.7 Farmers' Perspective of Agroforestry as an Adaptation Strategy to Climate Change

The impacts of climate change observed by farmers in the study communities include frequent drought, floods, winds storms, food insecurity and soil infertility. Table 4.14 shows the contribution of agroforestry to climate change adaptation from farmers' point of view. Farmers have relied on these strategies in order to minimize considerably the impacts of climate change.

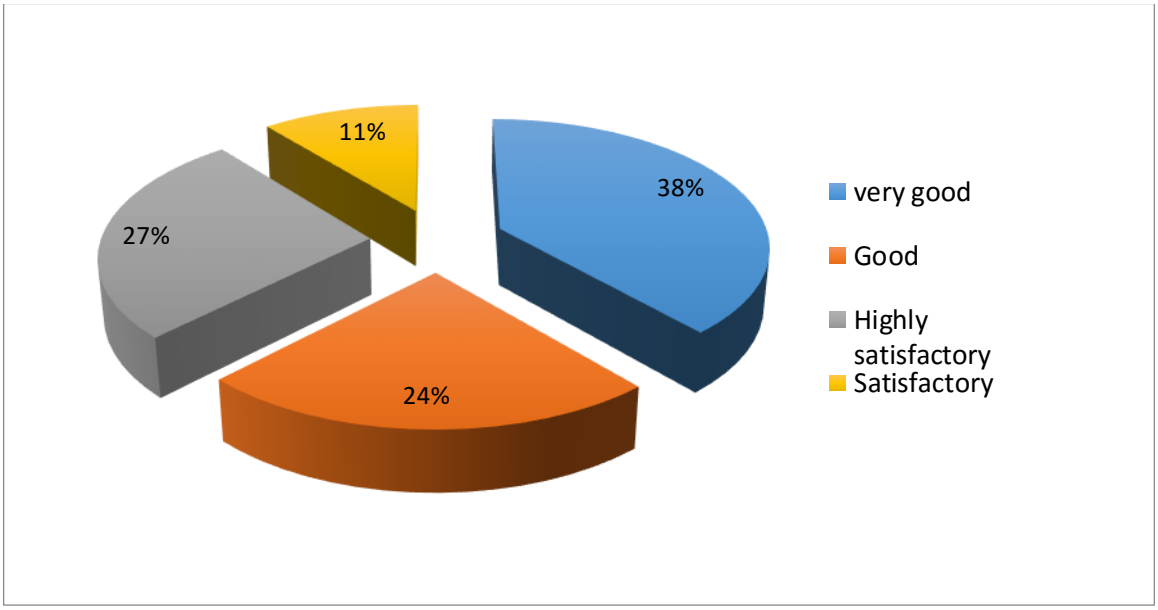
Table 4.14: Agroforestry's Contribution to Climate Change Adaptation

Impacts	How Agroforestry help farmers to adapt	Percentage of responses
Drought	Access to fodder	20
	Trees are more are resistant to drought	32
	Increase soil moisture	42
	Moderate microclimate	37
Floods	Reduce erosion	42
	Reduce runoff	15
Wind storms	Protect food crops	41
	Protect houses	38
	Reduce wind erosion	45
Food insecurity	Increase food crop production	42
	Increase access of income	55
	Source of food for households	58

Soil infertility	Improve soil nutrients	62
	Provide soil cover	47

Source: Author (2015)

Figure 4.16: ranking of agroforestry as an adaptation strategy



Source: Author (2015)

Based on the benefits derived from agroforestry practices, 38% of the study respondents ranked agroforestry as a vibrant adaptation strategy, 27% considered agroforestry practices as a good adaptation strategy, 24% of respondents saw it as highly satisfactory adaptation option for climate change and 11% believed that it is a satisfactory measure in dealing with the observed impacts of climate change.

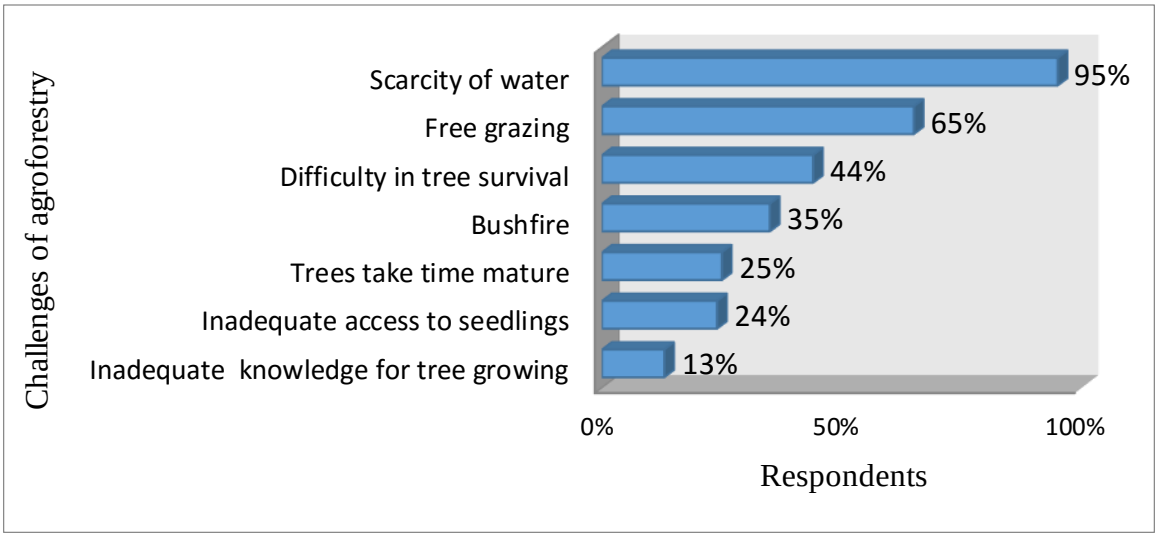
4.8 Farmers Coping Strategies to the Challenges of Agroforestry

This section looks at the various challenges associated with agroforestry practices, the effects of the challenges on the success of tree growing and how farmers are dealing with the challenges.

4.8.1 Challenges of Agroforestry

With regards to the challenges farmers encountered in the practice, overwhelming majority of farmers (95%) said that variable rainfall has resulted in scarcity of water for successful tree growing in the study district, 65% of farmers reported that free animal grazing was the next serious challenge associated with agroforestry practice in the area especially in the dry season, 44% of farmers noted that it is difficult for tree survival, 35%, 25%, 24% and 13% reported bushfires, trees take time to manure, inadequate of access to seedlings, and inadequate knowledge for tree growing respectively as the other challenges of agroforestry.

Figure 4.17: Challenges of Agroforestry



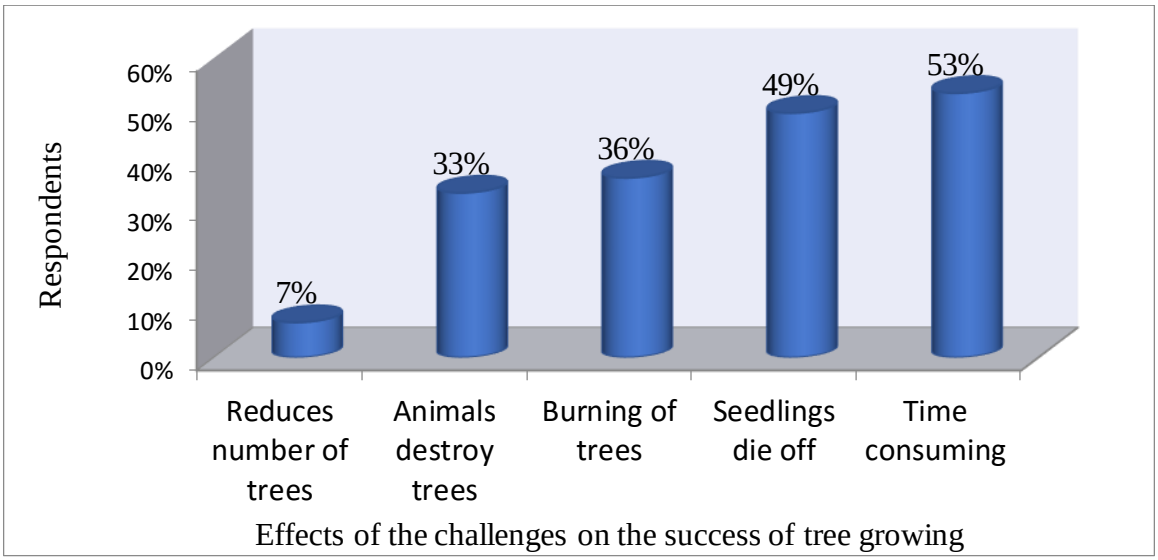
Source: Author (2015)

4.8.2 Effects of the Challenges on the Success of Tree Growing in the Study Area

Results in Figure 4.19 indicate that 53 percent of farmers realized that the challenges encountered in agroforestry makes it time consuming endeavour, 49% believed that seedlings die off as a result of the challenges faced, other effects of the challenges on

successful agroforestry practice include bushfires burning trees (36%), animals destroying trees (36%) and 7% were of the view that number of trees planted has reduced. It is evident that challenges encountered in agroforestry practice have had diverse effects on the success of tree planting.

Figure 4.18: Effects of the Challenges on the Success of Growing in the Study Area

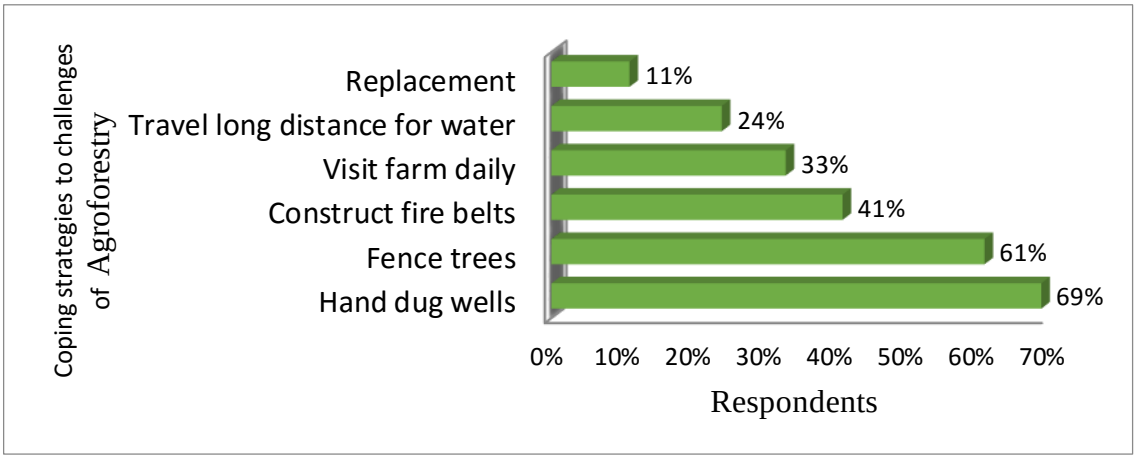


Source: Author (2015)

4.8.3 Coping strategies to the challenges of agroforestry

Farmers have taken certain measures to be able to deal with the challenges of agroforestry practices in the KNWD (Figure, 20). Majority of farmers (69%) have resorted to hand dug wells to water the trees especially in the dry season. Sixty one percent of respondents' fence trees to protect them from animals' destruction, construction of fire belts by 41% of the farmers, 33% of farmers visit farms daily to take of the trees. Similarly, 24% of farmers cover long distances to fetch water with donkey carts and gallons, while 11% of respondents replace the seedlings that die off.

Figure 4.20: Coping strategies to the challenges of agroforestry



Source: Author (2015)

Farmers explain that trees cannot survive without water hence the need to dig wells to provide reliable source of water for tree planting (Plate 8).

Plate 4.8: Hand dug well at Nakolo

Source: Field Survey, 2015

CHAPTER FIVE

DISCUSSION OF STUDY RESULTS

5.1 Introductions

This chapter discusses the findings of the study in detail. The chapter discusses farmers understanding of climate change, farmers perspectives on agroforestry practices, agroforestry as an adaptation strategy and challenges associated with agroforestry practices.

5.2 Farmers Understanding of Climate Change in the Kassena Nankana West District

Farmers' understanding of climate change in the study area was assessed by using their experience and knowledge of changes in some climate variables- rainfall, temperature, sunshine and wind over the past three decades. Farmers have demonstrated that some changes took place in the last thirty years and stated that such changes in the climate variables came along with varied impacts on agricultural activities in the study site. Farmers expressed varied opinions on the causes of the changes observed.

5.2.1 Changes Observed in Climate Variables in the Study Area

Farmers observed that rainfall has been varying in the last 30 years in amounts, distribution and in frequency. In addition, the onset of the rains have shortened in recent times, rains for the farming seasons now starts in June/July instead of April/May. Majority of farmers (88%) concluded that rainfall has been decreasing over the past 30 years. The statistical data obtained from the Ghana Meteorological Service was in support of the views expressed by farmers in terms of changes in rainfall. A study

conducted by Owusu and Klutse (2013) came out with similar findings which indicated that rainfall has taken a downward trend in the last 30 years.

Besides that, the current study discovered that temperature is also on the increase, this position was supported by majority (81%) of farmers in the communities. Farmers further explained that more than three decades ago, the raining season was always associated with low temperature but it changed in recent times. They noted that temperature is rising because less rainfall is being recorded especially in the last five years. Yaro (2013) reported that farming communities have noticed that temperature is increasing even in months which normally record low temperatures. However, empirical data from Ghana Meteorological Agency did not show a clear increase in temperature in the last 30 years.

With regards to wind, it was reported that wind speed is increasing leading to wind storms that are quite disastrous for farming activities. Based on the severity of the destruction experienced by wind storms, most of the respondents reported that wind storms were extremely severe because they sometimes uproot trees and rip off roofing sheets. Scholars have pointed out that farmers in Africa have appreciable knowledge of climate and can detect and communicate changes in rainfall, temperature and wind (Thomas et al., 2007; Mertz et al., 2009; Ifejika et al., 2009 cited in Yaro, 2013). Similarly, Maddison (2007) revealed that African farmers have knowledge of climate change based on their experience of changes in temperature and precipitation.

An interview with key informant at Ghana Meteorological station at Navrongo revealed that indeed wind storm of between 51-70 knots which is considered extremely severe has occurred in the study area a of number times. By this revelation, the study concludes that observation is a reliable source of knowledge and relevant means of gathering

information concerning climate change because what has been observed is consistent with empirical data from the meteorological station.

5.2.2 Causes of Climate Change

In the course of the study, farmers were interviewed to find out why rainfall and other climate variables are changing, the responses were varied. Majority of farmers (52%) indicated that the change came about as a result of the unprecedented disappearance of trees because they believe trees attract rains. Respondents strongly argued that southern Ghana receives more rainfall than Northern because the former has more trees than the latter.

Respondents noted that people are cutting down trees for various purposes including charcoal production. Some were of the view that the use of tractors and chain saw disturb the environment and hence the changed in climatic conditions. This finding is consistent with the observation made by Salinger et al. (2000) and the IPCC (2001). Salinger et al. (2000) found out that agricultural activities as well as settlement development are among the causal factors of climate change; while IPCC noted that changes in the climate are attributed to human activities that lead to emission of gases in the atmosphere. This means farmers are not only aware of changes in climate but also the factors that triggered the change. However, some farmers stated that climate change is the act of God, they maintained God is angry because of the bad deeds of human beings, as such it was considered as punishment from God. Yet a minority group of the respondents (21%) said they do not know the causes of the change.

5.2.3 Impacts of Climate Change

From questionnaire administration and focus group discussions, study respondents indicated and explained that they experience drought frequently due to low rainfall accompanied by poor distribution patterns in the last three decades. It was further explained that drought comes with negative effects which include poor germination of seeds, stunted growth and development of food crops, and difficulty in harvesting crops such as groundnuts. Farmers usually resort to beating the ground to harvest these crops while others take the pain to water the ground to facilitate easy uprooting of groundnuts. It was revealed that farmers who adopted the beating as a strategy usually lose substantial quantities of the groundnuts to the soil.

Similarly, empirical studies conducted by Stern, (2006), Bryan et al. (2010), FAO, (2010), Codjoe, Owusu, (2011) and Ozor et al.(2012) concluded that agricultural drought and other extreme weather events are the means by which the actual impacts of climate change are felt by the farmer. This implies that drought is a serious impact of climate change that threatens agricultural activities in the study communities. This situation has made agriculture one of the most risky human activities in the Kassena Nankana West District, therefore, farming could become unattractive to those who do farming for commercial purposes and burdensome to the subsistence farmers. This finding is consistent with Bryan et al. (2010) and Macchi et al. (2011) who noted changes in rainfall will put the farmer at risks which suggest strongly that successful farming activities are contingent on rainfall or at least the moisture content. The poor germination of seeds indicates that farmers sometimes have to do the second sowing which comes with additional costs to the farmer.

This study examined the impact of wind on agricultural development in the area. According to farmers, the devastating effects of wind storms include destruction of crops, trees and soil erosion. Farmers observed that storms usually carry some soil particles and nutrients away which contribute to soil infertility. Wind storms force some crops to bend down and also break down some crops as well. The timing of the storms is very crucial in this matter, when the crops mature before the wind storms come, farmers will still harvest something significant. However, if the storms start before the crops are fully matured, animals and poultry birds will consume a greater portion of the crops resulting in serious loss to the farmer. Also branches of trees are not spared at all by the storms and sometimes severe wind storms uproot some of the trees. A farmer noted that wind storms break down crops and trees like elephants in the bush.

However, sunshine especially when the intensity is extremely high can make life unbearable to the farmer as well as the crops, the scorching sun will affect the ability of the farmer to work for long hours on the farm, as the farmer cut some of roots of the crops during the weeding the sunshine will facilitate wilting and dying of the crops. Eventually, most of the crops fail when the rains do not come to promote survival of crops, this will result into loss of investments of the farmer. In the light of the above, it is clear that farmers have knowledge on the changes in climate. This is in line with the empirical findings Ozor et al. (2012) that farmers' awareness of climate change impacts is an expression of their knowledge.

It emerged from this study that floods constituted another impact of changed climatic conditions overtime. Farmers said within the 30 year period, a number of floods situations have occurred in their communities even though it was difficult for them to

mention the specific years apart from the recent one in the second millennium which occurred in 2007. Focus group discussions and key informant interviews revealed that floods have dire consequences on farming activities and the soil. It washes away manure, fertilizer and other soil nutrients from the topsoil and causing crops to submerge in water and destroy human property. Ozor et al. (2012) reported that floods are among the numerous consequences of climate change which is much felt by farming communities as it triggers erosion and also leads to loss of agricultural lands when it occurs.

Another climate related disturbance in the study area was emergence of pests and diseases. Farmers explained that certain strange pests and diseases attack crops, trees and especially vegetables within the past 30 years than ever before. It was reported that farmers have to rely on chemicals to be able to cope with the situation while others relied on sprinkling of neem extract and cow dung as local adaptation strategy. This finding corroborates the finding of Ozor et al. (2012) which revealed that farmers in Nigeria are suffering from the damaging effects of pests and disease.

The combined effect of erratic rainfall, drought, wind storms and intermittent floods has led to the loss of soil fertility. Respondents explained that the soil has become impoverished and for that matter unproductive which compromise agricultural activities. Consequently, food crop production in the study district is falling, this is evident in figure 4.4 where yield per ton of some crops are decreasing. Generally, the impacts of climate change have had negative repercussion on household food security and income levels of households.

5.2.4 Vulnerability to the Impacts of Climate Change

Focus group discussions with the farmers suggest that the farming communities are vulnerable to the impacts of climate change because their livelihood which comes mainly from agricultural activities depends on climate. As such the shock in climate will affect the source of livelihood greatly and place farmers at vulnerable position. For instance, some farmers mention that water sources such the Tono dam and other smaller irrigation dams dried up in 2015 making dry season farming impossible. This findings agrees with the findings (Breisinger et al., 2008 cited in Pinto et al., 2012) which noted that majority of Ghanaians depended heavily on rain-fed agricultural which is susceptible to the shocks of climate change. Again, the poor germination of seeds requires farmers to sow about 2-3 times in order to achieve good crop production, but due to inadequate financial resource availability, farmers are unable to sow again when the first one fails.

5.3 Agroforestry Practices in the Study Area

This section looks at the various measures in agroforestry practices in the study communities. It covers the types of agroforestry technologies, the management practices adopted to ensure survival of planted trees, crops that are cultivated with the trees, animals and their source of feeding and the benefits of agroforestry.

5.3.1 Types of Agroforestry Practices Adopted by Farmers

The study discovered that five specific agroforestry technologies have been adopted and practiced by farmers in the Kassena Nankana West District of the Upper East Region.

5.3.1.1 Scattered Trees (Parklands)

Among the five agroforestry practices in the study communities, scattered trees (parklands) is the most prevalent, every farmer in the communities have consciously retained some trees on their farm lands. Trees retained by farmers on crop fields include Shea, dawadawa tamarind, neem, baobabs, and whitethorn among others. One unique characteristic of this practice is the irregular and haphazard nature in which trees are distributed on crop lands with varying degrees of spacing. This finding agrees with the empirical findings of several scholars; Agidie et al. (2013) Gebrehiwot, (2004) and Jamala et al. (2013). These scholars found out that deliberate retention of preferred trees on agricultural landscape is one of the commonest agroforestry practices that have received widespread adoption. Farmers reported that these trees are retained on crop lands because they provide shade, fruits, fodder and also help to improve the nutrients of the soil. The study revealed that retention of scattered trees on farmlands is the easiest practice because trees occur naturally; the farmer only has to make a decision not to destroy the tree.

5.3.1.2 Trees on Farm Lands

Another agroforestry practice in the KNWD is trees on farm lands. This practice refers to the conscious integration of in-situ trees and ex-situ trees on the same agricultural field. In this practice, farmers do not only retain trees on farm lands but also plant additional ones with the intention of increasing tree population on agricultural lands and maximize the benefits of trees. The study found out that farmers planted preferred species such as mango, cacia, cashew, dawadawa, Shea among others for economic and land management benefits. Trees provide shade, fruits, income and also improve the soil

nutrients. It was interesting to note that some local tree species such as dawadawa and Shea have propagation potentials in the study district. This finding relates to Aloa and Shuaibu (2013), who indicated that the combination of naturally occurring trees and planted ones yield a number of benefits which include access to food and income, improvement of local environmental conditions and the provision of shade during unfavourable weather conditions.

5.3.1.3 Home Garden

The study found out that farmers plant woody species, crops, variety of vegetables and rear poultry just by the home stead on the same piece of land for a long time. This finding is consistent with the views of (Oluka-Akileng et al., 2000) that home garden involves the growing of trees, crops, shrubs as well as medicinal plants on the same land management unit which help the farmer to manage land resources. Mango, guava, dawadawa, moringa, pawpaw and cashew were some of the trees found in home gardens in the study communities. These help farmers to enjoy fruits, fresh vegetables and crops such as maize in the dry season.

Farmers who combine this with scattered trees on farm will have access to food fodder, fruits and vegetables all year round because the home garden take of the dry season while the scattered trees cater for the wet season. According Badege et al., (2013), the farmer manages the garden to ensure complimentary interaction which will yield benefits to farmer as well as the land. From the focus group discussion and personal observation, home garden is the most successful and the oldest agroforestry practice in the study area. From Farmers perspective, the success of home garden is attributed to the fact that trees receive optimum conditions such as manuring, watering, regular weeding and fencing

that contribute to survival and support the growth of trees. Regular application of manure and watering provide the necessary soil nutrients and moisture content for trees to do well, the weeding also prevent weeds from competing with trees for the same nutrients in the soil and finally, the fencing protect the trees so that animal do not destroy them. In addition, the farmers usually create fire belts around the garden for protection during fire outbreaks which are becoming annual events. Thus, home garden is one of the most important livelihood strategies which qualify it as an essential adaptation strategy to climate change.

5.3.1.4 Plantation and Crop Combination

Plantation development is yet another agroforestry practice in KNWD. Farmers have planted trees on relatively large parcels of land in the area. Plantation tree species in the study area are mainly fruit trees such as mango and cashew. This is done for commercial purposes, crops are cultivated alongside during the early stages, but as the tree mature and cover the whole place, the crop component is omitted. However, those who are doing grafted mangoes continue to plant crops for a long time because such trees do not spread much to affect the crops. Yong (1989) realized that farmers plant banana, coffee and tea trees in plantation fields which contribute in reducing the effect of deforestation. Similarly, Long and Nair (1999) explained that plantation crop combination is mixture of multistory trees and crops on large parcels of land for economic gains.

5.3.1.5 Farm Woodlot

Intentional planting of trees on parcels of land for timber, poles, fodder and fuel wood is referred to as farm woodlot. This is the least adopted practice in the farming communities where the study was conducted. Farmers elucidated that trees takes longer periods to

mature and also farm families do not harvest fruits from such trees and hence woodlot does not address the immediate household needs such as food and income. Trees found on farm woodlot include eucalyptus, cacia, and teak and in some few cases mahogany species. The farmer harvests the trees as they mature for personal use and for sale.

5.3.2 Agroforestry Management Practices

Farmers are aware that it is not enough just to plant a tree but the tree must be tended to grow well, the same applies to the crops and animals. As a result, farmers engaged in various agroforestry management practices that are necessary and helpful to the three components of agroforestry.

5.3.2.1 Tree Management Practices

With regards to tree management practices, the study found out through questionnaire administration, focus group discussion and key informant interviews that farmers are doing watering, weeding, construction of fire belt, fencing, application of manure, mulching and the use of bone/flour to enhance the survival, growth and development of the trees especially during the initial stages. These practices can be categorized into (i) attempts to increase and sustain moisture content of the soil which involves watering and mulching (ii) efforts to reduce competition for soil nutrients which involves regular weeding (iii) enhancement of the security of trees through fencing and fire belt construction (iv) improving soil nutrients by applying manure and (v) minimizing the effect of termites by using bones and flour as remedy.

A closed examination of the tree management activities undertaken by farmers revealed that the solutions to the challenges are embedded in the management practices. Therefore,

any farmer who pays serious attention to the tree management practices will contribute to reduce the challenges of agroforestry to the tolerance level which will reflect positively on the success of agroforestry practices. Due to variation in farmer attitude towards these practices, there are varying degrees of successes in agroforestry in the study communities.

Studies conducted by Nair (1993) and Agidie et al. (2013) revealed that farmers undertake a number of tree management operations that are beneficial and help the farm to maximize economic and production objectives. The authors mentioned that management practices include application of fertilizer and manure, mulching, coppicing, lopping and pruning. According to Gebrehiwot (2004), farmers are aware of the benefits associated with tree management practices; hence they undertake some operations on their farms.

It also emerged from the study that agroforestry contribute significantly to curtail bush fire on farms, this is an interesting revelation. In a FGD, farmers explained that during the harvesting season some farmers convey the crop residues to their homes while the remaining ones on farms are completely consumed by animals leaving a bare land. This implies that the crop residues which would have fuelled bush fires are no longer available on the farm. Hence combinations of crops and wood perennials have been identified by farmers as a panacea to perennial bushfires in the study distinct. Wind storms especially the harmattan virtually sweep the ground. This research also brought to light the fact that integration of trees, crops and animal on the same land management unit is beneficial to the tree component. Study respondents unanimously agreed during a focus group

discussion session that trees on farms bear more fruits than those in the wild. Respondents said application of manure/fertilizer makes the difference.

As part of the tree management practices, farmers used barbed wire, trees branches and young trees as material for fencing seedlings and the young tree species. Farmers adopted the following combination during the fencing process; barbed wired and bigger tree branches erected as poles, tree branches together with millet and corn straws, tree branches with long grasses and tree branches and young trees.

5.3.2.2 Importance of Some Selected Agroforestry Trees to the Farmer

At focus group discussions with farmers in the study communities, it emerged that some agroforestry trees are very important in diverse ways. The respondents noticed that the stem and the branches of Shea trees are used as constructional material for traditional building, for fencing home gardens and serve as fuel wood for households. Fruits from the trees are consumed as food by everybody in the farming communities while some are sold to earn income farm families. Likewise, the nuts are sold in raw form to make money while others extract butter for the same reason. Falling leaves play an important production role as they decay to fertilize the soil. This finding relates to the findings of empirical studies carried out by Gebrehiwot (2004) and Thorlakson and Neufeldt (2012). These scholars saw that agroforestry has income generating potential which helps farmers to earn income by selling products such as fuel wood, timber, honey, fruits and even herbs.

In addition, whitethorn is a naturally occurring tree which has been recognized by farmers as the most suitable agroforestry tree in terms of productions because of its

unique characteristics. It shed its leaves in the raining season, which means that there is no shade to impede crops from getting enough sunshine. Furthermore, the leaves decompose to fertile the soil for an increase agricultural production. Farmers said, *"We record the highest crop production on fields where whitethorn species are found*". It gains its leaves in dry season, a period in which most of trees lose their leaves, making it possible for farmers to have access to fodder for animals. Apart from the production benefits, respondents reported that the leaves and fruits are good source of feed for animals, because the animals enjoy the fruits, they will always come home in the evenings after roaming for the whole day.

Baobab is another agroforestry tree with several socioeconomic benefits in the KNWD. The leaves are used to prepare soup for households; some sell it to earn income for their families. Within the past three years, women have earned huge incomes from selling both the seed and the powder locally and internationally. During a key informant interview with the Programme Coordinator of ORGIIS-GHANA in Paga, it came out that this organization has linked up with international buyers thereby creating high demand for baobab products. Lastly, the pods are used as fuel for preparing meals in the study area. This finding confirms the finding of Garrity (2006) that agroforestry practices have the potential of increasing food production and household income thereby reducing hunger and poverty.

Among the planted tree species, majority of farmers' plant mango trees than any other tree. Farmers believed that mango helps them to earn income for their households which in turn enable them pay children's school fees and medical bills. Animals are purchased for rearing using the income from the sale of mango. Moreover, it enables farmers to buy

seeds for the farming season. A farmer said, *"I will never lack seed even when my crops fail because I can always buy seeds from the sale of mango fruits."* The bark and leaves are used as medicine and the dry branches are a source of fuel wood. It is also an important source of food as people eat the fruits. In FGD, women said *"our children skip their lunch during the season of the mango fruits*". This is an important food supplement for households.

The dawadawa tree has several socio-economic benefits. The fruit is eaten raw; some use it to prepare cakes for households and for sale. The women boil the cover of the fruit and use the liquid *(berena)* to sprinkle on the outer walls of the local buildings to make them strong and last longer. The seed is sold in its raw form to earn income. Finally, the seed is converted into a processed dawadawa *(cho)* which is an important ingredient for preparing soup. Processing the seed into a finished product is an important income generating activity in the study district.

5.3.2.3 Crop and Tree Management Practices

Crop and trees species are combined on the same land management unit which requires careful and helpful management practices to reduce negative competition between the components to bring about the needed increase in food crop production. Identified crops and tree management practices include pruning which refers to the selective removal of tree branches to reduce shade, lopping is the cutting of branches from the base of a stem, spacing trees. The pruning and the lopping are usually done at the beginning of the farming season before planting the crops.

Another way is to plant shade loving crops to agricultural fields which farmers do in the study communities so that crops rather take advantage of the shade. Several studies have

pointed out that pruning, lopping and spacing are among crop and tree management activities that farmers do in order to reduce negative competition between the two components (Nair, 1993 and Agidie et al., 2013).

5.3.2.4 Animal Care Practices

Any effective interaction of the various components depends largely on the farmer's actions. Farmers are responsible for providing animals' pens and ensuring that the animals are well fed at all times. Animal pens are constructed using tree branches and sometimes in combination with soil. For instance, in the study communities cattle kraals are fenced using branches while the leaves are used as fodder to feed the animals. In addition, farmers normally gather crop residues and put them on silos at the beginning of the harvesting season for feeding the animals in the dry season. It is evident that agroforestry management activities are the key responsibility of the farmers as far as agroforestry is concerned. The farmer facilitates the flow of energy as the needs of trees, crops and the animals of are catered for, this enhance beneficial interaction amongst the various components of agroforestry which will help the farmers derive maximum benefits from their own efforts.

5.3.3 Benefits Agroforestry

5.3.3.1 Socioeconomic Benefits

Farmers reported that agroforestry contributes importantly to household income generation process, tree products such as fuel wood, fruits and poles are sold to earn income for farm families in the study communities on sustainable basis. Likewise, trees are a good source of medicine for land owners as well as the community at large. Also, AF practice increase food crop production and hence increase farm households' access to

food. In the final analysis, incorporation of trees on crop land is an important step towards the achievement of food security.

Furthermore, integrating trees on farm lands is a prominent strategy that minimizes drastically the cost of farm inputs such as fertilizer to the farmer. It came out that farmers in the study district are using manure and compost which comes from crops, trees and animals droppings to fertilize the soil and improved substantially the nutrients content of the soil. Trees also provide shade and constructional materials of building houses in the communities.

5.3.3.2 Environmental Benefits

Farmers explained that agroforestry plays a major role in moderating micro-climate, they noted that where trees are found on agricultural landscape, the temperature in that area is usually lower than the areas without trees. Trees on farm lands also contribute to improve the vegetative cover in the area thereby creating serene environment which protect biodiversity.

5.3.3.3 Biological Benefits

Agroforestry increases and sustains soil moisture of a place which goes a long way to increase production. Various forms of interaction between the components of agroforestry and other living organism yield some to benefits to the farmer and the land as well.

5.4 Agricultural Adaptation to Climate Change in the Study District

Farmers' responses to climate change include planting crops late and cultivating improved varieties. This study revealed that majority of farmers' plant late because the

rains do not come early in recent years. This has disrupted local farming calendar in the Kassena Nankana West District. Farmers have also resorted to planting of improved varieties such early maturing and high yielding crops to overcome the impacts of climate change. Consequently, indigenous crops species are cultivated by few farmers which threatens the sustainability of indigenous crop species in the study district.

5.4.1 Some Coping Strategies in Periods of Low Crop Production

This study revealed that farmers have adopted some coping strategies in periods of low crop production. The majority of farmers (72%) stated that they purchase more food in such situations to be able to survive till the next harvesting season. Farmers use income from the sales of animals and tree products to buy more food for their households. Some of the farmers also reduce the quantity of food prepared by the households and the number of daily feeding is also reduced from three to two. This finding is in consonance with Rious (2012) who revealed that climate change has adversely affected availability of food for household compelling them to reduce the number of daily feedings.

5.4.2 General Agricultural Adaptation Strategies

This study identified many agricultural adaptation strategies through focus group discussion and key informant interviews. The researcher has categorized them into soil nutrients improvement strategies, water and moisture content management strategies, as well as weeds, pests and disease control measures.

5.4.2.1 Soil Nutrients Improvement Strategies

Farmers have observed that the fertility of the soil is going down as time progresses and have taken some measures to ameliorate the situation. These include gathering of manure,

preparation of compost and the subsequent application of these on farm lands in order to boost agricultural productions. In addition, chemical fertilizer is used to improve the nutrient content of the soil.

However, farmers argued that chemical fertilizer is out reach of most of the poor peasant farmers. The withdrawal of subsidies has further compounded the problem. Farmers explained that due to unreliable rainfall, fertilizer application in itself is risky activity because when one applies and the rain fails to come the crops will wilt and die off. Another way of improving soil nutrient is through crop rotation, moving one crop from one plot of land to another in different production seasons. Farmers mentioned that leguminous crops such beans improve the nutrients of the soil and as crop rotation is being practiced the entire land will benefit.

5.4.2.2 Water and Moisture Management Mechanisms

The government, through the District Assembly and MOFA is constructing small dams for water harvesting which complements rain-fed agriculture. Some farmers are also digging wells to enable them to do dry season farming in the study communities. Farmers are practicing mulching which minimizes soil water losses and improve the moisture content of the soil. In addition, drought resistant crops are cultivated.

5.4.2.3 Weeds, Pests and Disease Control Measures

Farmers lamented that weeds are growing faster on their farmers creating competition between the weeds and food crops for soil nutrients. Therefore, it is the responsibility of the farmer to reduce this unhealthy competition to the bearers minimum in order to

enhance the growth and development of food crops by either weeding regularly, spraying with chemicals or both.

Some farmers adopted both regular weeding and spraying to be able to deal with weeds while others argued that chemicals are beyond reach, hence they have adopted only the multiple weeding. Farmers also noticed that new pest and diseases are emerging on farms and posing a serious threat to crops. The study found that there are two coping strategies to this, using chemicals and the sprinkling of cow dung/neem extract. Farmer either uses chemicals, sprinkling of cow dung/neem extract or both depending on the financial status of the farmer.

5.5 Agroforestry as an Adaptation Strategy to Climate Change

All the study respondents strongly believed that agroforestry can help them to adapt to the consequences of climate change in the KNWD. This stems from the fact that farmers who practice agroforestry have taken note of the benefits of trees on agricultural fields. Farmers ranked the adaptation role of agroforestry as vibrant, good, highly satisfactory and satisfactory. This ranking was based on the enormity of benefits farmers have enjoyed as a result of their involvement in the agroforestry practices.

Thirty eight percent of farmers ranked adaptation role of agroforestry as vibrant because they have benefited most from agroforestry. These farmers are doing at least three of the various practices, making it possible for them to enjoy multiple benefits from the practice. They mentioned that agroforestry has cushioned them to be able to absorb the shocks of climate change in the study area by providing them a source of food, fruits, and constructional materials among others. This indicates that farmers are mindful of the

benefits that accrue from agroforestry practice and by extension, how agroforestry plays a very crucial role in climate change adaptation. These findings are consistent with other empirical research findings regarding agroforestry as an indispensable land management practice that strategically position farmers to be able to sustain food crop production.

Specifically agroforestry is very important agricultural adaptation strategy to climate change as it helps to adapt to drought. Farmers realized that in times of drought, trees are more resistant thereby providing fodder, shade and increase soil moisture content. This is quite relevant contribution of agroforestry to farmers at the farm level, since drought has become a frequent phenomenon in the study area.

Floods are also climate change hazards that occurred in the KNWD in the last three decades especially the flood in 2007 was very destructive as farmers' crops, animals and valuable life properties were lost to the flood. In addition, the top soil particles containing vital soil nutrients were washed away. However, agroforestry farmers reported that impacts on their farms were minimal because of the important role trees played. Trees on their farms reduced the amount of nutrients that running water carried away. This shows that the root of trees and the lower part of the stems blocked and maintained soil nutrients during floods occurrence. Moreover, the fallen leaves contributed in adding nutrients to the soil; hence the lost nutrients were replenished.

The study discovered that changes in climatic conditions have brought about wind storms in the KNWD. Farmers mentioned the breaking of crops and trees, wind erosion and pulling down of unripe fruits as the effects of wind storms they observed. They argued that trees can reduce the effect of wind because they provide cover to the soil and for that

matter trees on farm lands reduce soil erosion and also protect crops from falling on the ground.

Furthermore, farmers acknowledged that trees on agricultural landscape increase crop production, increase farmers access to income and in addition serve as a source of food to the farmer. By implication agroforestry practice contributes to food security status of farming families in the farming communities' where the practices have been embraced by farmers.

The study also revealed that households that practice agroforestry successfully have been able to deal with soil infertility. From farmers perspective coupled with observation, trees on farm lands especially fruit trees attract animals who feed on the leaves and the fruits/seeds. This way, animals leave their droppings on the crop lands which contribute to improve soil nutrients. Some trees also provide shade for animals and in the process animal droppings are dotted around the trees.

In addition, the falling leaves also decompose and help increase the nutrient content of the soil largely. Trees also cover the top soil which helps to retain moisture control of the soil to enhance the growth and develop of the crops. On the other hand, crop residues, tree leaves and animal dropping also serve as manure for the trees. The farmers in the study area discovered that trees on farm lands bear more fruits than those in the bush due to the organic matter and animal addition to soil emanating from crop residues and animal dropping. This suggests that all the components agroforestry benefit mutually from one another.

5.6 Farmers Coping Strategies to the Challenges of Agroforestry

This section assesses the various challenges involved in agroforestry practices and how farmers are dealing with such challenges in the KNWD. Tree planting on agricultural land scape comes with its attendant challenges which impede successful agroforestry practice.

First of all, the study brought to the fore, the challenge of scarcity of water for watering of trees especially during the dry season. Overwhelming majority (97%) of farmers practicing agroforestry stated that erratic and inadequate rainfall have affected the availability for water in the communities, water sources such as small dams were drying up. As result, it is very difficult for trees to survive in the area. Hence some farmers decided to dig wells while others cover long distances with gallons and donkey carts fetch water from ponds, streams and dugouts for watering the trees, the study discovered these as the coping mechanisms to deal with the challenge.

Free animal grazing was also one of the serious threats to successful tree planting on in study district. This situation becomes most serious during the dry season when animal are roaming freely and grazing on anything they find on farm lands, thereby destroying young trees and seedlings bringing the effort of the farmer to naught. Likewise, bushfires also threatened security of trees both planted and naturally occurring ones as trees are consumed by the unbearable flames of bush fire that is usually fueled by strong winds in the dry season. These challenges reduce survival rate, work against the interest of farmers practicing AF and kills the interest of those who want to adopt it. It is clear that free animal grazing and bushfires are very detrimental and inimical to tree growing in the district.

Following the determination of farmers to succeed in agroforestry, some of the farmers have taken steps not only to fence the trees but also to construct fire belt to reduce and if possible eliminate the effect of these factors on the survival, growth and development of trees. Some farmers resorted to replacing the seedlings that have been destroyed by fire and free grazing. Additionally, respondents reported that they have to visit the farm daily to watch and tend the trees. These indeed demonstrate and confirm the determination of farmers who make successful agroforestry a possibility, but this is only applicable to those who endured.

Another challenge of agroforestry concerns inadequate access to seedlings and knowledge for tree management. Study respondents argued that it is not easy to have access to the needed seedlings because one has to buy the seedlings since some of the farmers do have knowledge on how to develop personal nurseries, inherently; finance is one of the challenges of agroforestry. Farmers also complained that they do not have adequate knowledge to manage the situation where seedlings die off. Nonetheless, the study found out that farmers were using bones and flour as coping mechanism to be able to deal with issues of termites attack on the seedlings because, bones and flour normally attract ants which can drive the termites away.

The study also found out during FGD with women that land tenure arrangements limit greatly the involvement of women in agroforestry practices and for that matter women cannot derive maximum benefits from agroforestry practice. That is why women are just a small fraction of the study respondent, only 29% of respondents were females.

CHAPTER SIX

SUMMARY AND CONCLUSION

6.1 Introduction

This is the final chapter which provides brief overview of the study, highlighting the summary of major findings, conclusions as well as some recommendations. The main objective of the study was to assess the use of agroforestry by farming communities as an adaptation strategy to climate change in the Kassena Nankana West District. Specifically, the study: (1) explored farmers' knowledge on climate change, (2) investigated the various measures involved in agroforestry practices, (3) ascertained farmers' perspective on agroforestry as an adaptation to climate change, (4) assessed various challenges of agroforestry in the Kassena Nankana West District. The study used the case study approach to interact with farmers in order to assess their knowledge on pertinent issues regarding climate change and agroforestry.

6.2 Summary of Findings

6.2.1 Major Findings on Objective One: Farmers' Knowledge of Climate Change in the Kassena Nankana West District

This study revealed that experience is an important source of knowledge for the farmers in the study communities. Farmers relied on their own experiences acquired through careful observations and interactions among peers and realized that climate variables explored in this study have changed over time; supporting the position that climate has indeed changed.

It was revealed that apart from rainfall which farmers said was reducing, temperature, wind and sunshine were all rising. Reduction in rainfall and increment in the other three variables have detrimental impact such as drought, wind and water erosion, floods, and consequently, poor soil fertility as noted by farmers. These impacts have manifested in poor germination of seeds, stunted growth and wilting of crops, crop failure, difficulty in harvesting some crops and survival of tree seedlings, breaking down of crops and trees. Farmers are vulnerable to these impacts because their activities depended heavily on the behavior of the climate variables especially rainfall. The respondents blamed the change in climate on the continuous felling of trees for various purposes including charcoal production.

6.2.2 Major Findings on Objective Two: Agroforestry Practices in the Kassena Nankana West District

The study further revealed that farmers in the district have adopted five agroforestry practices namely; scattered trees (parklands), home gardens, plantation and crop combination, trees on farm lands and farm woodlot, the scattered trees is the dominant one while farm woodlot is the least. Apart from scattered trees which are naturally occurring trees, home garden is the most successful agroforestry practice with regards to the planted species. Farmers combine crops such as millet, maize, rice, groundnuts, beans and vegetables with the trees species such as mango, whitethorn, cashew, dawadawa, shea and baobab. Farmers strongly argued that agroforestry practice leads to improved food crop productions.

In terms of food crop production, farmers discovered that whitethorn is the most suitable agroforestry tree because of its unique features which include the fact that it shed its

leaves in the raining season and also its incomparable production role. Tree management activities include watering, weeding, application of manure/fertilizer, construction of fire belt, fencing, mulching and the use of bones/flour. In addition, pruning, lopping, crop spacing and cultivation of shade tolerant crops were viewed as tree and crop management activities in the study communities. These management activities are beneficial to all the three components of agroforestry- woody perennials, herbaceous species and the animals. It is the farmer who is facilitating the process of energy flow on the farm to the various components of agroforestry. For instance, the farmer carries fodder and crop residues from the trees and the crops to the animal, animals' droppings are conveyed back to the farm to fertilize both crops and trees.

An interesting finding in this study has to do with the source of material for tree fencing in the communities. Some farmers were cutting young trees to be able to fence the planted ones, meaning killing trees to protect trees. However, they argued that those species were undesirable ones such short thorny species and shrubs. This suggests clearly that farmers will only take conscious steps to protect desirable tree species by destroying the ones that are not preferred.

6.2.3 Major Findings on Objective Three: Farmers' Perspective on Agroforestry as an Adaptation to Climate Change

All farmers interviewed in this study reported that successful agroforestry practice is a good adaptation strategy to the negative consequences of the changes in climatic conditions in diverse ways. First of all, trees are more resistant and resilient to drought; hence the farmer is able to access fodder and fruits as well as income during drought years. Secondly, in flood years, trees reduce the effect of floods on the crops and the land

through reduction in runoff and more importantly soil erosion. Thirdly, trees on farmland reduce the effect of wind storms on farms by providing a cover and also serve as wind break which protect crops and prevent soil erosion. The leaves of trees fall on farm lands and add organic matter to the soil which is translated into good crop production and contribute appreciably in reducing food insecurity and in the long run poverty levels of farming communities.

6.2.4 Major Findings on Objective Four: Farmers Coping Strategies to the Challenges in Agroforestry

Agroforestry practice in the study communities has never been without challenges. In fact, the practice is faced with myriad of challenges that have the potency of hindering successful agroforestry activities in the district. To begin with, rainfall is arguably the main driving force of agricultural development. This study found out that inadequate rainfall in the study area is adversely affecting tree survival because the raining season is becoming shorter overtime; hence water requirement for tree survival is not met, most especially in the dry season.

Farmers coping strategies in dealing this challenge include digging of wells for watering the trees during the dry season, some respondents also travel long distances to fetch water from available water bodies. Free animal grazing was equally a setback for farmers to deal with in order to achieve success in agroforestry practices. Farmers explained that where animals are roaming freely trees cannot be left unprotected and hence the need for farmers to come out with prudent strategies that are less costly to overcome the situation. In the same vein, perennial bushfires in the communities constitute another source of

worry for farmers because bushfires can render farmers investments a waste. As a result, farmers who could not fence trees and construct fire belts to protect the trees from these destructive forces are no longer in business as far as agroforestry practice is concerned.

Moreover, the study noted that inadequate access to seedlings and knowledge for management is yet another factor confronting agroforestry practice. Farmers indicated that they have to buy the seedlings and it is not easy to be able to do so. Quite apart from that, some of the farmers do not benefit from training that will enable to have access to knowledge on proper tree management techniques to enhance their practice.

Lastly, women farmers do not have direct access and ownership of land resources to encourage direct involvement in agroforestry practices. This stems from the unfavourable traditional land ownership arrangements that deny women farmer equal opportunity to own land as their male counterpart. However, in Nakong some arrangement is currently on-going that permit groups comprising male and female to access and own land directly from landlords for the purpose of agroforestry practices.

6.3 Conclusions

6.3.1 Conclusions on Objective One

Farmers have demonstrated that they are closely monitoring their activities and can notice changes in climatic conditions. This shows that farmers are actively engaged in experiential learning, which involves learning by doing. Climate change is affecting agricultural activities in the study district negatively. Its impacts include drought, floods, erratic rainfall, wind storms, emergence of pests and disease and soil infertility in the KNWD. These impacts have manifested in poor germination of crops, wilting of crops,

crop failure, and ultimately low crop production. Clearly, agriculture is facing the brunt of climate change because it is sensitive to changes in climate.

6.3.2 Conclusions on Objective Two

Farmers in the study area have adopted five agroforestry practices, namely; scattered trees (parklands), home gardens, woodlot, trees on farmlands and plantation and crop combination. Tree management practices include but not limited to watering, weeding, fencing and construction of fire belts which enhance tree survival and growth. Tree management practices propelled trees on agricultural fields to bear more fruits than those in the wild. Moreover, lopping, pruning, spacing trees and crops as well as cultivation of shade loving crops are the effective tree and crop management practices in the study site.

6.3.3 Conclusions on Objective Three

To a large extent, agroforestry is indeed a viable adaptation strategy to climate change since it strengthens farmers' ability to adapt to the impacts of climate change in the study district. It is evident from the findings that agroforestry makes it feasible for farmers to have access to food, fruits, fodder and herbal medicine. Trees on agricultural land scape increase soil nutrients and improve the productive capacity of the land. The study concludes that home garden is the most successful agroforestry practice in the study area in terms of intentional planting of trees, but it is much easier to retain naturally occurring trees.

6.3.4 Conclusions on Objective Four

The study concludes that agroforestry practice in the District is a challenging task as farmers grapple with bushfires, free grazing and inadequate water for watering the trees.

However, farmers have accumulated knowledge on agroforestry practices which depends largely on their long years of experience in farming, making it possible for farmers to deal with the challenges in AF practices. Adoption of effective tree management practices make it possible for farmers to cope with the challenges of agroforestry.

By and large, climate change impacts captured in the conceptual frame (Ozor et al., 2012) also reflects the situation in the study area. Also, to some extent this study found most of the agricultural adaptation strategies to climate change in the conceptual framework (Ozor et al., 2012) with exception of rouging, using of weather forecast technology, using pests and disease resistant crops, green manuring, controlled grazing, construction of rocks molls and barriers against ocean surges and climate change education across all levels as well as biotechnology and nanotechnology application. It means that some of the adaptation strategies in the conceptual framework do not fit local situation of the study area.

However, the current study also uncovered certain climate change impacts and agricultural adaptation strategies that are not captured in the conceptual framework. These include poor seed germination, difficulty in harvesting crops, and difficulty in tree survival, the use of bone/flour and cow dung/neem extract among others.

6.4 Recommendations

6.4.1 Recommendations on Objective One

Agricultural Extension Agents should not just view farmers as users of knowledge but also a source of indigenous knowledge on climate change and its attendant impacts on agriculture. Farmers' indigenous knowledge should be the foundation upon which scientific knowledge can be introduce to farmers and fused with it for a potent solution to

climate change. Therefore, Agricultural Extension Agents should create a good platform for interactions and experience sharing on the way forward with respect to climate change adaptation in the District.

6.4.2 Recommendations on Objective Two

MOFA should profile agroforestry farmers, and assist them with fencing materials and small dams to promote agroforestry practices in the district. In addition, non-agroforestry farmers should be sensitized on the importance of agroforestry in climate change adaptation. This way, agroforestry adoption in the KWND will increase considerably.

6.4.3 Recommendations on Objective Three

Farmers should be encouraged to retain more trees on their crop lands, especially, those cultivating new farms. In addition, landowners should make trees planting a requirement for farmers who want land for farming purposes instead of receiving farm produce from farmers (tenants) at the end of the farming season.

6.4.4 Recommendations on Objective Four

Traditional Authorities should take a second look at land tenure arrangements to ensure that female farmers have more access to land and can own it. By so doing, women participation in AF will increase which could decrease poverty levels among women. Farmers along valleys and water bodies should be encouraged to plant trees since survival rate is comparative high when trees are planted along the valleys.

This study recommends that MOFA should continue to support farmers to be able to identify low cost agricultural adaptation strategies to climate change in KNWD.

Strategies that are more environmentally friendly should be encouraged so that agricultural adaptation will engender sustainable development.

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APPENDICES

Appendix A

Research Questionnaire

UNIVERSITY FOR DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES

MPHIL: ENVIRONMENT AND RESOURCE MANAGEMENT

RESEARCH TOPIC: *AGROFORESTRY AS AN ADDAPTATION STRATEGY TO CLIMATE CHANGE IN THE KASSENA NANKANA WEST DISTRICT, UPPER EAST REGION, GHANA*

Name of community……..……

Name of interviewee ……..……..

Questionnaire number …….

A. Personal information

1. Sex: a. Male ( ) b. Female ( )
2. Age: a. 40-49 ( ) b. 50-59 ( ) c. 60- 69 ( ) d. 70-79 ( ) e. 80+ ( )
3. Level of education: a. No education ( ) b. Primary ( ) c. J.H.S ( ) d. S.H.S ( ) e. Vocation ( ) f. Tertiary ( )
4. Religion: a. Christian ( ) b. Islamic ( ) c. Traditional [ ] others (specify)…….

5. What is your main occupation? A. Farming ( ) b. Public/Civil servant ( ) Trading ( ) Artisan ( ) Other (specify)……

6. Marital status: a. Never Married [ ] b. Married [ ] c. Devoice [ ] d. Widower [ ] e. Widow [ ]

B. Farmers understanding of climate change in the Kassena Nankana West District

1. Which of these changes did you observe in rainfall in the last 30 years? a**.** Increasing [ ] (b) reducing [ ] c. no change [ ]

3 Indicate the starting and ending months of rainfall for the farming season. a. April- November [ ] b. May – October [ ] c. June- September/October [ ] d. July- September/October [ ]

4 How often do you receive rain in this community during the raining season? A. every 3days [ ] b. weekly [ ] c. every 2weeks [ ] d. every 3weeks [ ] e. once a month [ ] f. others (specify) ……..

5 How does change in rainfall affect your agricultural activities within the last 30 years? A. crop failure [ ] b. low survival of trees [ ] c. low crop yield [ ] d. difficult to harvest crops [ ] e. wilting crops [ ] f. others (specify)……..

6 What changes occurred in temperature 30 years ago? (a) rising [ ] (b) decreasing [ ] c. no changes [ ]

7. How does changes in temperature impact crop farming? A. crops don't germinate well [ ] b. crops germinate well [ ] c. wilting of crops [ ] d. low crop yield [ ] e. no effect [ ]
8. How do changes in wind affect livelihood activities? A. affects crop yield [ ] b. breaks crops/trees [ ] c. affect fruiting process negatively [ ] d. cause soil erosion [ ]
9. Which of the following climate change impacts did your household experience in the last 30 years?

   A. wind storms [ ] b. drought [ ] c. floods [ ] d. loss of soil fertility [ ]

   e. incidence of pest and diseases [ ] f. erratic rainfall [ ] 1, 2, 3, 4, 5

   Mark all that apply

10. How did you receive information regarding the changes in climate?

    a. Personal experience [ ] b. MoFA [ ] c. NGOs/CSOs [ ]

11. In your opinion, what causes the changes in climate over the past 30 years? a. Cutting down of trees [ ] b. Charcoal/bush burning [ ] c. The act of God [ ] d. use heavy farm implements [ ] e. don't know [ ] f. others (specify) …….

C. Agroforestry practices in the Kassena Nankana West District

1. Idicate whether your trees are (a) naturally occurring ones [ ] (b) planted ones [ ] (c) both [ ]
2. Which of the following agroforestry technology(s) do you practice? A. Home garden ( ) b. Woodlot establishment ( ) c. trees on farm lands ( ) d. scattered trees

on crop lands ( ) e. plantation/ crop combination ( ) f. other (specify) ……

3. Which of the following tree management activities are most important in the initial stages trees growing? A. Watering [ ] b. weeding [ ] c. fire belt [ ] d. Fencing [ ] e. manuring [ ] f. use bones/flour [ ] g. mulching [ ] h. others ……
4. How do you get material for fencing your trees? a. barbed wire [ ] b. tree branches [ ] c. cut young trees [ ] others ……
5. Mention the crops you grow together with the trees a. Maize [ ] b. Millet c. Rice [ ] d. Groundnuts [ ] e. Beans [ ] f. vegetables [ ] others …….
6. How do you manage the trees and the crops to ensure good yield? A. pruning [ ] b. space crops and trees [ ] c. lopping [ ] d. plant shade tolerant crops [ ] e. others ……..
7. Which of the following tree species are most suitable for this area/community? A. eucalyptus [ ] b. mango [ ] c. dawadawa [ ] d. neem [ ] e. acacia f. shea [ ] g. cashew [ ] h. others
8. Which of the following is the dominant animal species in your household? a. Goat[ ] b. Sheep [ ] c. Cattle [ ] d. Pigs [ ] e. donkeys [ ] f. others
9. How do you feed your animals? a. Fodder & free grazing [ ] b. free grazing & crop residue [ ] c. Buy feed, fodder & free grazing [ ] d. crop residue, fodder & free grazing [ ] e. free grazing [ ]

10. Which of the following benefits do you enjoy from agroforestry? [**Rank your answers, 1=most important, 2=important, 3= least important]** a. cash ( ) b. fodder ( ) c. medicine ( ) d. shade ( ) e. fuel wood [ ] f. constructional material [

D. Agricultural adaptation strategies to climate change in the district

1. Have you done something to reduce the impacts of a changing climate? Yes [ ] No [ ].
2. Due to climate change, do you plant your crops (a) late [ ] (b) early [ ] c. no change [ ]
3. Have you changed the type of crops you plant in the last 30 years? Yes [ ] No [ ]
4. Do you plant improved varieties? Yes [ ] No [ ]
5. How do you deal with low crop yield? a. Reduce the number of daily feeding [ ] b. Buy more food [ ] c. Borrow from neighbours [ ] d. reduce quantity of food [ ] others ……
6. What measures have you taken to reduce the impacts of climate change on your household? A. practice mixed cropping [ ] B. sells firewood [ ] C. dry season gardening [ ] D. protects naturally occurring trees [ ] E. hunting/fishing [ ]

   F. others ……

E. Farmers perspective of agroforestry as an adaptation strategy to climate change

1. Do you think agroforestry can help you to adapt to the impacts of climate change? Yes [ ] No [ ].

2. If yes, which of these adaptations do you practice a) autonomous adaptation (farm level adaptation) [ ] b) planned adaptation (adaptation due to government intervention) [ ]
3. How did agroforestry help your household to adapt to the impacts of climate change?
   A. Vibrant [ ] B. good [ ] C. highly satisfactory[ ] D. satisfactory [ ] E. unsatisfactory [ ]

Impacts and how agroforestry help farmers to adapt
Drought- trees are more resistant to drought [ ] increase soil moisture [ ] moderate microclimate [ ] access to fodder [ ] others specify……
Floods- reduce runoff [ ] reduce erosion [ ] others (specify) ……
Wind storms- protect crops [ ] protect houses [ ] reduce erosion [ ] Others ……
Food insecurity- increase yield [ ] increase access to income [ ] source of food [ ] Others ……
Soil infertility- improve soil nutrients [ ] soil cover [ ] improve biodiversity [ ] Others ……..
Others (specify)

F. Farmers coping strategies to the challenges of agroforestry

1. What challenges hinder agroforestry practices in your community? **(rank them in order of seriousness, 1=not serious, 2= serious, 3= very serious) [tick all that apply]**

   a. Scarcity of water [ ] b. Free grazing [ ] c. Difficulty in tree survival [ ] d. bushfires [ ] e. trees time take to mature [ ] f. lack of knowledge for tree management [ ] g. lack of access to seedlings [ ] h. lack of access to land [ ] i. others ……..

2. How do challenges mentioned above affect the success of agroforestry practices in this district? a. seedlings die off [ ] b. burning of trees [ ] c. animals destroy trees [ ] d. time consuming [ ] e. reduces number of trees [ ] others (specify)

3. How do you deal with the challenges you have encountered as an agroforestry farmer? A. use hand dug wells [ ] b. fence trees [ ] c. visit farm daily [ ] d. replacement [ ] e. construct fire belt [ ] f. cover long distance to get water [ ] g. use bones/flour [ ]

4. In your opinion, how can government/development partners help in overcoming such challenges to ensure successful agroforestry practices? A. provide small dams [ ] b. provide fencing materials [ ] c. provide extension services [ ] d. train farmers' group leaders [ ] e. others ……

Appendix B

GUIDE FOR FOCUS GROUP DISCUSSIONS

A. Farmers understanding of climate change

1. What changes did you observe in rainfall in this community within the past three decades?
2. How do changes in rainfall affected farming activities in this area?
3. What changes occurred in temperature in the last 30 years?
4. How does changes in temperature impact agricultural activities in this community?
5. How do changes in wind affect livelihood activities of your household?
6. Mention other climate change impacts you have noticed in the last 30 years.
7. Please, explain how the impacts mentioned in (question 6) affect agricultural activities in this district.
8. In your opinion, what are the causes of climate change?

B. Agroforestry practices in the Kassena Nankana West District

1. Kindly explain in detail how farmers practice agroforestry in this community?
2. Which tree species grow well in this community? Where do you obtain the seedlings?
3. How do you manage the trees and the crops in this community?
4. What are the fencing materials for fencing the trees?
5. How does agroforestry benefit your household?
6. Please mention shade tolerant crops in this area.

C. Farmers perspectives on agroforestry as an strategy to climate change

1. How does agroforestry help farmers to adapt to the following (a) wind storms (b) soil infertility (c) drought (d) floods (e) food insecurity
2. Please mention and explain other roles of agroforestry in climate change adaptation

D. Farmers coping strategies to challenges of agroforestry

1. State and explain the challenges farmers face in agroforestry practices in this area.
2. How do the challenges mentioned in question (1) affect the success of agroforestry practice?
3. How do farmers deal with these challenges?
4. How can government help in addressing these challenges in order to promote agroforestry practice?

E. Agricultural adaptation to climate change

1. Please, mention the agricultural adaptation practices in this area.
2. Kindly explain how agricultural adaptation practices mention in question1 can reduce the impacts of climate change on your household.
3. Have you changed the type of crops you plant in the last 30 years? Why?