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THE ROLE OF LOCAL INSTITUTIONS IN FARMERS' HOUSEHOLDS' ADAPTATION TO CLIMATE CHANGE AND VARIABILITY: A CASE STUDY OF BONGO DISTRICT, GHANA

Thesis N°……

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DEDICATION

To the Living God Almighty who guided in my entire life, my academic course till this level and particularly for this course: all glory.

To My mother AMAYI Balamwe, my sister LANKE Yawa Kekeli, my uncle AMAYI Mesmein, aunties AMAYI Yvonne and AMAYI Veronique.

Thank you for inspiring me always to look higher. May the Lord reward you!

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TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

AC:	Area Council
ACDEP:	Association of Church Development Project
ADRA:	Adventist Development and Relief Agency
CBO:	Community Based Organization
CFC:	Canadian Feed the Children
CRS:	Catholic Relief Services
DA:	District Assembly
EDIF:	Export Development Investment Fund
FHH:	Farmers' Household
FBO:	Faith Based Organization
FBO:	Farmers Based Organization
GSOP:	Ghana Social Opportunities Project
GSS:	Ghana Statistical Service
ICOUR:	Irrigation Company of Upper Region
IPCC:	Intergovernmental Panel on Climate Change
IPM:	Institution Perception Mapping
LEAP:	Livelihood Empowerment Against Poverty
LI:	Local Institution
MEO:	Monitoring and Evaluation Officer
MoFA:	Ministry of Food and Agriculture
NABOCADO:	Navrongo-Bolgatanga Catholic Agricultural Development Office
NADMO:	National Disaster Management Organization
NAPA:	National Adaptation Plan for Action
NBSSI	National Board for Small Scale Industries
NGO:	Non Government Organization
NRGP:	Northern Rural Growth Program
RESULT:	Resilient and Sustainable Livelihoods' Transformation project
SARI:	Savannah Agricultural Research Institute
SNA	Social Network Analysis
SSA:	Sub-Saharan Africa
TC:	Traditional Council
UC:	Unit committee
UDS	University of Development Studies
UER:	Upper East Region
UNDP:	United Nation Development Program
WASCAL:	West African Science Service Center on Climate Change and Adapted Land Use
WFP:	World Food Program

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Low rainfalls are already a challenge for crop production in Bongo district, UER, Ghana. But these last decades, the area experienced a decrease in rainfall, and an increase in temperature associated with frequent droughts and storms. These new changes, attributed to climate change leave severe negative impacts on farmers' households as they lead to crop failure and death of livestock. However, there are formal and informal institutions, including public, civic and private, intervening in various domains of rural life of farmers' households in the area. This study assessed the role of local institutions in farmers' households' adaptation to climate change and variability. Primary data were obtained through combination of household survey, key informant interview with local institutions, focus group discussions and role playing games in 12 communities in Bongo district while secondary data were gathered from published and non-published papers. Results showed that local institutions facilitate farmers' households' adaptation by mediating external interventions, by shaping risk and vulnerability associated with drought and by offering them a framework of adaptation options through their supports. However, this study revealed that local institutions are more involved in knowledge and on farm management while farm financial management, investment in infrastructure and diversification (on farm and off farm) are less addressed. Therefore, building local institutions capacity in enabling diversification, farm financial management and investment in infrastructure could amplify their role in enhancing farmers' households' adaptation to future changes in the climate.

Key words: Adaptation, Climate change, Farmers' households, Local institutions

RESUME

Les faibles pluies sont déjà un défi pour la production agricole dans la préfecture de Bongo, UER, Ghana. Mais ces dernières décennies, la préfecture a expérimentée une réduction des pluies, et une augmentation de la température associe à de fréquentes sècheresses et vents violent. Ces nouveaux changements attribués aux changements climatiques laissent de sévères négatives conséquences sur les ménages agricoles à travers la perte des cultures et la mort du bétail. Néanmoins, il y a des institutions formelles et informelles comprenant le publique, le privé et le civique, intervenant dans plusieurs domaines de la vie rural des ménages agricoles a Bongo. Pour cette raison, ce mémoire a évalué le rôle des institutions locales dans l'adaptation des ménages agricoles aux changements et variabilités climatiques. Les données primaires ont été obtenues à travers une combinaison d'enquêtes, d'interview de personnes ressources au niveau des institutions, des 'focus group discussion' et des 'jeu de rôles' dans 12 communautés tandis que les données secondaires sont obtenues grâce à une revue des documents publiés ou non. Les résultats ont montré que les institutions locales facilitent l' adaptation des ménages agricoles en arbitrant les interventions extérieures, en façonnant les risques associer a la sécheresse et en offrant un cadre d'options pour l'adaptation a travers leur soutien. Néanmoins cette étude a révélée que les institutions locales interviennent plus dans la gestion des connaissances ou savoirs et dans la gestion agricole interne pendant que la gestion des finances agricole, l' investissement dans les infra structures et la diversification (au niveau et au-delà du champ) sont peu considéré. Ainsi, le développement des capacités des institutions locales à permettre la diversification, la gestion des finances agricole et l'investissement dans les infrastructures, amplifiera leur rôle dans l'accroissement de l'adaptation des ménages agricoles aux changements climatiques future.

Mots clés : Adaptation, Changement climatique, Ménage agricole, Institution locale

CHAPTER ONE: INTRODUCTION

This chapter presents the research problem of this study, the research questions and objectives assigned and the hypotheses that underpin the overall research.

1.1 Problem Statement

In this 21st century, one of the greatest threats to humankind is posed by the negative impacts of climate change and variability (IPCC, 2007). These negative impacts have been observed already in Africa where they are associated directly with climate dependent activities (such as agriculture) and indirectly with social systems (poverty, conflict, education and health) (Orindi and Murray, 2005).

Africa is reported to be the most vulnerable region to climate change and variability because of its heavy dependence on rain-fed agriculture and its low adaptive capacity due to extreme poverty, poor infrastructure and insufficient safety nets (Boko et al., 2007). In addition, reports indicate that Africa is one of the regions that will be the hardest hit by the impacts of climate change (IPCC, 2007). Furthermore, recent studies have shown a decline in precipitations over West Africa since 1960s, ranging from 20-40% between the period of 1960to1990 (IPCC, 2007; Sissoko et al., 2010). Meanwhile, an increase in temperature has been observed since the 1970s, ranging between 0.2 °C and 0.8 °C (Sarr, 2011).

Based on climate-crop modeling studies, agriculture is the sector that will be disproportionately affected due to its rain-fed character in Africa (Lobell et al., 2008; Ericksen et al., 2011; Thornton et al., 2011). Several authors have demonstrated that climate change is very likely to lead to a reduction in yields of major cereal crops in Sub-Saharan Africa (SSA), (Lobell et al., 2008; Liu et al., 2008; Walker and Schulze, 2008; Thornton et al., 2009a; Lobell et al., 2011; Roudier et al., 2011). In addition, the Intergovernmental Panel on Climate Change (IPCC) estimates that climate change in SSA will reduce crop yields by 8% by 2050 (Porter et al., 2014) whereas the reduction in rain-fed cropland yield is expected to be as high as 50% by 2020 (Nakooda et al., 2011).

Ghana, like countries in West Africa, has been already experiencing considerable variations in temperature and rainfall patterns since 1960s (EPA, 2007; World Bank, 2010a) as well as sea level rise (World Bank, 2010a) associated with increase in some extreme events' incidence especially droughts, floods and bush fires (Boko et al., 2007; Christensen et

al., 2007). In addition, Owusu et al. (2008) reported that there has been a shift in the rainfall regime in Ghana towards a longer dry season and vanishing short dry spell. Meanwhile, the temperature has increased by 1°C across the country representing an average increase of 0.21°C per decade (Agyeman-Bonsu et al., 2008).Furthermore, based on climate change scenarios IPCC predicted that Ghana is likely to experience greater rainfall variability and higher temperatures in the future (Rademacher- Schulz and Mahama, 2012:107). An increase in temperature averaging 0.25 °C is expected from 2010 to 2020 while rain fall is projected to decrease in most of agro-ecological zones (including Guinea and Sudan Savannah zone).Likewise, an increase in the rain forest zone is projected (Rademacher- Schulz and Mahama, 2012). As a result, Ghana will be highly challenged by climate change and climate variability because of its reliance on rain fed agriculture sector, the backbone of its economy (i.e., contributes to about 44% of the country GDP and employs about 57% of the population). Since agriculture is directly affected by climate change, adaptation strategies are becoming increasingly adopted to promote development in SSA (Clement et al., 2011).

Although climate change is a global challenge, its impacts are localized and are more severe for those who depend solely on natural resources for their livelihoods. Thus, actions against climate change impacts are required at the local level (IPCC, 2007; Khatri et al., 2013:14).

For generations, rural communities have used a variety of coping strategies to respond to environmental stresses (Berman et al., 2012). However, several studies argue that many future climatic changes are beyond the past experiences of rural communities (Parry, 2009; Adger et al., 2003). Hence, these local strategies would not be sufficient in dealing with medium to long-term impacts of climate change. However, Agrawal (2008) showed how institutions have affected rural residents' response to environmental challenges in the past. According to Agrawal (2008), local institutions remain the key actors that structure risks and people' sensitivity to climate hazards, facilitate individual and collective responses and shape the outcomes of such responses. Hassan and Nhemachena (2008) found that support to local farmers' coping strategies through appropriate public policy and investment, and collective actions can help increase the adoption of adaptation measures that will reduce the negative consequences of predicted changes in future climate, with great benefits to vulnerable farming communities.

Local institutions are claimed to be important in facilitating adaptation to climate change at local level as well as managing and implementing locally driven adaptation initiatives, creating opportunities for collective learning and by mediating interventions

suitable to the local context (Adger, 2000; Agrawal, 2008; Rodima-Taylor et al., 2011; Amaru and Chhetri, 2013). However, few studies have carefully analyzed the relevant local institutions that intervene in climate change adaptation in the region, how they contribute to farmers' households' adaptation to climate change in the area and shape their decision making to avoid further land degradation process. Most of the previous studies, however, have focused on the livelihood adaptation strategies of farmers to climate change and variability (Antwi-Agyei, 2012; Antwi-Boasiako, 2012; Etwire, 2012). Thus, this study explores the role of local institutions in adaptation to climate change in Upper East Region.

1.2 Research Questions

The following are four research questions of this study:

1. What are the relevant local institutions intervening in climate change adaptation in Bongo district?
2. Do farmers' households have access to local institutions?
3. What supports have farmers' households received from local institutions regarding adaptation to climate change?
4. Do local institutions and local farmers' households share the same perceptions on coping strategies relating to climate change?

1.3 Research Objectives

Overall objective

The overall objective of this study is to assess the diverse roles of local institutions in enhancing farmers' households' long-term adaptation to climate change and variability in Bongo District, Ghana.

Specific objectives

More specifically, the study attempts to:

- Identify relevant local institutions in the dry land systems that are instrumental in enhancing farmers' households' adaptation to climate change and variability.
- Assess farmers' households' access to local institutions.
- Examine support provided by local institutions regarding the adaptation of farmers' households to climate change and variability.

- Determine if local institutions share similar perceptions with local farmers' households on ways to cope with and adapt to climate change and variability.

1.4 Research Hypotheses

The underpinning hypotheses of this study are:

- Farmers' households (FHHs) have access to local institutions working in the area.
- The enhancement of farmers' households' adaptation to climate change depends on their access to local institution.
- Local institutions in Bongo are more reactive than anticipative.
- Local institutions and local farmers' households share the same perception on coping strategies to climate change and variability.

1.5 Organization of the Study

This work is organized in five different chapters. This introductory chapter covers the problem statement, the research questions, the research objectives, research hypotheses and the scope of the study.

The second chapter is the literature review. It presents climate change and variability in SSA, the related vulnerability and the implication for food and livelihood security, climate change adaptation, the role of local institutions in climate change adaptation and the concept of social learning and its importance in climate change adaptation.

The third chapter presents the methodology, including the localization of the study area, materials and methods employed in data collection and analysis. While the fourth chapter presents the results and discussion pertaining to the research questions, the fifth one concludes the study and suggests policy recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews some pertinent literatures on Sub-Saharan Africa's (SSA) vulnerability to climate change and its associated impacts. It addresses the adaptation to climate change and the role of local institutions in climate change adaptation as well as social learning and its importance in adaptation to climate change.

2.2 Climate Change and Variability in Sub-Saharan Africa

Like most parts of the African, SSA is acknowledged to be the most vulnerable to the adverse impacts of climate change and variability (Boko et al., 2007; Lobell et al., 2011). Its vulnerability is caused by its low adaptive capacity and its over-dependence on rain-fed agriculture (Boko et al., 2007).

A decline in annual precipitation has been observed, particularly in the Sahel (Nicholson et al., 2000; Hulme et al., 2001; Nicholson, 2001); increase in temperature in Africa has become greater since the 1960 with a decadal warming rate of 0.29 º C (Boko et al., 2007). An increased incidence of extreme weather events across Africa, particularly in SSA, happens as a result of changes in the climate (seasonal and annual rainfall variability).

Future projections are showing an average increase of temperature between 3 º C and 4 º C for Africa by 2080–2099, based on the 1980–1999 period, under medium-high IPCC emission scenarios, using the 20 General Circulation Models (Christensen et al., 2007).

2.3 Vulnerability of Sub-Saharan African Farming System to Climate Change and its implication for Food and Livelihood Security

Agriculture is the main industry in SSA and employs 60 % to 90 % of the total labor force (Thornton et al., 2006). It accounts for about 1/3 of its gross domestic product (World Bank, 2008).

In some SSA countries, 90% of the production is essentially held by smallholder farmers (80% of farming populations) (Wiggins, 2009; Wiggins and Sharada, 2013). Climate change particularly threatens the livelihoods and food security of these small-scale farmers (Malo et al., 2012). This threat is explained by the heavy reliance of agricultural production of most of the SSA countries on rainfall (90 %) with only 0.6 % irrigated (AGRA, 2014). Farming system vulnerability in SSA is partly due to low investment in agriculture sectors in

SSA (5-7 % on average) and low adoption of key production technologies that enhance adaptation to climatic change and increase productivity (Evenson, 2000; RESAKSS, 2010). As an example, Evenson (2000) found that area planted with improved crop varieties in 1998 in SSA was only 27 %, compared to 82 % in Asia, 52 % in Latin America and Caribbean countries, and 58 % in North Africa and Near East.

Climate change will either decrease the area of crop land suitable for agricultural production (Arnell, 2009) or reduce the length of growing period, impacting food availability (Thornton et al., 2011). Therefore, devastating effects on the livelihoods of many croppers and livestock keepers in SSA is probable (Thornton et al., 2011), especially where rain-fed agriculture contributes about 30 % of GDP (Sarris and Morrison, 2010) as a result of changes in the climate.

According to projection, many African countries are expected to face 50 % reductions in crop yield by 2020 with an estimated 90 % reduction in crop net revenue by 2100 (Boko et al., 2007). Therefore, SSA is at risk of food and livelihood insecurity. The region's small-scale farmers and pastoralists need adaptation in order to increase their productivity under changes brought by climate change and variability (FAO, 2014).

2.4 Climate Change Adaptation

According to Atkinson et al (2007), climate change adaptation has received comparatively less attention compared to mitigation, although both of them are equally important. Much of the research on adaptation to climate change focuses on understanding the concept of adaptation rather than looking at other aspects of adaptation (Aakre and Rubbelke, 2010).

2.4.1 Types of Climate Change Adaptation

Depending on its timing, the goal and motive of its implementation, adaptation can either be reactive or anticipatory, private or public, and planned or autonomous. It can also be short or long-term, localized or widespread (IPCC 2001).

Reactive or Anticipatory: While reactive adaptation takes place after the initial impacts of climate change have occurred, anticipatory adaptation takes place before impacts become apparent.

Private or Public: Adaptation is private when it is motivated by individual households and companies, while public adaption is of public interest (government).

Planned and Autonomous: Planned adaptation is the consequence of deliberate policy decision, based on the awareness that conditions have changed or are expected to change and that some form of action is required to maintain a desired state. Autonomous adaptation involves changes that systems will undergo in response to changing climate, irrespective of any policy, plan or decision.

Climate change adaptation action is undertaken both by public and private actors through policies, investment in infrastructure and technologies and behavioral change (Fankhauser et al., 2008). This paper addresses private versus public adaptation.

2.4.2 Climate Change Adaptation Options

In order to improve the response of farmers to climate change and variability and to support crop farming, the use of one or more of the available adaptation options which are in accord with the aspirations of the National Adaptation Programs of Action (NAPAs) and national documents is necessary (Sagoe, 2006; Howden et al., 2007; Harrington et al., 2008; Ngigi, 2009; Woodfine, 2009; Below et al., 2010; Adesina and Odekunle, 2011; World Bank, 2011b; Farauta et al., 2012).

Below et al. (2010) classified adaptation options based on a series of case studies (including data from more than 16 countries in Africa, the Americas, Europe, and Asia) on existing micro-level practices that could help small-scale farmers in Africa to adapt to climate change, such as 1) farm management and technology; 2) diversification on and beyond farm; 3) farm financial management; 4) government interventions in infrastructure, health, and risk reduction; and 5) knowledge management, network, and governance.

On the other hand, Rhodes et al. (2014) classified climate change adaptation options specific for farmers' households such as 1) usage of improved varieties tolerant to climate change stresses, 2) adjustment of planting date and cropping systems (Kra and Ofosu-Anim, 2010 and Waha et al., 2013), 3) crop residue management (Akponikpe et al., 2011; MacCarthy et al., 2009; Schlecht et al., 2006; Bationo and Buerkert, 2001; Bationo et al., 1996; Rhodes et al., 1996), 4) integrated soil fertility management (Mapfumo et al. 2013), 5) conservation agriculture and carbon sequestration (Ngigi, 2009), 6) agroforestry (Torquebiau, 2013; FAO, 2010), 7) biotechnology (Howden et al., 2007); and 8) the reducing post-harvest losses, improving marketing and value addition.

In the context of livelihoods, Agrawal (2008) classified coping and adaptation strategies into a set of five analytical types such as 1) mobility (it pools or avoids risks across space), 2) storage (pools/reduces risks experienced over time), 3) diversification of activity

(reduces risks across assets), 4) communal pooling (reduces risks experienced by different households), and 5) exchange.

2.4.3 Importance of Anticipative Governance in Climate Change Adaptation

According to Poli (2011), all attempts to understand, imagine, and benefit from the future can be seen as modes of anticipation, a constant feature of human behavior. The concept of anticipation has been used in various fields (philosophy, biology, psychology, physics, anthropology, resilience, futures planning) with different definitions. However, anticipatory governance is a new concept that has significant relevance for developing strategies under uncertain environmental futures, for its ability to involve changing short-term decision making to a longer-term policy vision, including the notion of foresight (Boyd et al., 2015). It is, therefore, important for managing events instead of waiting until a climate-related or regulatory/socio-economic event results in crisis (Boyd et al., 2015). This study considers the definition of anticipation adopted by future planners where this notion is well developed (Boyd et al., 2015). Hence, anticipatory governance is considered as ‘‘*a system of institutions, rules and norms that provide a way to use foresight for the purpose of reducing risk, and to increase capacity to respond to events at early rather than later stages of their development*’’ (Fuerth, 2009 as quoted in Boyd et al., 2015:151). Furthermore, the study takes into account the point of view of Nuttall (2010) who noted that anticipation may be a prerequisite for thinking about climate change adaptation (CCA).

2.4.4 Social Learning and Climate Change Adaptation

2.4.4.1 Importance of Social Learning in Climate Change Adaptation

The concept of social learning has been used across disciplines. It started evolving since the seminal work of Bandura and has been used in human resource and knowledge management areas and participatory planning and decisions making of natural resources areas.

Climate change is difficult to describe. It is characterized by the absence of solutions or solutions disputed or which could not be judged on it correctness, equity or optimality (Rittel and Webber, 1973), making it a wicked problem. In addition, climate change is characterized by the prevalence of uncertainty, both on itself and on the possible outputs of adaptation actions. Furthermore, climate change adaptation involves multiple stakeholders (Collins and Ison, 2009), making a successful adaptation function of the value alignment of multiple stakeholders at different scales (Adger et al., 2009).

To achieve a successful adaptation, flexible approaches that capitalize on experimentation with new ideas and focus on building people's adaptive capacity are required (Tompkins and Adger, 2004). Social learning has been suggested among various approaches that can help deal with the wicked nature of climate change (Tompkins and Adger, 2004; Pelling et al., 2008; Collins and Ison, 2009; Pelling, 2011) and also help actors develop shared understanding of the future and collective action based on mutual understanding (Pahl-Wostl, 2009). Therefore, social learning is of a great importance in climate change decision making and adaptation.

2.4.4.2 Social Learning Mechanism

Social learning process involves change in understanding, the scale at which the change takes place as well as the mode through which the leaning occurs (Reed et al, 2010). According to Reed et al (2010), for a process to be considered as social learning it must:

- Demonstrate that a change in understanding has taken place in the individuals involved. This may be at a surface level (via recall of new information) or deeper levels (demonstrated by change in attitudes, world views or epistemological beliefs).
- Go beyond the individual to become situated within wider social units or communities of practice within society, and occur through social interactions and processes between actors within a social network.

2.4.5 Local Institutions and Climate Change Adaptation

2.4.5.1 Conceptual Framework

Figure 1 depicts Adaptation, Institutions and Livelihoods (AIL) Framework, developed by Agrawal (2008) as a method to assess the role of local institutions in climate change adaptation. It aims to bring out the ways through which local institutions can enhance adaptation under climate change.

This conceptual framework has been used in assessing the role of local institutions in climate change adaptation in the context of Asia (Agrawal, 2008) and central Africa (Ochieng, 2014). In this study, the AIL framework is used in the SSA context, by analyzing the role of local institutions in enhancing farmers households adaptation to climate change and variability, particularly drought events.

According to Agrawal (2008), local institutions influence the impacts of climate hazards on communities and households livelihoods in three key ways:

1. *Local institutions structure environmental risks and variability and thereby the nature of climate impacts and vulnerability.* When a climate extreme (drought, flood and decrease in rainfall) strikes, it has varying impacts on the livelihoods of residents in a given area. The effects of the climate extreme on the community will be reduced when there is more equitable access to local institutions and their resources together with open communication and governance in contrast to a context where access is highly stratified with communication monopolized by a small group (Agrawal, 2008).
2. *Local institutions create a "motivational framework" within which outcomes of individual and collective action unfold.* Agrawal (2008) highlights that local institutions provide incentive framework such as closer social networks within which households and collectives choose specific adaptation practices, making it easier to pool community resources.
3. *Local institutions are the media through which external intervention strengthens or weakens existing adaptation practices*. Agrawal (2008) argues that one of conditions for external interventions to strengthen local community's capacity to adapt is the reasons why households and communities prefer one type of adaptation practice to another. Therefore, local institutions appear as means of delivery of external resources to facilitate adaptation.

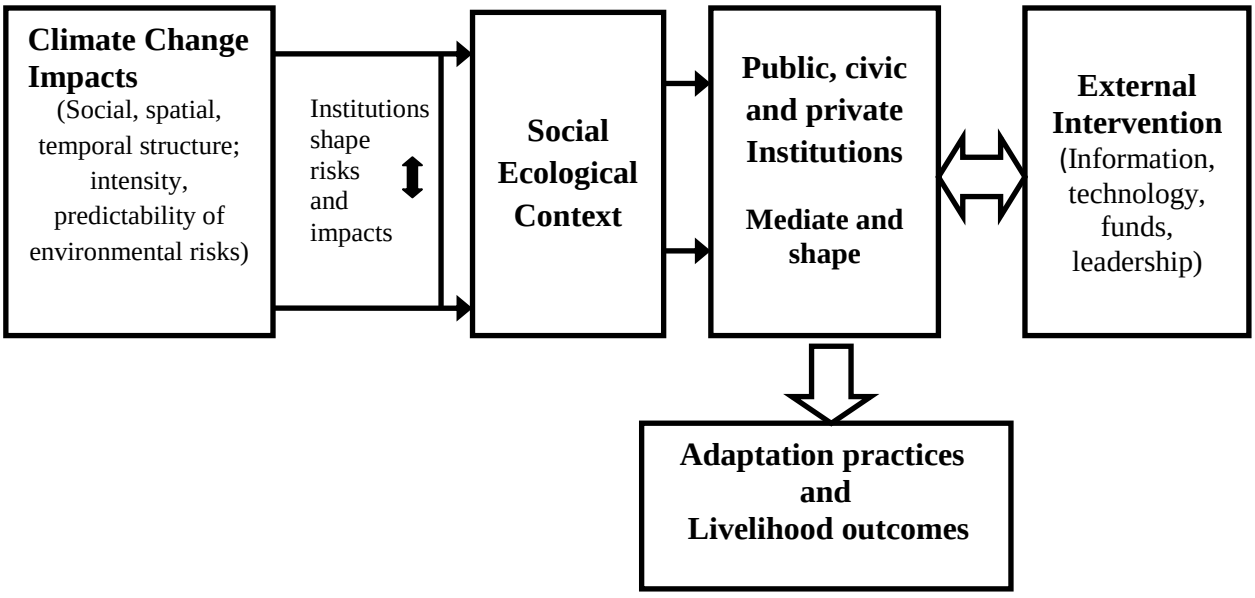

Figure 1: Adaptation, Institutions and Livelihoods (AIL) Framework adapted from Agrawal (2008)

2.4.5.2 Classification of Relevant Local Institutions for Adaptation

The relevant local institutions to climate change adaptation can be classified based on their formality/informality, their hierarchical nature or whether they are sector specific or multi-sectoral (IFAD, 2003).

To cover the range of institutions relevant to adaptation to climate change (and addressing the different forms of vulnerability that the rural poor are likely to suffer as a result of climate variability and change), Agrawal (2008) suggested to focus on the three broad domains of social action, including civic or community, public or government and private or market in their formal and informal forms. These are described below:

- **Public Institutions:** are considered to be those within the existing government or governance structure, whether elected or appointed.
- **Civic Institutions:** are more about non-governmental organizations, hybrid organizations such as cooperatives, and other organizations that perform major functions related to provision of support during times of crises, facilitating social and cultural interactions and promoting social capital, and supporting the provision of social services and information; and
- **Private Institutions:** are considered to be those working for the own.

2.4.5.3 Linkage between Institutions: Access and Articulation

Institutional linkages are comprised of institutional access and institutional articulation. According to Agrawal (2008), social groups and households access to institutions within a certain area is the extent to which they are connected to these local institutions, including them having the ability to benefit from assets and resources (money, farm input, climate and weather information, and advice) of these institutions as a consequence of their connections. In addition, the capacity and the interconnections of institutions at a given location are important in how they affect adaptation. Agrawal (2008) stated that "*institutional linkages are critical to adaptation because of the ways in which institutional linkages affect flow of resources and influence amongst them and to households and social groups"*

Institutional Access

According to Agrawal (2008), within the same territory or village, households and social groups will have varying degrees and links to the institutions that are present. While some households may be not connected to local institutions, others may take part in every day running and decision making of an institution. Therefore, households which are connected to local institutions may benefit, while those which are not connected will be untouched. At the same time, these households and social groups may also shape or not what an institution does. The benefits gained by households from institutions depend on the degree and type of their access to these institutions.

Institutional Articulation

Institutional articulation refers to the linkage that exists between institutions (Agrawal, 2008). Agrawal (2008) argues that within the same community, various rural institutions have various impacts on adaptation. This difference depends on their degree of connectedness, whether they are organized or not but also how they organize their response to climate hazards and lastly their articulation with extra local institutions and resources. Furthermore, regarding the degree of connectedness of institutions, it is found that institutions that have conflictual connections to other institutions are often less effective as compared to those with multiple positive links. Therefore, understanding of these linkages is vital in order to learn how local institutions influence adaptation practices (Agrawal, 2008).

CHAPTER THREE: METHODOLOGY

This chapter is subdivided into two sections. The first section presents the study area, its location as well as its demographic and socioeconomic characteristics. The second one describes the methods used to achieve the research objectives.

3.1 Study area

Upper East Region (UER) is reported to be the region with the most vulnerable crop production area to climate change and variability, particularly drought (experienced in 1961, 1974–77, 1981, 1983–84, 1991, 1993, 1995, 2002, 2005 and 2006) in Ghana due to its medium exposure to drought coupled with high sensitivity and low adaptive capacity (Antwi-Agyei, 2012). In addition to climate change threat, the region experiences level 4 land degradation in the 1 to 5 scale, with level 5 being the worst (Owusu, 2012).

Within the UER region, Bongo district is the most vulnerable because of its particularly high poverty level and low literacy rates (Antwi-Agyei, 2012: 98). As one of the West African Science Service Center on Adapted Land Use (WASCAL) pilot program, the Bongo district is a suitable area to assess how local institutions are helping farmers' households and to determine if the local farmers' households are taking advantage of this opportunity.

3.1.1 Location

Ghana is one of the West African countries which shares its northern border with Burkina Faso, eastern border with the Republic of Togo, western border with Cote d'Ivoire and bordered on the south by the Gulf of Guinea. It lies between latitude 4 º and 12 º north of the equator and between longitude 0 º and 10'east (Figure 2). One of the 10 regions of Ghana, UER is the smallest region located on the northeast corner of Ghana. It is bordered by Burkina Faso in the north, Togo to the east, upper west region in the west and the northern region in the south. It covers a total land area of 8,842 square kilometers, representing 3.7 % of the total area of Ghana (GSS, 2000).

One of the 13 districts in the UER is Bongo district, which lies between longitudes 0.45º W and latitude 10.50 º N to 11.09 and has a total land area of 459.5 square kilometers. It shares boundaries with Burkina Faso to the north, Kassena-Nankana east to the west, Bolgatanga Municipal to the south-west and Nabdam District to south east (GSS, 2014). It has

a population of 84,545 with an average household size of six (6), approximately 94% of which is rural (GSS, 2014).

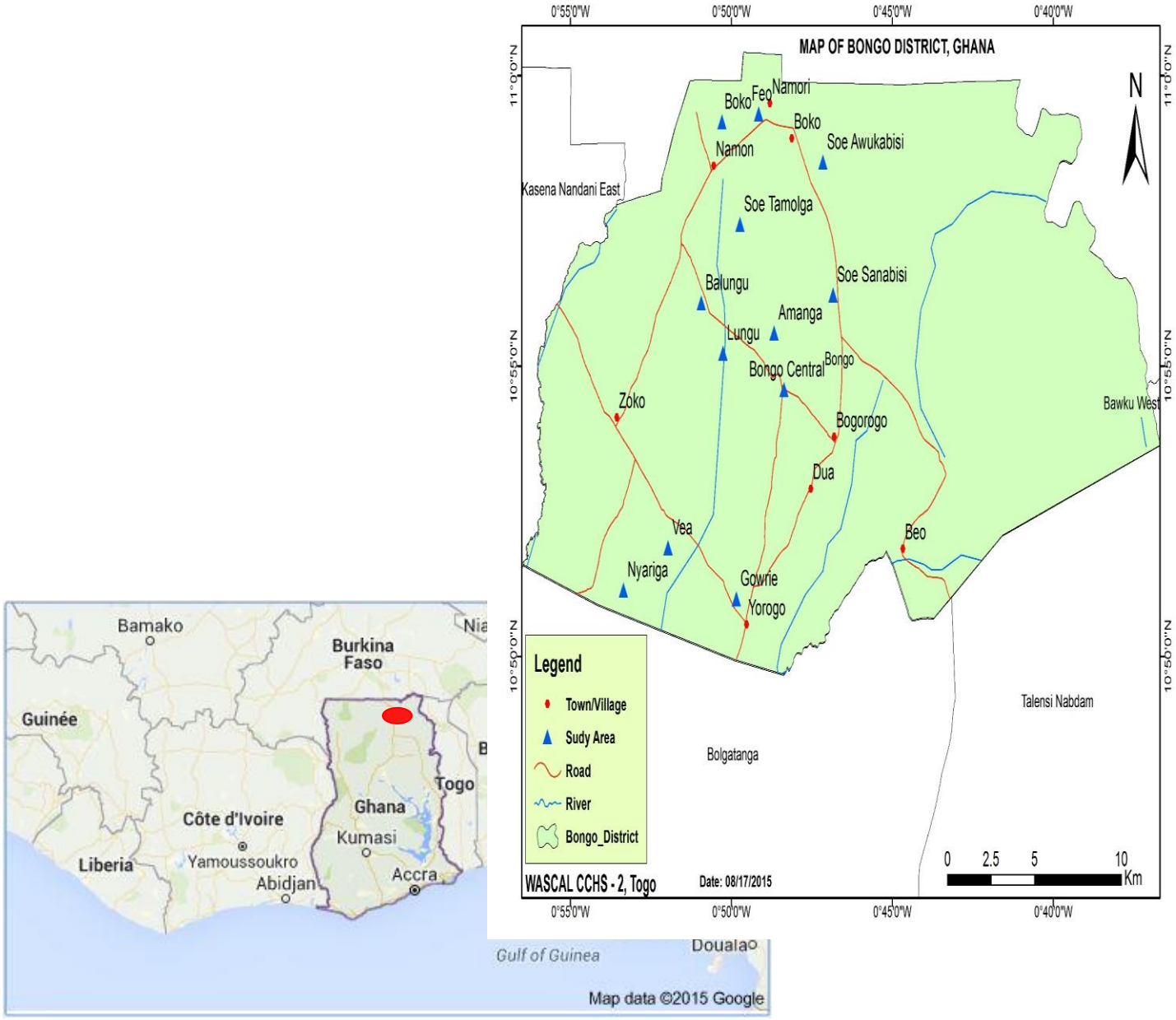

Figure 2: Map of Ghana showing the location of the study area
Source: WASCAL-MRP CCHS (Google/ field work, 2015)

3.1.2 Demographic and Socioeconomic Characteristics

The key demographic and socio-economic characteristics of the Bongo district are summarized in Table 1.

Table 1: Key demographic and socioeconomic characteristics of Bongo district

Characteristics	Bongo
Population (inhabitants)	84,545 (as of 2012)
Ethnic population	Majority *Frafras*
Main livelihood	Entirely crop farming with few livestock
Farming system	Bush farming
Main crops	Millet, sorghum, groundnut and guinea corn
Population in agriculture (%)	95.7 (as of 2012)
Climate	Tropical continental or interior savanna climate
Agro-ecological zone	Northern Savannah Zone
Vegetation	Guinean Savannah type
Soil type	Lixisols, Acrisols, Luvisols and Gleysols
Rainfall patterns	Uni-modal
Major rainfall period	May/June–Sept/Oct
Mean annual rainfall	600–1400 mm (with 70 rainy days)
Temperature	Min 21 º C, Max 40 º C

Source: Data compiled from MoFA (1998) and Ghana Statistical Services (2012)

Generally, the rainy season in the UER is relatively short and marked by variations in its onset, duration and intensity (Villamor and Badmos, under review) that create inter-annual variation in agricultural production potential (IFAD, 2007).

The amount of rainfall in the district is offset by the intense drought that precedes the rain and by the very high rate of evaporation that is estimated at 168 cm per annum (GSS, 2014). Furthermore, Bongo district experienced an increase in temperature between 1º C and 5º C compared to the temperature that prevailed in 2007 (min 20º C and max 35º C) associated with high variability in the rainfall pattern.

Besides all these facts, Bongo district experienced over a period of 5 years (from 2007 to 2012) a growth in its population of about 6.7 %, while the agricultural community within the same period increased only by 5.7 % (EPA, 2007; GSS, 2012), potential source of food insecurity in the area.

3.2 Methods

3.2.1 Sampling Design

To achieve the above objectives, a multistage sampling technique was employed. In the first stage, five (Namoo, Soe, Bongo, Balungu, Gowrie) out of seven areas councils (Namoo, Soe, Bongo, Balungu, Gowrie, Beo, and Zorkor) were purposively selected. From the

selected area councils, 12 communities were selected (second stage). In order to compare the results of coping strategies developed by farmers' households and local institutions in response to climate change. The third stage consists of selecting local institutions working in the study area and farmers households.

- **Local Institutions Sampling**

Local institution in this study refers to public, civil or private organizations and individuals whose accountability and legitimacy is derived within the scope of the communities within which they normally operate. Local institutions assessed are those identified by farmers' households but also those given by Bongo district assembly (social welfare department). The local institutions assessed follow the structure of the Table 2. Thus, a total of 28 institutions were identified and were available and accessible during the period of data collection (i.e., June-August 2015).

Table 2: Structure of local institutions enabling adaptation in Bongo district

	Public (State)	Private (market)	Civic (civil society)
Types of institutions	District Assembly (DA) departments	Service organizations	NGOs, CBOs, FBOs
	Traditional Authority (TA)	Private businesses	Cooperatives at the community level
	Unit Committee (UC)		

- **Farmers' Households Sampling**

This sampling is carried out to explore farmers' households access (type and degree) to local institutions, evaluate the impacts of the actions and activities undertaken by local institutions on farmers' households adaptation to climate change. Therefore, from the 12 communities previously selected, based on the understanding that the majority of residents in the study communities are involved solely in the practice of subsistence agriculture and only minority of them are employed through government or private professions **,** 10 households were randomly selected for further investigation (Table 3). In total, 120 farmers' households were included in the study.

Table 3: Communities assessed and farmers' households sample size

	AREA COUNCILS					
	Namoo	**Soe**	**Bongo**	**Balungu**	**Gowrie**	**Total**
Community	2	3	2	2	3	12
Respondents	20	30	20	20	30	120

3.3 Data Collection and Analysis

3.3.1 Data Collected and Methods of Collection

Both primary and secondary data were collected to address the objectives of this study. Therefore, a particular method has been used for each objective (Figure 3).

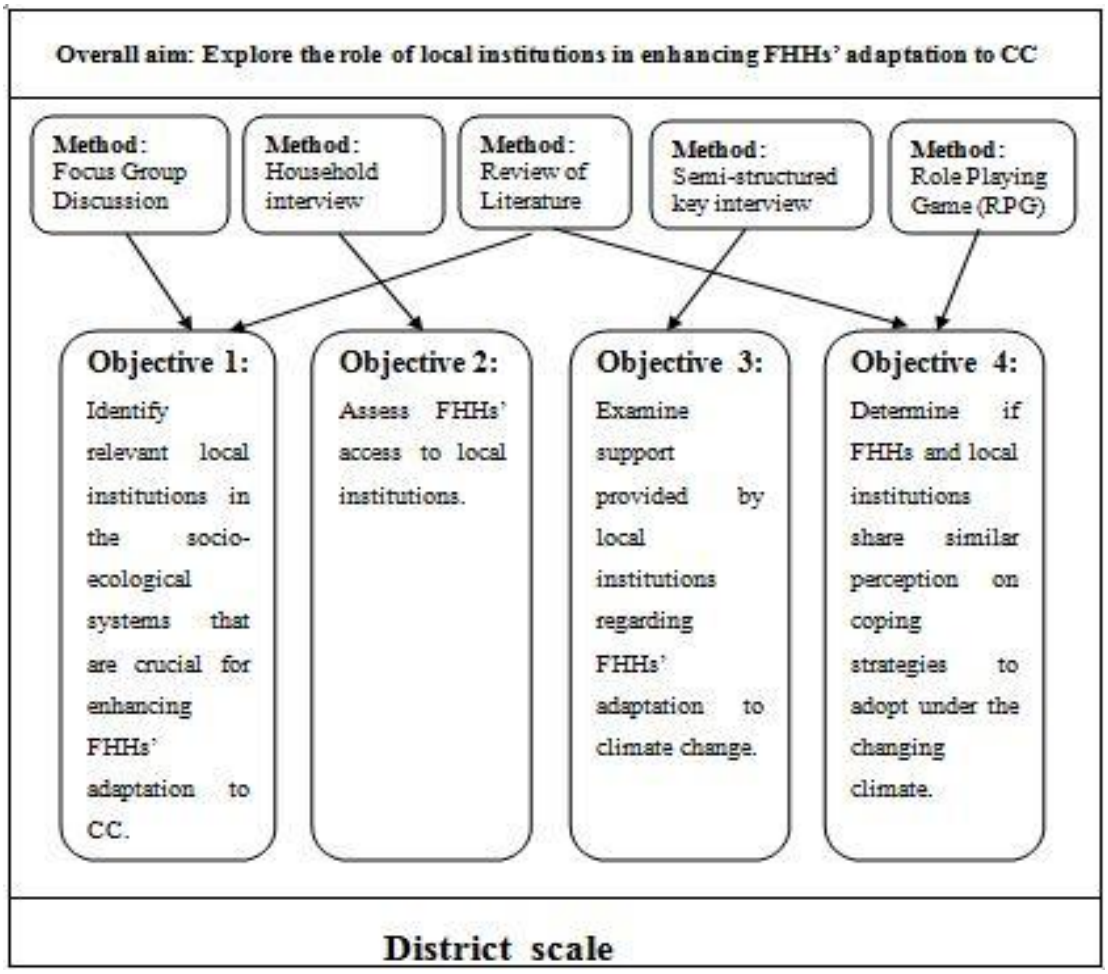

Figure 3: A summary of research design and links between different methods used and the research objectives

3.3.1.1 Primary Data

Primary data were collected using focus group discussion, semi-structured interview, household survey and role playing game. Data on the institutions awareness about climate change and its impacts on farming activities in the district level, farmers' households' access to actions and activities undertaken by local institutions and their impact on farmers' households' adaptation to climate change, and local institutions coping strategies under climate change were collected through these approaches.

- **Focus Group Discussion (FGD)**

Used for its ability to create interaction between respondents, aspect that may lack in a one-to-one interview (Darlington and Scott, 2003), FDG allows a full exploration of certain issue in full depth (Bryman and Bell, 2007). Therefore, FGDs bring out group interaction and allow different meanings that the local farmers may have about climate change and variability to be fully explored.

The overall aim of the FDG is to identify relevant institutions in the study site (See Annex II for the detailed IPM approach). A total of 12 FGDs were conducted in each community in the district, using the Institutional Perception Mapping (IPM) approach (Brocklesbury, 2002). This approach investigates all the institutions working with the local farmers and their level of importance and accessibility to the community. The discussion was in local dialect (Gurunee).

- **Semi-Structured Key Informant Interviews**

A semi-structured interview was conducted with identified institutions (through IPM) to investigate their awareness about climate change and its impacts on farming activities in Bongo district and actions and activities undertaken regarding farmers' households' adaptation to climate change (See Annex III for the detailed questions). The overall key person interview was done with a key person of the identified institution (Director/Monitoring and Evaluation Officer /Project manager/leader), who is knowledgeable about or who work in the context of Bongo district. In this study, project based institutions are also considered as institutions.

- **Role Playing Games**

Role-playing games (RPGs) were used as a participatory technique for simulating adaptation to climate change (Berkes and Jolly 2001; Washington-Ottombre et al., 2010). For

this study, the grazing game developed by Villamor and Badmos (under review) was adopted to explore the coping strategies of the identified institutions in response to climate change. A total of four RPGs were conducted with institutions (in Bolgatanga and Bongo) working with Bongo farmers' households (See Annex IV for the detailed procedures of the game).

- **Household Interviews**

To explore farmers' households' access to local institutions as well as the impacts of local institutions actions and activities on farmers' households' adaptation, a household interview was held (see Annex V for the detailed questions). In this study, a household is considered as a group of people who own the same productive resources, live together and feed from the same pot (Yaro, 2006).

3.3.1.2 Secondary Data

Secondary data were obtained from published and non-published papers. They include the profile of development partners (Non-Governmental Organizations, Civic Society Organizations, and Community-Based Organizations) working in Bongo district and coping strategies developed by local farmers' households under the changing climate in Bongo district. The data is described in the Table 4.

Table 4: Description of secondary data used

Data	Source
Profile of development partners working in Bongo district	Social Welfare Department of Bongo district
Data on farmers' households coping strategies under climate change	Badmos, 2013

3.3.2 Data Analysis

Articles, theses, reports processing consisted in the reading of documents in order to come up with a consistent literature review. After this first step, social network analysis was done to determine local institutions that are central to climate change adaptation in the study area. In addition, local institutions supports were analyzed to determine the class of adaptation

they belong to and to bring out classes of adaptation that are neglected for capacity building for future changes in the climate.

3.3.2.1 Social Network Analysis

To determine the prominence, the structural importance of each local institution, within the network in term of power, communication and influence control, centrality measures and Net Draw software has been used for mapping. The three most widely used centrality measures are degree centrality, closeness centrality, and betweenness centrality (Freeman, 1979).

- **Degree centrality**

Degree centrality of a node (institutions) is a measure of the node's (institution) connections to other nodes (other institutions) (Cambridge intelligence, 2014). Then the institutions with the highest degree score are the most important in the network. Actor-level degree centrality is simply each actor's number of degrees in a non-directed graph:

$$C_{\mathrm{D}}(n_i) = \frac{d_i(n_i)}{(n-1)} \quad (1)$$ (Wasserman and Faust, 1994)

- **Closeness centrality**

Closeness centrality calculates a node's (institution) proximity to other nodes (institutions). Institutions with a high closeness value can pass information through a network more quickly than other institutions (Cambridge intelligence, 2014). Actor (LI) closeness centrality is the inverse of the sum of geodesic distances from actor (LI) i to the g-1 other actors (LIs):

$$C_C(n_i) = (n-1) \times \left[\sum_{j=1}^{g} d(n_i, n_j) \right]^{-1} \quad (2)$$ (Wasserman and Faust, 1994)

- **Betweenness centrality**

Betweenness centrality is a measure of a node's (institution) connectedness within a network (Cambridge intelligence, 2014). Institutions with a high betweenness score are those which frequently control information flow around the network and which can cause most disruption to flow if removed. Actor (LI) betweenness centrality for actor (LI) i is the sum of

the proportions, for all pairs of actors (LIs) j and k, in which actor (LI) i is involved in a pair's geodesic(s). For directed graphs:

$$C_B(n_i) = \left[(n-1)(n-2)\right]^{-1} \left[\sum_{j<k} \frac{g_{jk}(n_i)}{g_{jk}} \right] \quad (3)$$ (Wasserman and Faust, 1994)

For undirected graphs:

$$C_B(n_i) = 2\left[(n-1)(n-2)\right]^{-1} \left[\sum_{j<k} \frac{g_{jk}(n_i)}{g_{jk}} \right] \quad (4)$$ (Wasserman and Faust, 1994)

n_i: institution i
n_j: institution j
n: number of institutions involved in adaptation
$C_{B:}$ Betweenness centrality
$C_{C:}$ Closeness centrality
$C_{D:}$ Degree centrality

3.3.2.2 Analysis of the Support Provided by Local Institutions

The section of support provided by local institutions was analyzed based on a combination of Below et al. (2010) and Rhodes et al. (2014) classes of adaptation. These classes include:

- **Knowledge management** includes both macro-level and micro-level practices (Below et al., 2010). Macro-level practices are more about practical trainings for farmers and agricultural extension officers while micro-level practices consist of using decision support systems and weather forecasts, wild plants and animals as bellwethers of ecosystem variability or change. Thus, includes education and training, awareness raising and the provision of weather and climate information.
- **Diversification (on and beyond farm)** includes non-agricultural livelihood strategies that are carried out on the farm, called on-farm diversification (e.g., extraction of non-timber forest product) and those undertaken beyond the farm, so called off farm diversification (e.g., petty trade, animal rearing, aquaculture) (Below et al., 2010).
- **Farm financial adaptation options** represent farm-level responses, using farm income strategies to reduce the risk of climate-related income loss (Smit and

Skinner, 2002). It includes insurance or micro insurance (Smit and Skinner, 2002; Boko et al., 2007) and credit (Osman-Elasha et al., 2006).

- **On-farm management** refers to changes in cropping systems (Kurukulasuriya and Mendelsohn, 2006), shift in livelihood activities (Thomas et al., 2007) and the use of improved crop varieties (high yielding, early maturing, weed competitive, and tolerant of Africa's major pests, drought).
- **Investment in infrastructure, health and public welfare** represents macro-level interventions with a strong potential to influence farmers' risk management strategies.

The rest of the analyses were undertaken with SPSS software version 16.0, which prescribe the descriptive statistics of the collected data. In addition, Excel (2013) was used to draw graphical patterns and trends, while Arc GIS 10.1 was used for mapping the study site.

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents the results of the analyses and discusses the results. Also, the chapter relates the results to the conceptual framework of the study.

4.1 Results

4.1.1 Local Institutions

4.1.1.1 Relevant Local Institutions

Several local institutions (LIs) are supporting farmers' households' (FHHs) adaptation to climate change impacts in Bongo district. Their interventions vary across communities. While some communities work with up to 12 local institutions (Figure 4b), others receive the intervention of only 4 (Figure 4a).

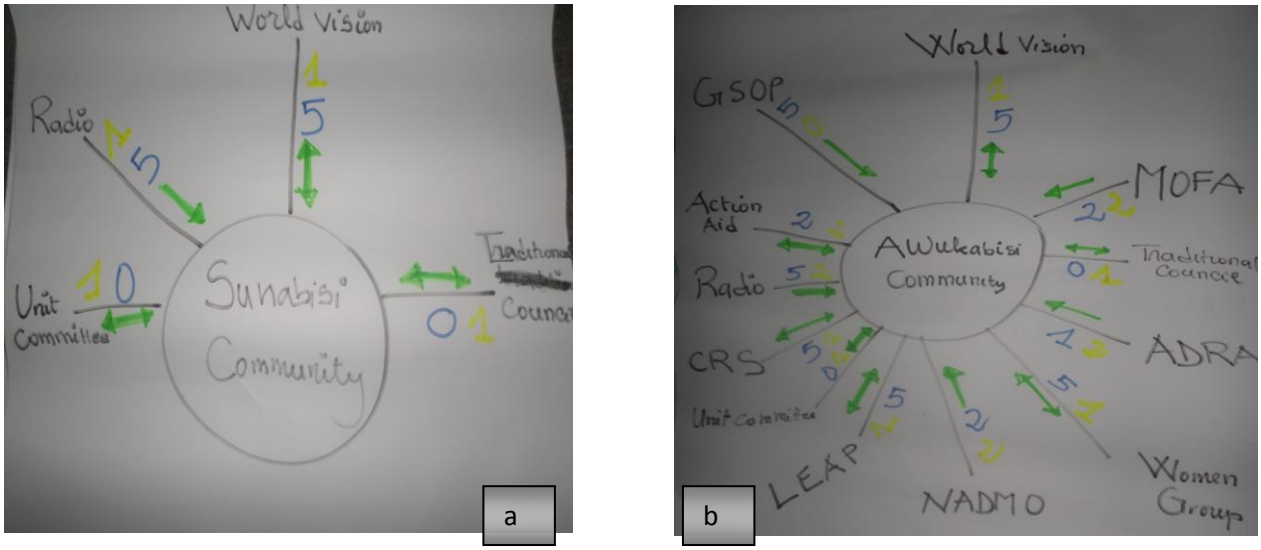

Figure 4: Institutional perception map in Sunabisi (a) and Awukabisi (b) (Photo credit: Mawulolo YOMO).

Some of these institutions were identified by farmers' households as key in assisting them to deal with and adapt to the negative impacts of climate change on their farming activities. Twenty-four of the identified institutions are formal while three are informal institutions. Out of the 25 formal institutions, eight are public, two are private and 15 are civic institutions, making a total of 28 LIs (Figure 5).

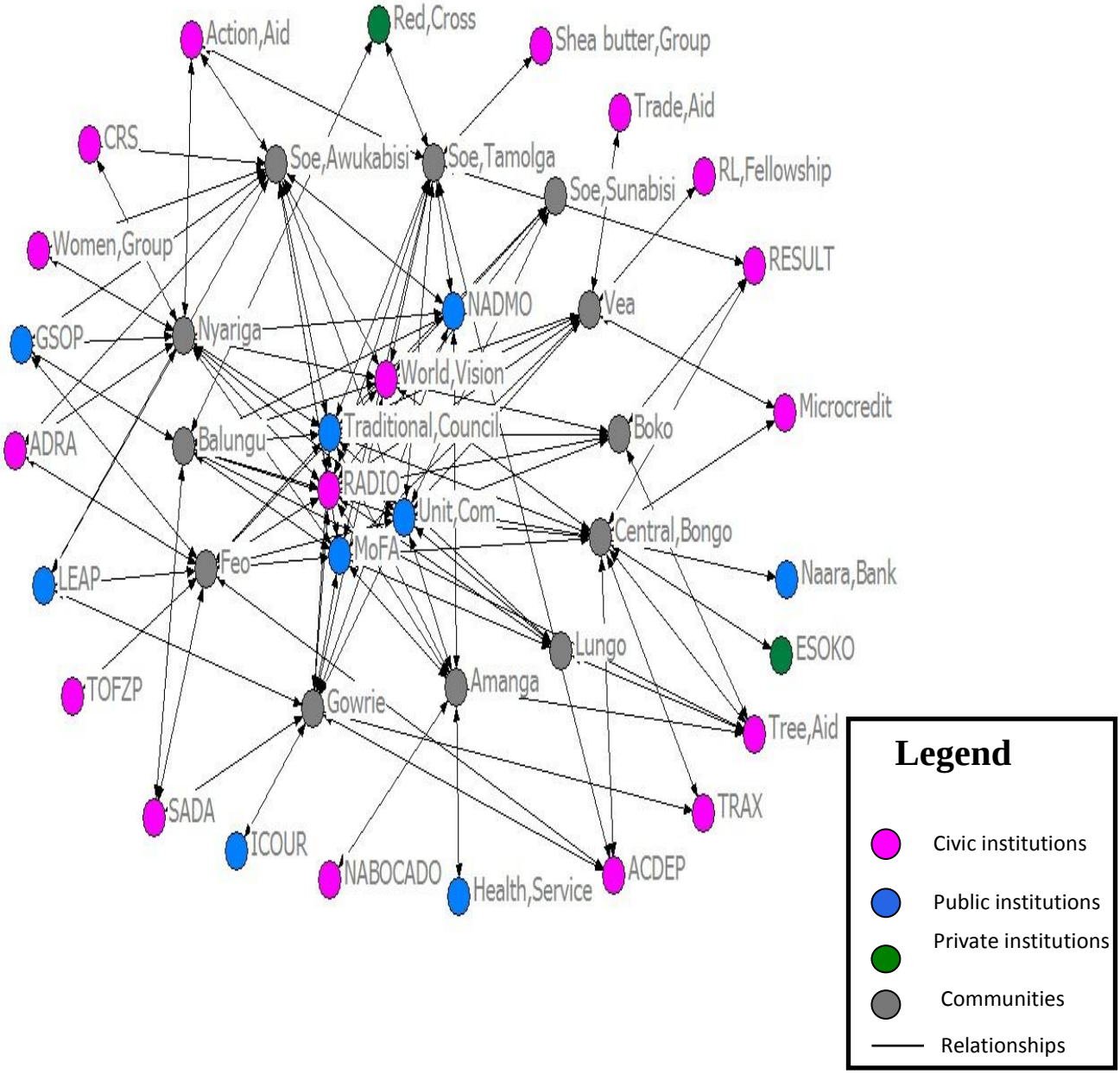

Figure 5: Network of relevant local institutions involved in farmers' households' adaptation to climate change (Source: Field work, 2015)

These institutions intervene in various domains that relate to most aspects of rural life such as agriculture, community development, forestry, education, disaster management, banking, water resource management, health and financial empowerment. However, among all these institutions, MoFA, World vision, unit committees (unit, com), traditional councils (traditional, council) and NADMO with the highest degree centrality score (0.12 – 0.44) (see annex II) were identified to be the most important LIs based on communities' perception (Figure 6). This is explained by, their intervention in almost all the communities, making them to be close to communities, which in return trust them. However, local institutions which are at the periphery play also a key role in adaptation but as their intervention are

limited only to some communities, they appear like not existing. Besides, the limited or lack of financial resources are pinned out by these local farmers to be an hindrance for institutions such as unit committees, traditional councils and MoFA compared to World Vision which is an international organization.

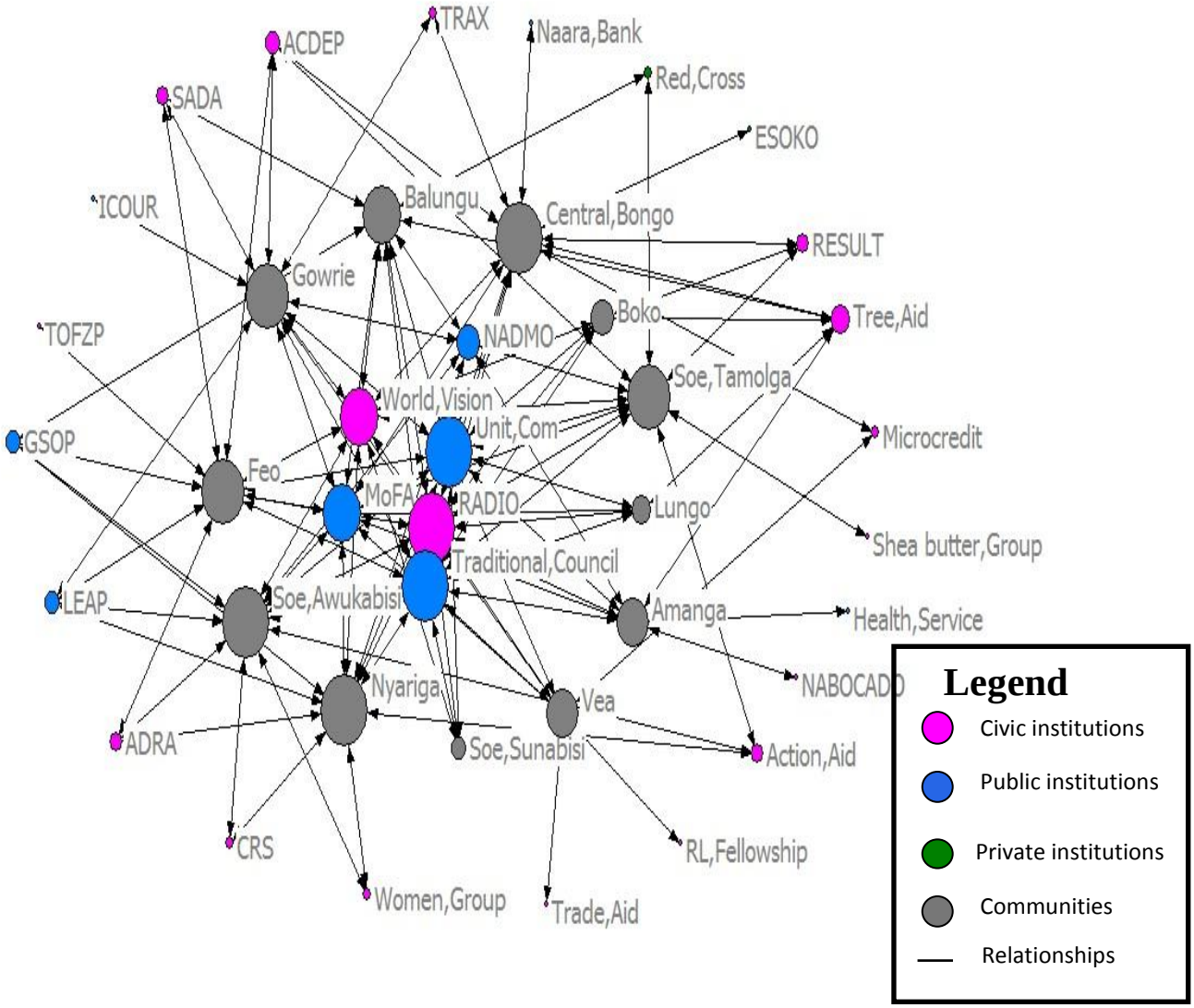

Figure 6: Network of relevant local institutions involved in farmers' households' adaptation to climate change based on the degree centrality (Source: Field work, 2015)

Besides, some institutions although are not the most important, act as communication bridges. These institutions can pass information through a network more quickly than other institutions. These institutions with the highest closeness centrality score (2970 - 3456) (see annex II) , include Trax-support (TRAX), Naara rural bank (Naara,bank), ESOKO, ICOUR, Trans-border Onchocerciasis Freed Zone Program (TOFZP), Trade aid (Trade,aid), Red cross

society (Red,cross), Real life fellowship (RL, fellowship), CRS, NABOCADO, and Ghana health service (health,service), Shea butter extraction group (Shea butter, group), microcredit, Women group, ADRA.

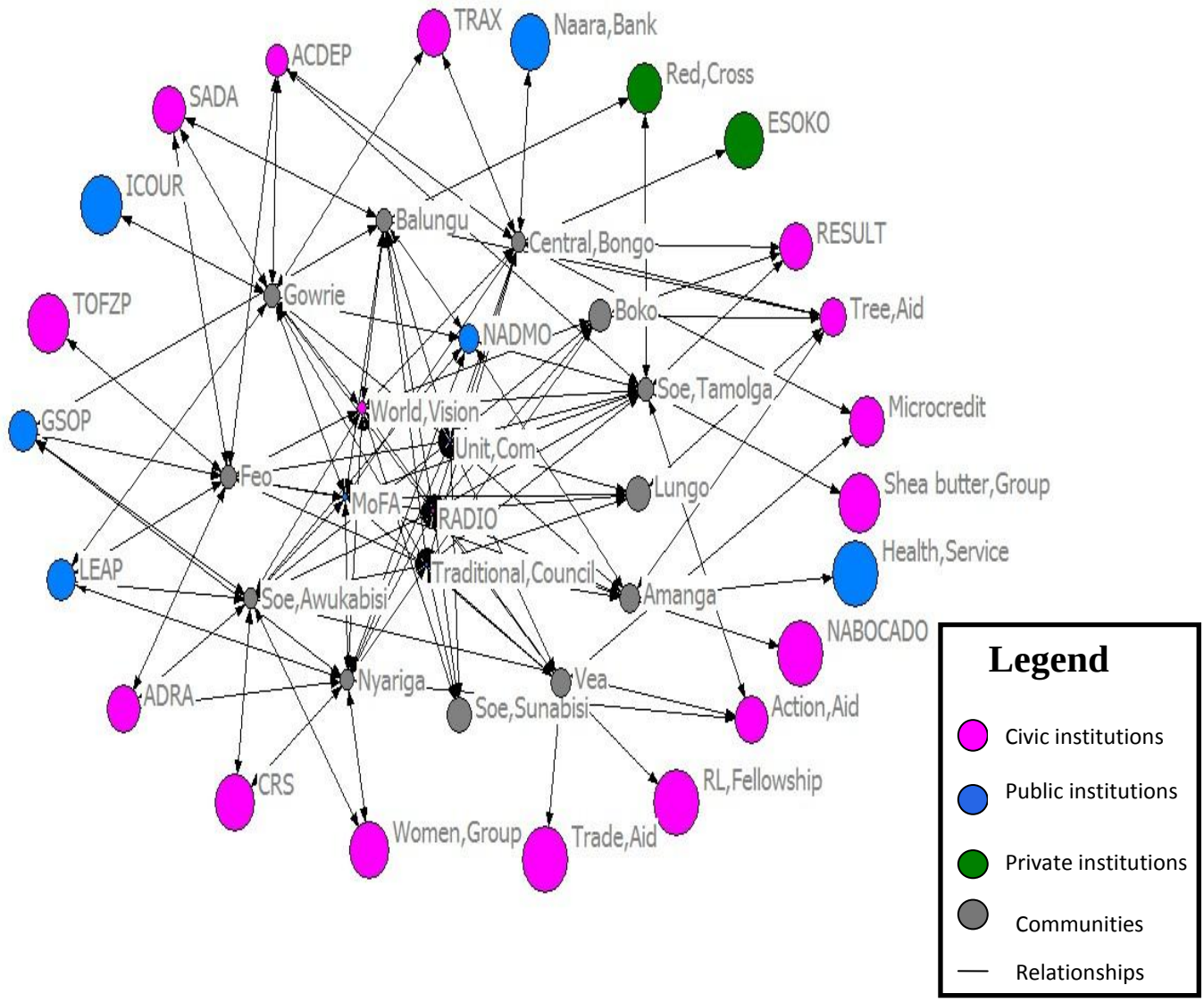

Figure 7: Network of relevant local institutions involved in farmers' households' adaptation to climate change based on the closeness centrality (Source: Field work, 2015)

Furthermore, some institutions frequently control information flow around the network and which can cause most disruption to flow if removed. It is the case of World Vision, unit committee (Unit, com), traditional council (traditional, council), Radio, NADMO and MoFA (Figure 8) which scored the highest betweenness centrality (0.16 - 0.25) (see Annex II). This can be explained by the fact that traditional council and unit committee exist within each community (ensure the development of the community), therefore, for any activities success, their incorporation is necessary. In addition MoFA as a public institution has the duty of

intervening in all the communities within Bongo district therefore is in contact with farmers' households at a weekly to monthly basis, therefore, for any activity with farmers, MoFA is the adequate institution to contact. Furthermore, World vision through its infrastructures (Schools, Shea butter extraction center, grounding mills…) put into place in communities rest always into contact with community members. Bongo district being a rural area, radio represents an effective institution from which to get information (weather, agricultural practices, usage of farm inputs….).

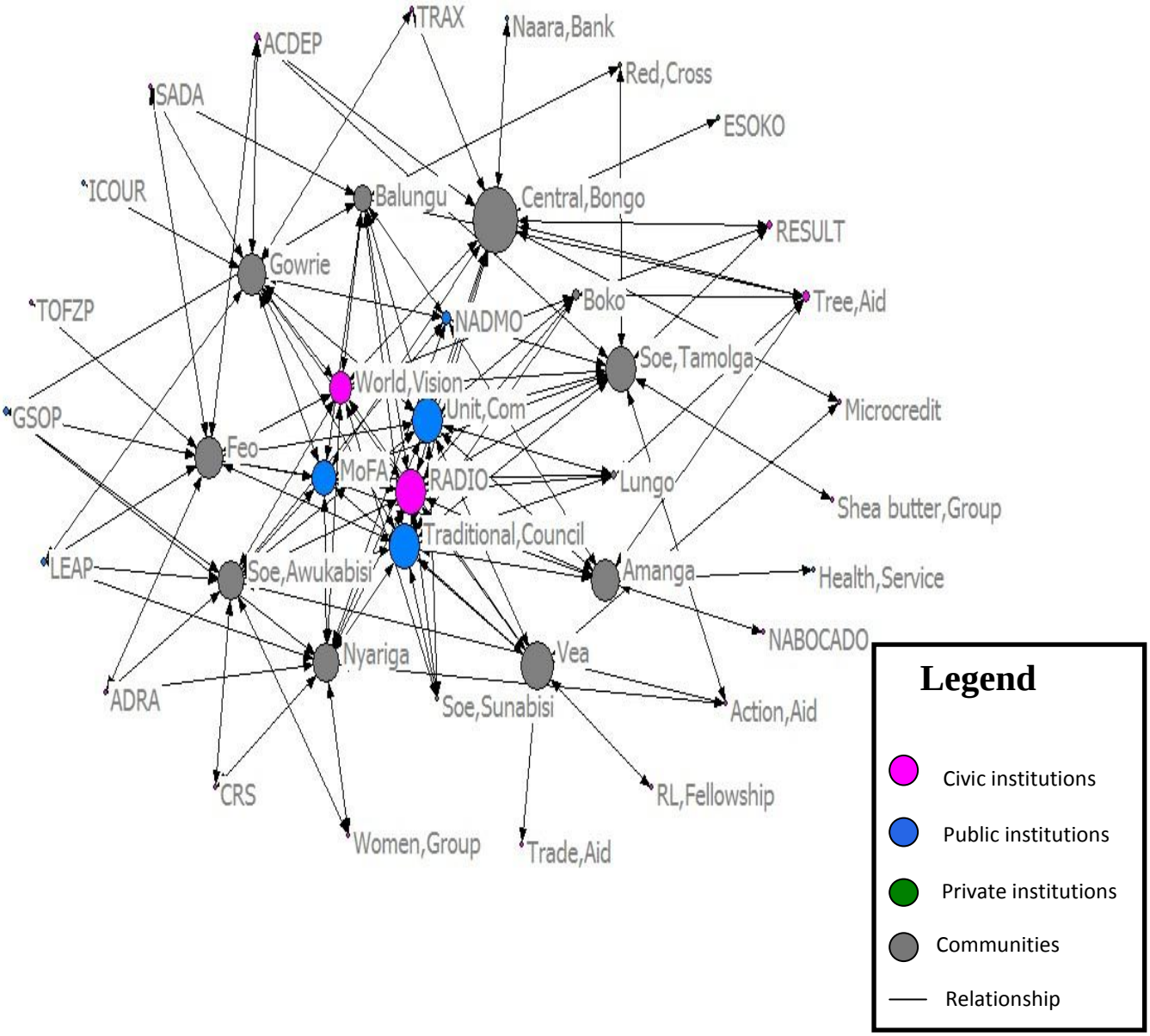

Figure 8: Network of relevant local institutions involved in farmers' households' adaptation to climate change based on the betweenness centrality (Source: Field work, 2015)

In summary, whether being the most important or the bridge of communication or the controller of information, all the institutions (public, private, civic) intervening in Bongo district are relevant in facilitating farmers' households' adaptation to climate change. However, these institutions are not working alone. They are collaborating/ cooperating and having partnership with other institutions whose accountability and legitimacy is derived beyond Bongo district. These institutions known as extra local institutions are summarized in the Table 5.

Table 5: Summary of extra local institutions intervening in the study area **(**Source: Field work, 2015)

Regional and National Government Agencies	**International Organizations / Research Centers**
Export Development Investment Fund (EDIF)	United Nation Development Program (UNDP)
National Board for Small Scale Industries (NBSSI)	World Food program (WFP)
Water Ressource Commission	Felix Foundation
Meteorological Agency	Catholic Relief Services (CRS)
Environmental Protection Agency	Tree Aid
Forestry Service Division	Canadian Feed the Children
	WASCAL
	University of Development Studies
	MILAN University
	Savannah Agricultural Research Institute (SARI)

4.1.1.2 Local Institutions' Perception on Climate Change and its Impacts on Farming Activities

- **Overall Local Institutions' Perception on Climate Change**

All the local institutions identified are aware of the changes in the climate occurring in the study area through specific observations. The most evident observations perceived by institutions as depicted in Figure 9 are high temperature (40 %), decrease in rain (25 %), change in seasons' length (20 %), and disturbance in the rain distribution (15 %). In addition some respondents linked drying up of rivers and trees, loss of soil fertility, and increased animals diseases and death to climate change.

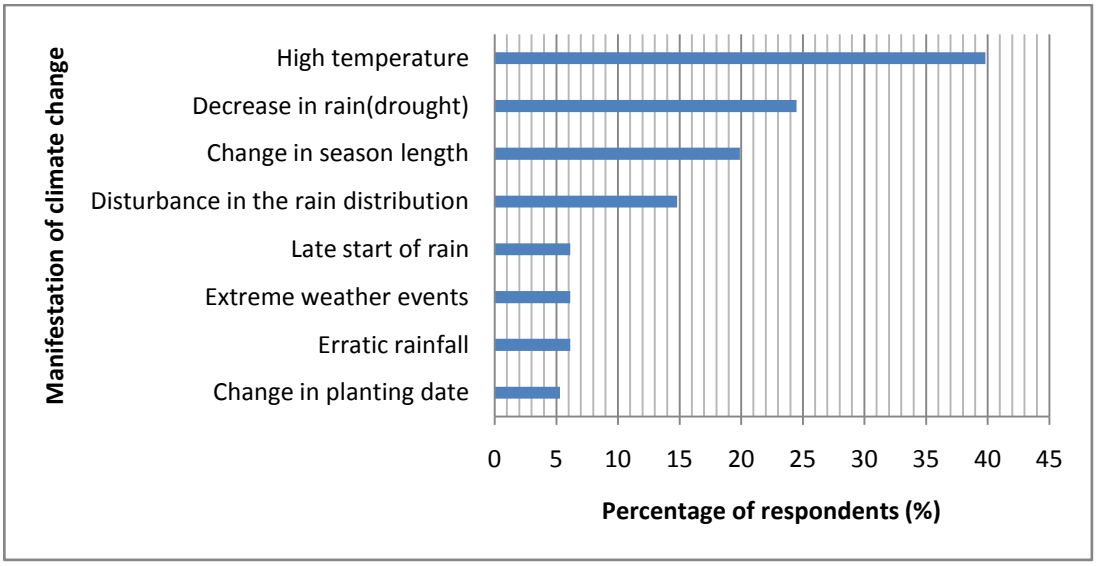

Figure 9: Local institutions' overall perception on climate change (n = 49) (Source: Field work, 2015)

- **Climate Events and their Frequency**

Local institutions identified drought and storm as the major climate events or hazards occurring more frequently in Bongo district (Figure 10a). Insect invasion (80%) and fire (61%) were also considered to be related to climate change events. In terms of frequency, storm and drought are the two climate hazard/events occurring more frequently these recent years (Figure 10b). The reduced frequency of bush fires that were rampant some years ago is explained by efforts that were done by the new Bongo chief Naba Baba Salifu Aleemyarum.

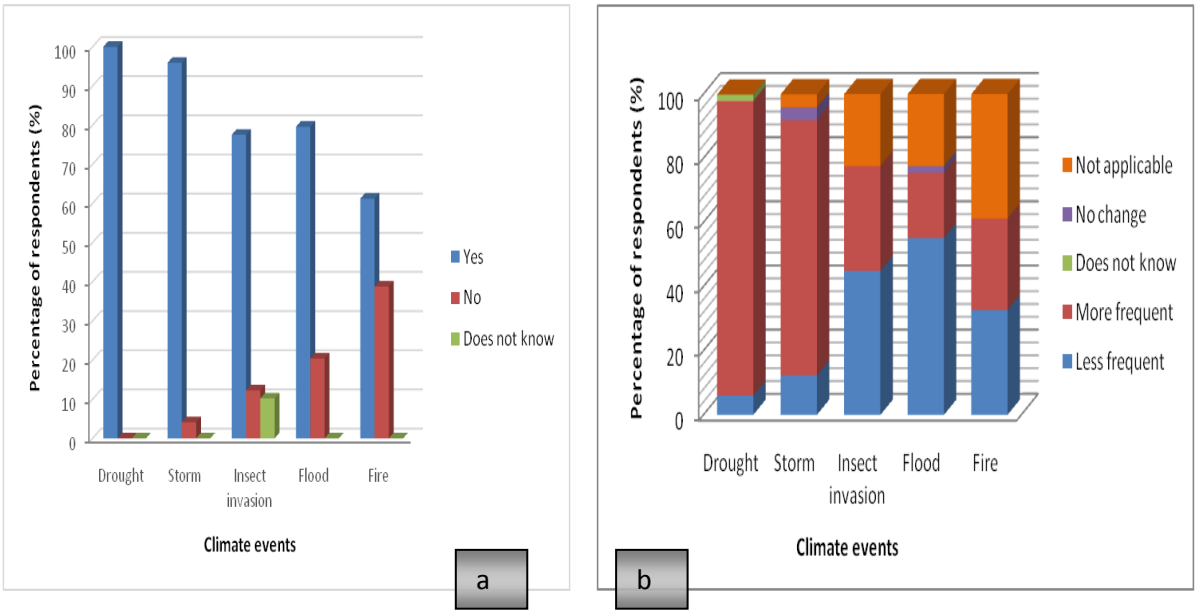

Figure 10: Local institutions' perception on climate events and their frequency (n = 49) (Source: Field work, 2015)

➢ **Causes of Changing Climate**

The major causes of climate change as depicted in Figure 11 are deforestation (84 %), abandon of traditions (38 %), bush burning (32 %), greenhouse gases emissions (20 %), increased in human sins (14 %) and adoption of bad farming practices (12 %).

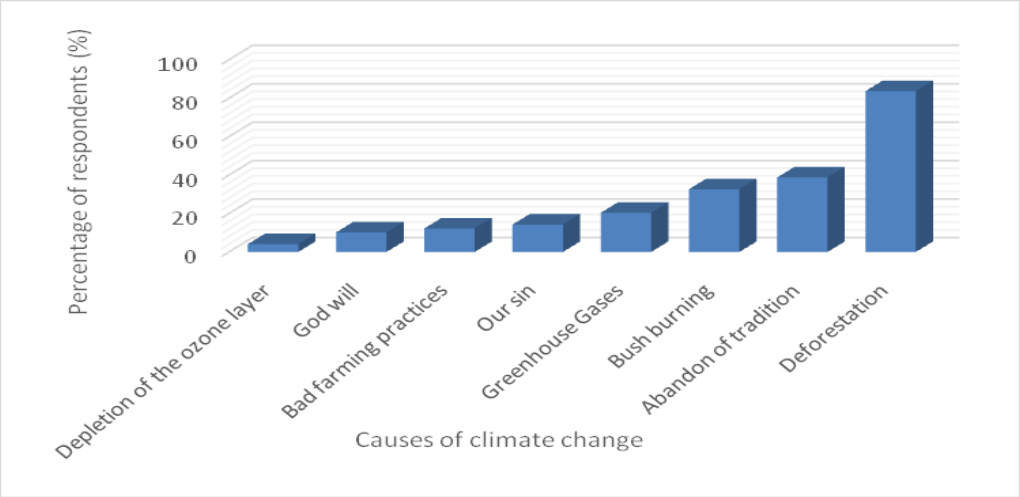

Figure 11: Local institutions' perception on the causes of climate change (n = 49) (Source: Field work, 2015)

➢ **Impacts of Climate Change on Farming Activities**

The major impacts of climate change on farming activities in Bongo as shown by the Figure 12 are the decrease in agricultural yield (100 %) and shift in the type of crops cultivated (33 %). These observations are really obvious because most of the livelihoods of the people are based on rain-fed agriculture.

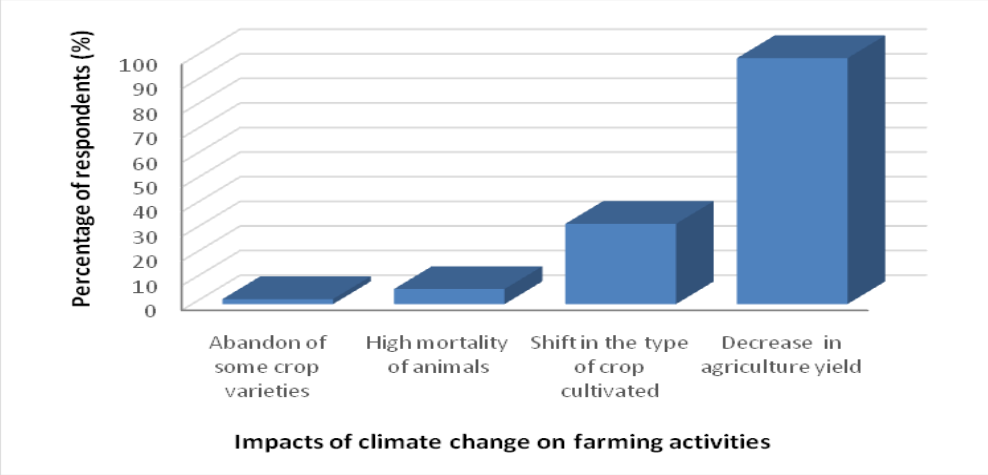

Figure 12: Impacts of climate change the on farming activities (n=49) (Source: Field work, 2015)

- **Farmers' Household's Coping strategies**

About 92 % of LI respondents believed that farmers' households' are able to cope with changes and only 4 % of the LI respondents found that farmers' households' are unable to cope with changes. Based on Figure 13, these 92 % of LI respondents believe that farmers' households' to cope with climate change, adopted various strategies such as soil conservation scheme (41 %) , which include ploughing across the slope, stone/grass bunding, compost /organic manure application; diversification (18 %) of activities (involved in the extraction of non-timber products, animal rearing, basket weaving, petty trade) and the type of crop grown (introduction of other types of crops such as water melon, maize, white sorghum); application of fertilizer (16 %) and migration down south to seek for jobs (12 %) while the less common strategies used by farmers' households' are the use of short duration crops (10 %), tree planting (10 %) and change in eating habit (8 %).

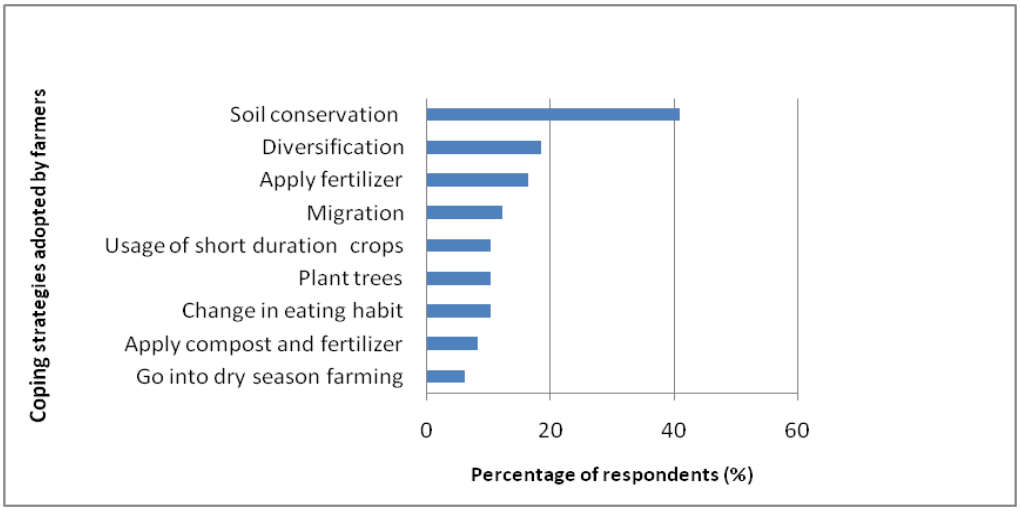

Figure 13: Local institutions perception on farmers' households coping strategies under climate change (n = 49) (Source: Field work, 2015)

4.1.1.3 Support Provided by Local Institutions Regarding to Farmers' Households' Adaptation to Climate Change.

Although most of local institutions (LIs) respondents admit that farmers' households'(FHHs) are coping with climate change impacts, their saying let believe that farmers' households' are not really able to face the changes. Their reaction can be summarized into "*They do not have choice than to farm*". In response to this situation, local institutions intervene to support FHHs to adapt to climate change. LIs' role in facilitating climate change adaptation is not discussed in terms of their nature and goal but based on Below et al. (2010) and Rhodes et al. (2014) classification of adaptation options. As shown by

the Figure 14a, LIs identified are mainly involved in knowledge management (38 %), farm management (32 %). However, they intervene also in farm financial management (11 %), diversification (7%) and in investment of infrastructure (3 %).

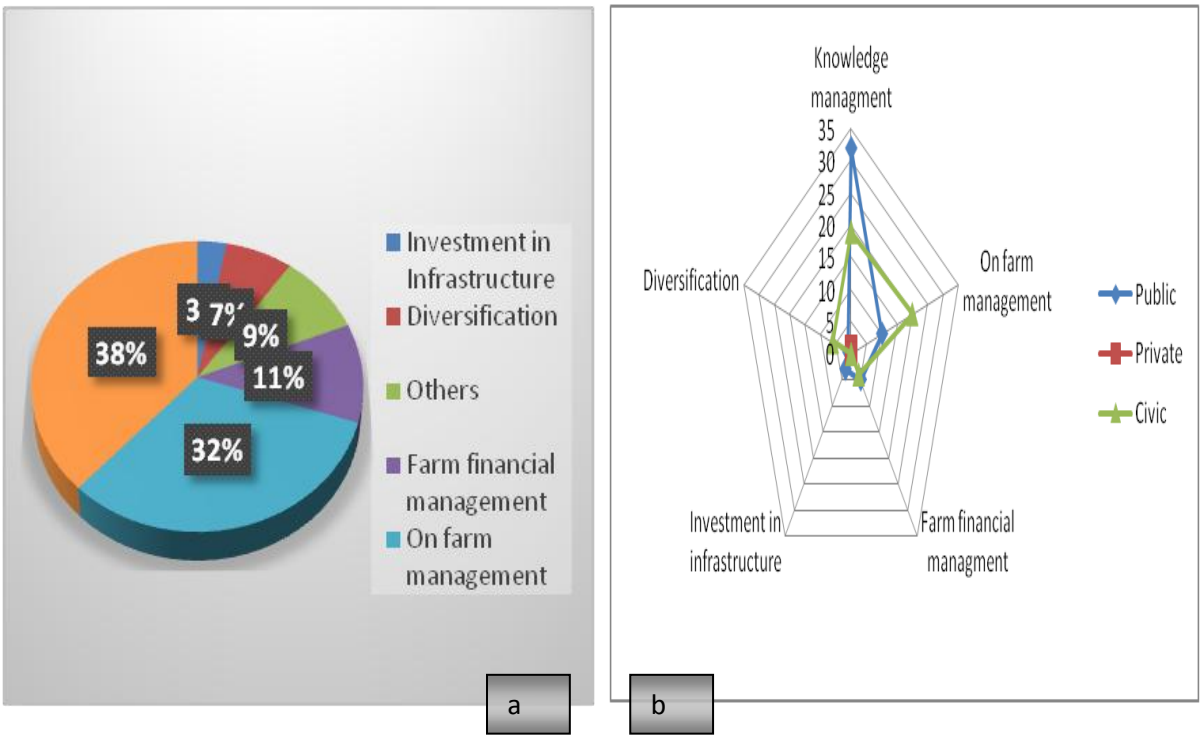

Figure 14: Classes of support provided by local institutions to farmers' households (n = 49) (Source: Field work, 2015)

The following are the details of each class of local institutions interventions or support**:**

1) On Farm Management and Technology

Figure 15 depicts LIs assistance through on-farm management. It involves the reduction of post-harvest losses (43 %), which consists of the provision of storage bags or bins; supply of improved crop varieties (23 %); and soil and water management (23 %) through the supply of farm inputs (farming tools, fertilizer, pesticide).This intervention is mainly done by public and civic institutions (Figure 14b), including MoFA, ICOUR, ACDEP, World Vision among others.

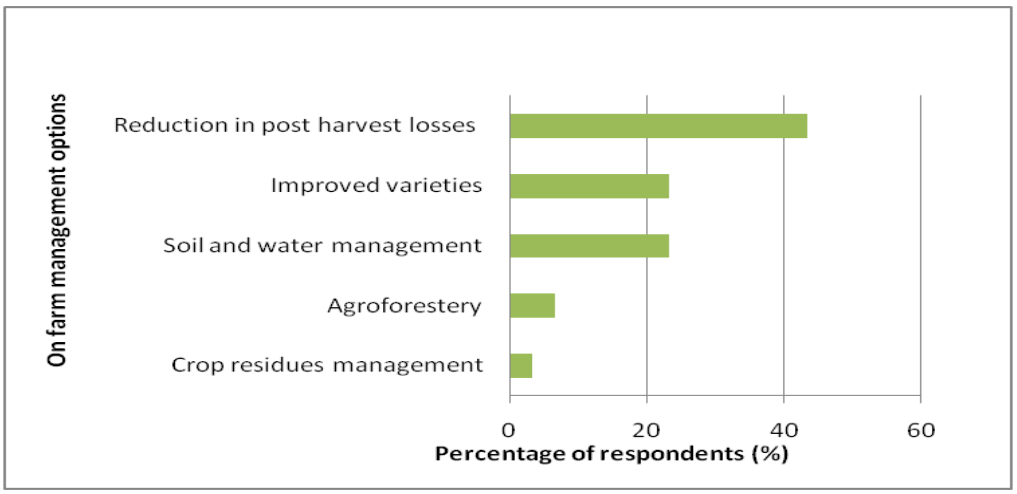

Figure 15: On farm management and technology (n=16) (Source: Field work, 2015)

2) Diversification On and Beyond Farm

Local institutions (LIs) take farmers' households (FHHs) into non-agricultural activities that are undertaken in the farm (on farm diversification) and beyond the farm (off farm diversification). On farm diversification consist essentially of the extraction of non-timber product (honey, Dawadawa powder and oil), undertaken often during the dry season while off farm diversification includes animal rearing, petty trade, aquaculture, basket weaving and soap production. As shown by the Figure 16, LIs are more involved in off farm diversification (86 %) than on farm diversification (14 %). Diversification options are provided mainly by civic and public institutions (Figure 14b), including world vision, RESULT, ACDEP, community self-reliance center, and Trax-support, NADMO among others.

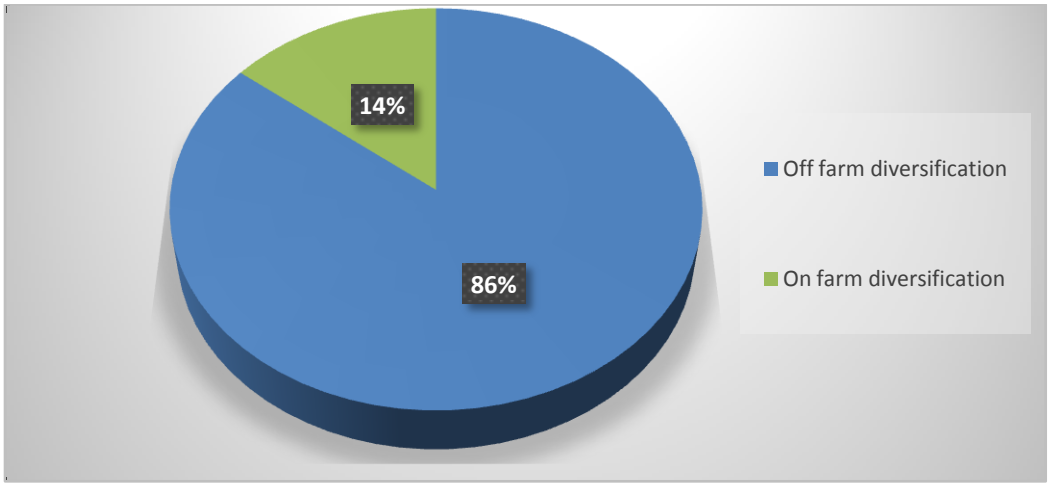

Figure 16: Diversification on and beyond farm (n= 3) (Source: Field work, 2015)

3) Farm Financial Management

With the objective to reduce the risk of climate related losses, local institutions (LIs) involved in farm financial management (Figure 17) intervene in credit provision (54 %), the improvement of the access to market (36 %) and provision of insurance scheme (9 %). Farm financial management is essentially undertaken by both public and civic institution, including financial institutions (i.e. Naara rural bank and Bongo rural bank), insurance companies (i.e. AR promising), ICOUR, Trade aid, and RESULT. However, the AR promising is an insurance company working with Bongo rural bank, therefore, only FHHs having access to the bank have also access to the insurance. In addition only FHHs in Bongo central have access to the bank.

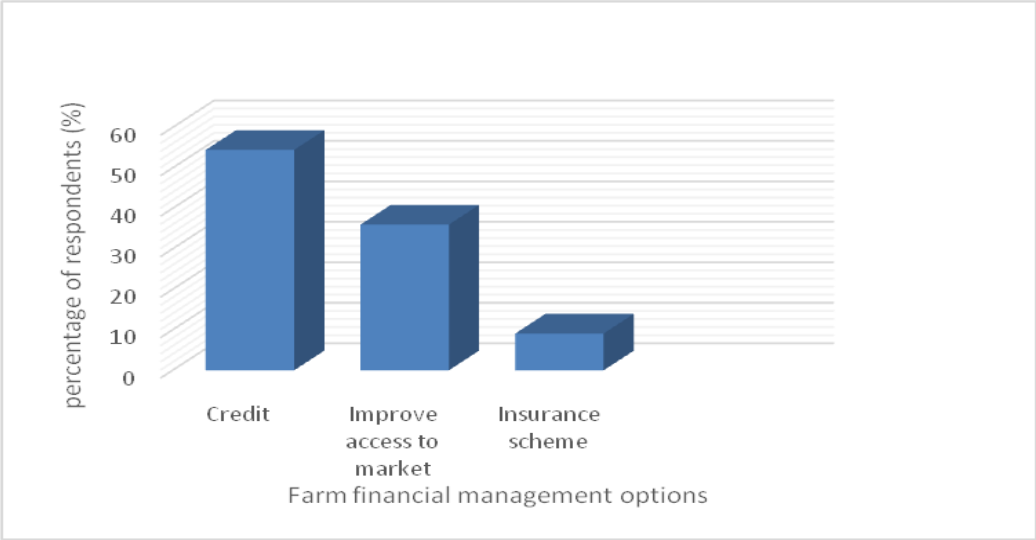

Figure 17: Farm financial management (n= 5) (Source: Field work, 2015)

Credit provision, the improvement of farmers' households' access to market and the provision of insurance scheme are done through a process called value chain. The value chain (Figure 18) is a process which consists on linking farmer groups with financial institutions (banks), input dealers, mechanized service providers and the market (buyers). The value chain is summarized as follow: the financial institutions pay the inputs dealers and mechanized service providers based on the farmer's needs, then inputs dealers and mechanized service providers provide in return their service to the farmer. At the harvest, the farmers sell their grain to buyers who belong also to the chain, and finally a part of the income gained by farmers is used to pay the financial institutions. This process is facilitated by both civic (i.e. ACDEP) and public institutions (i.e. MoFA, ICOUR).

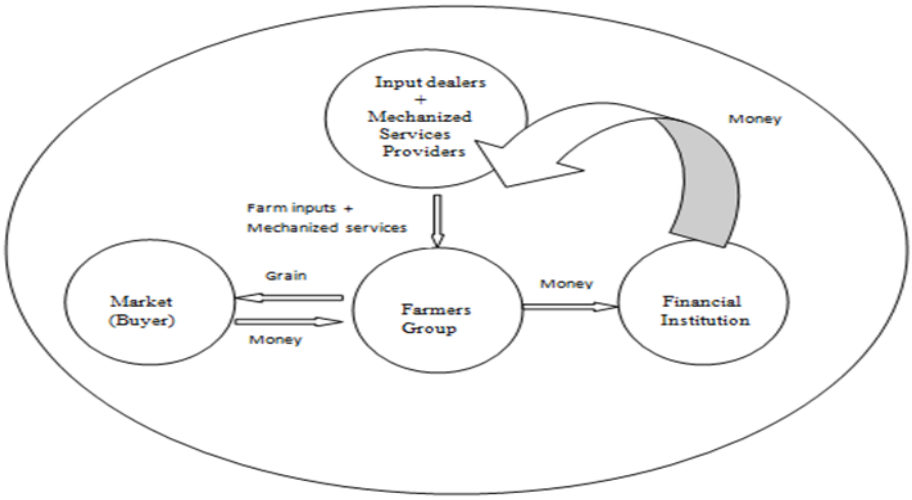

Figure 18: Value chain **(**Source: Field work, 2015)

Although the value chain is adopted to help farmers to be able to produce and have a better access to the market, this chain brings two risks that can affect both FHHs and the financial institutions. These are 1) FHHs could neither bargain the grain' price or store grain to sell them when the price would be high, thus, affecting farmers' households and 2) farmers can hide or sell a part of the harvest and put the fault on crop failure as result of changes in the climate, affecting financial institutions loans recovery. In addition FHHs are connected to insurance institutions only through the banks making those who have not access to be banks to be then, marginalized.

4) Government Assistance in Infrastructure, Health, and Risk Reduction

This type of adaptation has strong potential to influence farmers' risk management strategies. It is primarily done by public institutions (Figure 14b), particularly the local government (district assembly, NADMO, Ghana Health Service, ICOUR) through infrastructure development and rehabilitation (i.e., dams, dugouts, road, and bridges), but also the intervention in public health, disaster management (prevention and response) and afforestation. As the result of their efforts, several dams have been rehabilitated (Kansoe dam, Adaboya dam, Gambulgu dam, Feo dam, Go dam and Akasanga dam), dugouts have been built, roads have been constructed (Balungu-Gorigo, Gorigo-Tambulgo, Balungu-Soe, Apuwongo-Dua, Go kadare, Go akasarga and Apuwongo). However, civic institutions sometimes also intervene in the infrastructure investment. For example, Tree Aid built a reservoir in Amanga community for livestock during the dry season (Figure 19).

Figure 19: Reservoir built for livestock and tree watering during dry season in Amanga community (Photo credit: Mawulolo YOMO).

5) Knowledge Management, Network, and Governance

This class of adaptation includes the provision of climate and weather information to farmers' households, awareness raising and education. Out the 38 % of LIs involved in knowledge management, 57 % work toward education and training while 29 % are involved in awareness raising and 14 % in the provisioning of climate and weather information (Figure 20). However, knowledge management is ensured by all the type of local institutions (civic, private and public) but dominated by public ones (Figure 14b).

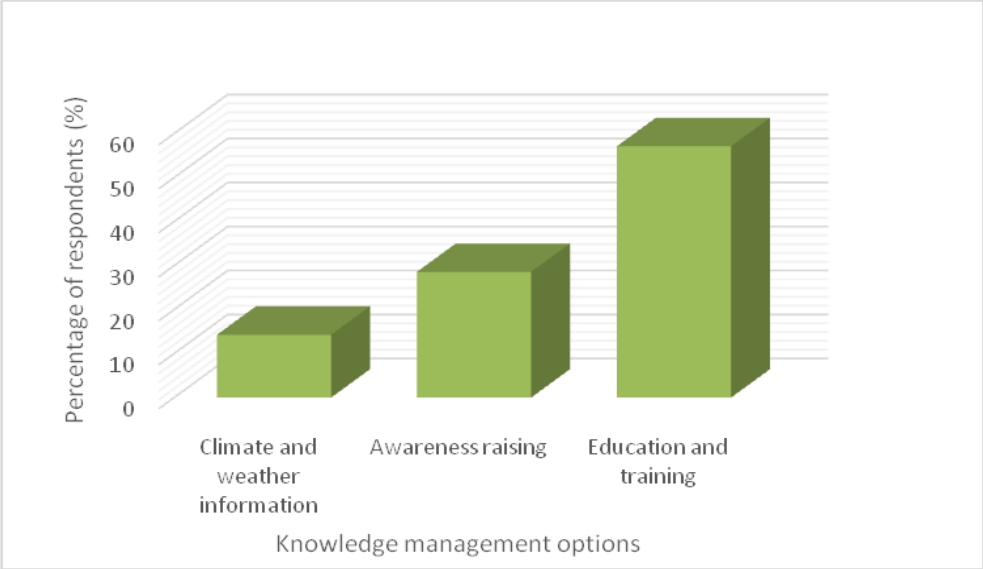

Figure 20: Knowledge management, network, and governance (n= 19) **(**Source: Field work, 2015)

Education and training are provided on agricultural practices (how to apply fertilizer, how to plant), pest and disease management, post-harvest management (crop storage and crop utilization), the preparation of organic fertilizers (compost and manure), the essence of afforestation, fund management, production and access to market, alternative livelihood programs, how to improve soil fertility and reduce soil erosion. Whereas, farmers' household's awareness is essentially raised on climate change, its impacts and ways to adapt to it; but also on how to prevent diseases that are recurrent in the area (such as Malaria, Meningitis).Weather forecast information is essentially access by FHHs through Radios (URA, Gurunee, and Word FM) and some private institutions (Esoko and Ignitia). Besides the actions and activities undertaken by these local institutions, the study revealed that only 22 % of the institutions assessed have integrated the Ghana National Adaptation Plan for Action (NAPA) directives into their activities. This explains the fact that the majority of these institutions are not directly involved in climate change adaptation.

In summary all the local institutions play a great role in farmers' adaptation through their intervention. However, as public institutions intervene in the five (5) classes of adaptation option against four (4) classes for civic institutions and one (1) class for private institutions, they are considered in this study as the most relevant ones.

4.1.2 Farmers' Households

4.1.2.1 Description of Farmers' Households Socio-economic Characteristics

Farmers' households'(FHHs) access to local institutions (LIs) and the impact of LIs' support on FHHs adaptation to climate change are obtained from a sample (n=120) which socio economic characteristics are described below (Table 6). From a total of 120 households, results shown that there are more male headed households (75) than female headed households (45). This is explained by the patrilineal nature of most of the communities in Northern Ghana, making men the head of households. These female households' heads are in most of the case widowers or divorced. In addition, the average households' size in the area is 8 with a seasonal income averaging 1043 GHS (273 USD). The majority of households heads assessed have no formal education (79 %) while those who obtained primary and secondary education constitute about 8 % and 10 % respectively.

Table 6: Farmers' Households socio-economic characteristics (Source: Field work, 2015)

Variables	**Characteristics**		
	N	Percentage proportion within the sample (%)	
Male headed households	75	63	
Female headed households	45	37	
Total households	120	100	
	Minimum	Maximum	Average
Household size (# of persons)	1	20	8,411765
Households seasonal income	600 GHS (157 USD)	2000 GHS (524 USD)	1042,8 (273 USD)
	Frequency		Percentage (%)
No formal education	95		79
Informal education	3		3
Primary	10		8
Secondary	12		10
Total	120		100

Furthermore, Figure 21 shows that the majority of household' heads assessed are within the category of 41 - 65, which is an experienced range, aware of the impacts of local institutions support on farmers' households' adaptation to climate change.

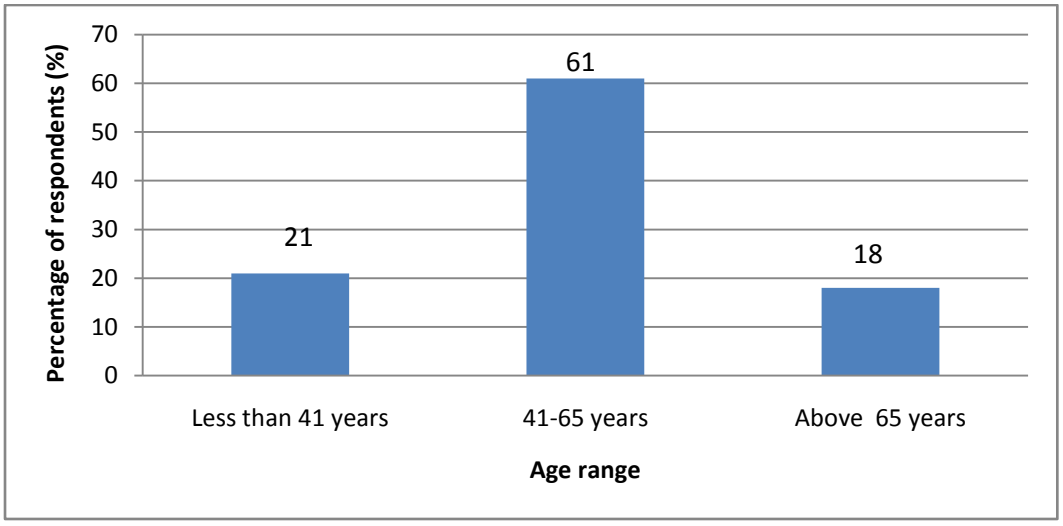

Figure 21: Age of household heads grouped by range (Source: Field work, 2015)

4.1.2.2 Farmers' Households' Access to Local Institutions

Most of the farmers' households' respondents have access to local institutions. Within the same district and even in the same community, farmers' households have different level of access to local institutions. While some of the households have access to more than one local institution (93 %), others (3 %) have access to only one (Figure 22).

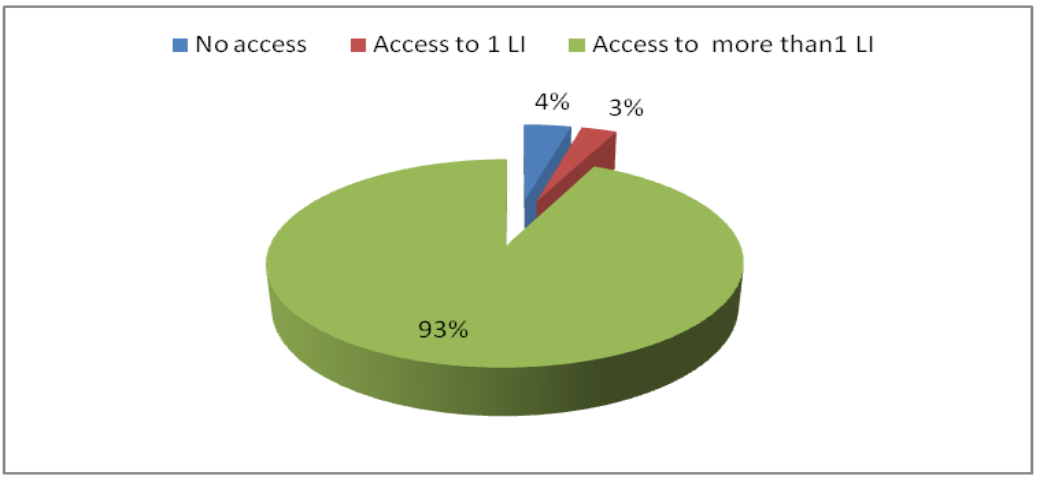

Figure 22: Farmers' household's access to local institutions in Bongo district (n = 120) (Source: Field work, 2015)

Among farmers' households having access to local institutions, some interact with these institutions through their participation in meetings (55 %) while others go beyond that to participate in decision making, therefore, shape these local institutions activities and initiatives (Figure 23).

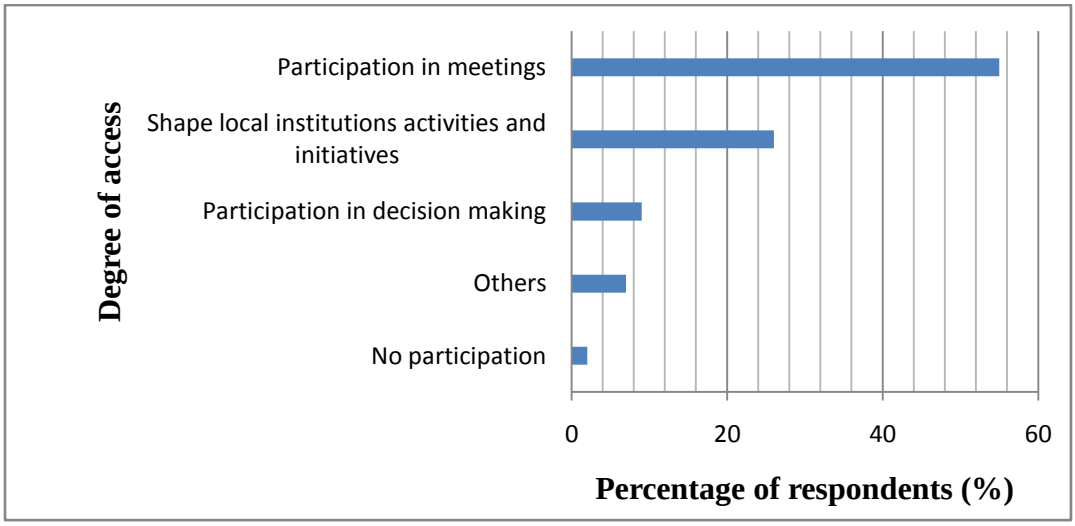

Figure 23: Degree of access to local institutions by farmers' households (Source: Field work, 2015)

As the result of their access to local institutions, farmers' households benefit cash money, livestock, food (resources) but also weather information and agricultural advice (consultation). However, Figure 24 shows that farmers' households in the study area access to local institution are more of consultation (61 %) than resources (32 %).

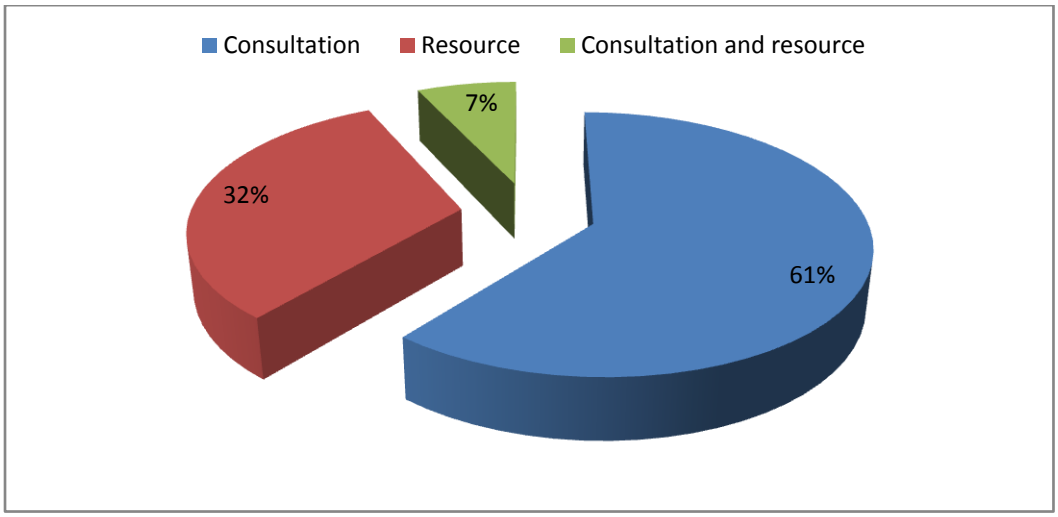

Figure 24: Type of access to local institutions by farmers' households (Source: Field work, 2015)

4.1.2.3 Farmers' Households' Perception on the Impact of Local Institutions' Interventions

As the result of the support provided by local institutions, majority of farmers' households' respondents (73 %) expressed their views on how LIs' interventions enhanced their adaptation to climate change whereas 27 % of the farmers' households' respondents did

not see any change (Figure 25). The absence of changes is viewed by these 27 % of the farmers' households' respondents as result of inadequate and untimely supports.

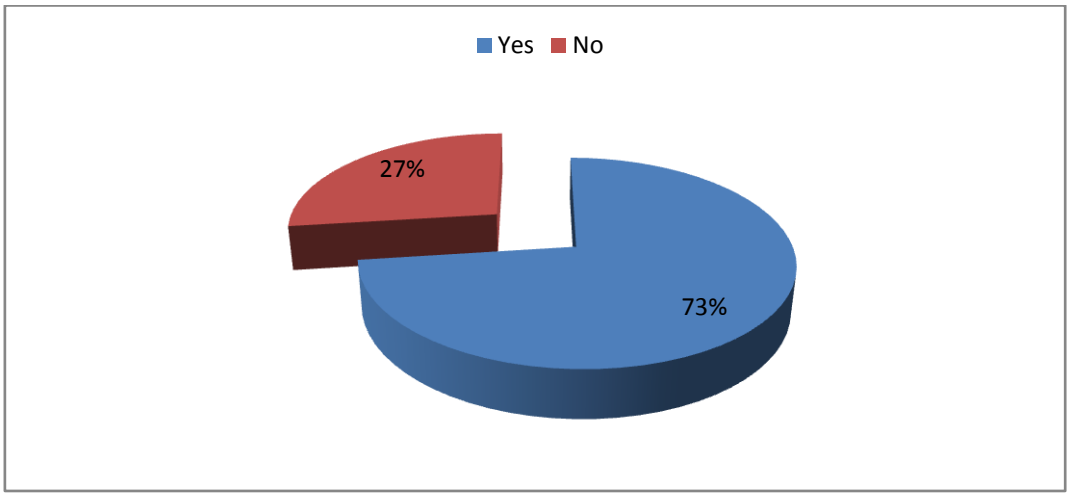

Figure 25: Farmers' households' perception on the impact of local institutions support on their adaptation to climate change (Source: Field work, 2015)

LIs' assistance was translated in FHHs adaptation to climate change on the following indicators:

1) **Increased Farmers' Households Income as the Result of Local Institutions Interventions**

Out of the 73 % of farmers' households'(FHHs) which perceived an enhancement in their adaptation to climate change, 64 % of the respondents experienced an increase in their annual income. This may be the results of alternative livelihood that have been introduced by local institutions such as aquaculture (RESULT), the extraction of non-timber forest product (RESULT, Community self reliance center), animal rearing (World vision), petty trade (World Vision), and basket weaving (Trade aid). These alternative livelihoods in fact, reduce FHHs' reliance on rain fed agriculture and offer to them other sources of livelihood.

2) **Increased Farmers' Households Food Security (farm productivity) as the result of Local Institutions' Interventions**

Out of the 73 % of respondents who perceived an enhancement in their adaptation to climate change, 62 % viewed that the support increased their farm productivity. Accordingly, the increase in FHHs' productivity is the result of technical support (MoFA), provision of farm inputs (ACDEP, World Vision, district assembly) and irrigation scheme (ICOUR).

3) Increased Farmers' Households Well-being as the Result of Local Institutions Interventions

As a result of the increased farm productivity and the increased annual income, farmers' households' well-being is also improved. Based on the Table 7, the major impacts the local institutions support has on FHHs' well-being are the availability of food for the households (48 %) and the ability for the households to ensure children education (13 %).

Table 7: Improved FHHs' well-being as the result of local institutions intervention (n= 61) (Source: Field work, 2015)

Improved farmers' households well-being	Percentage (%)
Availability of food for the household the next harvest	48
Ability to ensure children education	13
Availability of food for the household the next harvest + Ability to ensure children education	8
Ability to supplement food to the household	7
Ability to ensure children education + Ability to keep the environment clean	5

4) Reduced Farmers' Households' Vulnerability

In Bongo district the support provided by local institutions had also impacted farmers' households' vulnerability, particularly their sensitivity and adaptive capacity. About 73 % of the farmers' households' respondents perceived a reduction in their vulnerability to climate change. The respondent FHHs' sensitivity to climate change impacts decreased as a result of their involvement in other livelihood activities apart from farming (47%) and their awareness on climate change and its impacts on farming activities (32 %). In terms of adaptive capacity, the respondents confirmed that the usage of short duration crops (59%), improved seeds (14 %), fertilizer and manure (11 %) increased, therefore, increasing their adaptive capacity. These suggest that vulnerability is reduced as the result of decreased sensitivity and increased adaptive capacity.

5) Use of Natural Resource Base

Support to FHHs had also impacted the environment (83%). According to respondents, the benefits resulted from the support provided by the local institutions contributed mainly to the decrease of soil erosion rate in the area resulting in the low siltation of rivers. This is essentially the result of the adoption of good agricultural practices (planting of Vertivar grasses, plough across the slope….) provided by MoFA, trade aid among others.

4.1.3 Dynamic Perception on Coping Strategies under Climate Change

4.1.3.1 Local Institutions' Coping Strategies under Climate Change

The most common coping strategies developed by LIs under extreme rainfall variability are the selling of livestock (Table 8). It is usually done at the beginning of the rainy season when the rainfall pattern is not promising. Other coping strategies are tree planting and the harvest of rain water.

Table 8: Local Institutions' Coping Strategies under Climate Change, grazing game (Field work, 2015)

Coping strategy	**% of the cases (n= 19)**
Sell the livestock	34
Plant trees	20
Harvest rain water(build dams)	7
Supplementary feed	5
Usage of early maturing crop variety	5
Invest in the land's productivity	5
Usage of tree or crops branches to feed animals	3
Apply fertilizer	2
Sow nutritive pasture plants	2
Plant early	2

4.1.3.2 Local Ecological Knowledge for Coping with Uncertainty in the Climate

Besides the coping strategies, the games revealed local institutions reliance on ecological knowledge. Specific knowledge insights are shared by players during the games indicating means for coping with uncertainty.

1) **Small ruminants** - Although small animals were not represented in the game, several farmers reflected on the role of small ruminants (goat and sheep) as a way of coping with uncertainty. Small ruminants are considered as adapted to conditions with less pasture as the result of erratic rainfall.

2) **The role of bushes in soil fertility and microclimate** - Bushes were conserved and trees are planted as they provide regulating services (microclimate) and supporting services (soil fertility). However, they are development was considered as an unproductive land use in the game.

3) **The role of water bodies** - Ignored in the game board although very important component of ecological systems. Players precise their importance during dry season for vegetable growing and for water source for livestock.

4.1.3.3 Farmers' Households' Dynamic Perception against Local Institutions Perception on Coping Strategies under Climate Change

As local institutions are recognized to play a great role in individual or collective response to climate change, their coping strategies have been assessed and compared with farmers' households' coping strategies under dynamic setting using role playing games (Table 9). The following are the common and different strategies observed:

- The selling of livestock has been highly adopted by both local institutions and farmers' households. It represents also the only one strategy shared by both local institutions and farmers' households. However local institutions recognized that in reality, taking the decision to sell the livestock is not easy. On the other hand, it was observed that farmers let animals die rather than selling them.
- While local institutions adopt tree planting and rainwater harvesting as other major ways of coping with climate change impacts, farmers' households see the call for government help, seeking for jobs and the use of crops with less water requirement as very important.

Table 9: Cross analysis of the coping strategies between local institutions and farmers' households (Field work, 2015)

	Percentage of cases (n= 23)	
	Local institutions (Field work, 2015)	**Farmers' households** (Villamor and Badmos, under review)
Sell the livestock	41	39
Plant trees	24	3
Harvest rain water (build dams)/revive irrigation canals	8	3
Supplementary feed	6	0
Usage of early maturing crop variety	6	0
Invest in the land's productivity	6	0
Cut bushes / crop branches to feed livestock	4	3
Apply fertilizer	2	7
Sow nutritive pasture plants	2	0
Plant early	2	0
Call for government help	0	13
Seek for Job	0	13
Relocate near the dam	0	3
Relocate to forested area	0	3
Usage of crops with less water requirement	0	10

This difference in coping strategies developed by farmers' households and local institutions are due to many factors. Local institutions coping strategies under extreme climate are more oriented in tree planting may be because of the mandate they received to improve vegetative cover, based on their understanding of the role played by trees in climate change mitigation, microclimate and soil protection but also their awareness of laws regulating bush burning and deforestation, ensured by the Forestry Services Division. For example tree planting are reinforced by many local institutions including Bongo traditional councils through the Green Bongo for Sustainable Development, Tree Aid, NABOCADO, SADA among others. However, farmers' households coping strategies are oriented in calling for government help, seeking for job and using crops with less water requirement. This orientation means that farmers' households will depend on outside to cope with the changes, explaining how useful will be local institutions in their adaptation not only currently but also for the future. In addition, a comparison of the expected forms of support provided by local farmers and local institutions revealed the role of the government in assisting FHHs during extreme climatic events. The most important supports expected among other are the improvement of irrigation facilities and the provision of farm inputs (Table 10).

Table 10: Cross analysis of the expected forms of support from the government (Field work, 2015)

Form of support	**Frequency**	
	Farmers Households (Villamor and Badmos , under review)	Local institutions (Field work, 2015)
Irrigation services:	**14 (35 %)**	**16 (40 %)**
Restoring irrigation canals	7 (50 %)	5 (13 %)
Constructing a dam	6 (43 %)	5 (13 %)
Irrigation pump	1 (7 %)	5 (13 %)
Farm input:	**10 (25 %)**	**12 (30 %)**
Fertilizer subsidies	5 (13 %)	4 (10 %)
Machinery	3 (8 %)	3 (8 %)
New drought resistant varieties	2 (5 %)	5 (13 %)
Financial support	**7 (18 %)**	**5 (13 %)**
Food support	**5 (13 %)**	**3 (8 %)**
Create new jobs	**3 (8 %)**	**4 (10 %)**
No trust	**1(3 %)**	**0 (0 %)**

4.2 Discussion

Several authors highlighted the role of local institutions in facilitating local level adaptation to climate change (Adger, 2000; Agrawal, 2008; Rodima-Taylor et al., 2011; Amaru and Chhetri, 2013). Bongo district as a case study enabled to pin out relevant local institutions enabling adaptation, the support these institutions provide to farmers households and farmers households' access to these institutions.

4.2.1 Local Institutions

Local institutions (LIs) relevant to climate change adaptation are highly varied. Based on farmers' households' (FHHs) perception (degree centrality of each institution) and local institutions interventions in the various adaptation options, public institutions are found to be the most prominent in FHHs' adaptation to climate change at the district level. This result is contrary to several authors' findings. While Agrawal (2008) found informal social network as key actors in adaptation, Ochieng (2014) depicted formal civic institutions as key. This divergence could be explained by the fact that adaptation occurs in various contexts (disaster, Agriculture, forest management, water governance) and at various levels (village, community, district), therefore, involves different actors. All are nevertheless unanimous that local

institutions facilitating adaptation are public, civic (formal and informal) and private (Agrawal, 2008; Ochieng, 2014; Yaro et al., 2014).

Local institutions in Bongo district pinned out the increase in temperature, and the decrease in rainfall associated with frequent droughts and storms as being the way climate change is manifested in Bongo district. These results concur with farmers' households' perception on climate change manifestations (Antwi-Agyei, 2012). These results are confirmed by Obeng et al. (2009) who found an increase in temperature trend of about 1.9 ° Celcuis and a decrease in rainfall of about 20.5 mm in upper east region using 1931-2003 data series. According to local institutions respondents, changes in the climate are mainly caused by deforestation. The result concords with the general perceived cause of climate change in Ghana (Fosu- mensah et al., 2010). In addition, changes in the climate have been depicted to lead mainly to a decrease in agricultural yields as a result of crop failure and a shift in the type of crop cultivated. Aniah et al. (2014) have found the same results of the impacts of climate change on farming activities pinned out by farmers' households. To respond to these impacts, local institutions are supporting farmers households mainly with improved seeds (drought resistant crops, short duration crops), irrigation scheme in order to deal with climate risks associated with water stress through their intervention in on farm management . **These supports decrease the risk of crop failure; therefore build FHHs' capacity to adapt to crop failure**. Furthermore, through knowledge management, trainings in various subjects (including good agricultural practices, compost and manure preparation and crops storage for an effective production and a reduction in post-harvest losses) but also weather and climate information are provided helping FHHs to take decision relating to planting date and the type of crop to grow. In addition, Alternative livelihood opportunities such as animal rearing, aquaculture production, basket weaving, and extraction of non-timber product (honey, Shea butter, Dawadawa powder) are provided to FHHs, helping them to diversify their livelihood and to rely less on rain fed agriculture. **The low reliance on farming activities, the awareness of climate change and its impacts and the aptitude to adjust in planting date, reduce FHHs sensitivity to climate change**. **As a whole, LIs through their supports, shape risk (crop failure) and FHHs' vulnerability to climate change. In addition, these supports give to FHHs a framework to choose an adaptation options (diversification and storage).** The importance of the public investment in rural infrastructure, trainings (technical support), microcredit services and irrigation services in adaptation to climate change have been highlighted by several authors (Deressa et al., 2007; Nedumaran and Berger, 2009;

Below et al., 2012). However, less is done regarding livelihood diversification, farm financial management (credits, insurance scheme and access to market) and investment in infrastructure that are also very important in adaptation. The negligence of these aspects is found to be prevalent in upper east region (Yilma et al., 2008).

Local institutions identified are not working alone. They are assisted by national and regional government, international organizations and research centers in order to enable adaptation in Bongo district. Among things benefited by local institutions form extra local institutions are climate information (from Bolgatanga Meteorological Agency, WASCAL), fund (from Canadian Feed the Children, Phelix Foundation, Tree Aid), technology (Ministry of Food and Agriculture, Forest Resource Division, Water Resource Commission, SARI, UDS). **In this framework, local institutions mediate and ensure the flow of resources provided by extra local institutions regarding to FHHs adaptation to climate change. In summary local institutions facilitate farmers' households' adaptation to climate change by shaping their vulnerability and risks associated with climate change, offering a framework of adaptation options and by mediating external interventions.**

4.2.2 Farmers Households

Farmers' households are benefiting from these supports through their access to local institutions which act as mediators. However, this access varies within the same community. The result concurs with the view that within the same territory or village, households and social groups will have varying degrees and links to the institutions that are present (Agrawal, 2008; Ochieng, 2014). This is illustrated by households containing needy and elderly people having access to LEAP while those of farmers have access to MoFA and ICOUR, basket weavers having access to Trade aid and flood victims having access to NADMO. In addition access to local institutions varies across communities. This is due to the fact that local institutions intervention in a community depends on various factors, including the existence of a particular problem (NADMO in flood prone areas) and donors willing (particularly for NGOs) among others. Although most of farmers' households have access to local institutions through their participation in meeting, their access through the participation in decision making is the advised as it allow challenges faced by farmers' households as a result of changes in the climate to be integrated in local institutions activities as they interact with them.

4.2.3 Dynamic Perception on Coping Strategies under Climate Change

Local institutions and farmers' households have divergent coping strategies under projected extreme variability in rainfall. However, farmers' households to cope with these changes in the climate tend to rely on the outside (call for government help, revival of irrigation canals) and other activities (seek for jobs). Therefore, local institutions which have the ability to provide other alternative income activities and to provide support during crisis are key actors in facilitating adaptation at local level (Agrawal, 2008) but will continue to play this key role.

4.2.4 Verification of hypotheses

4.2.4.1 Farmers' Households Access to Local Institutions

Findings show that 96% of farmers' households' respondents have access to LIs with 93% having access to more than one LI and only 3% do not have access to any LI. Thus, hypothesis 1 (farmers' households have strong access to local institutions working in the area) is accepted.

4.2.4.2 The Enhancement of Farmers' Households' Adaptation to Climate Change Depends on their Access to Local Institutions

There is a correlation ($p = 0.01$) between farmers' households (FHHs) access to local institutions (LIs) and the enhancement of their adaptation to climate change (Table 11). Access to LIs influences positively FHHs' adaptation to climate change (41 %). Thus the hypothesis 2 (the enhancement of farmers' households' adaptation to climate change depends on their access to local institutions) is accepted.

Table 11: Correlation between the farmers' households' access to LIs and the enhanced adaptation (Source: Field work, 2015)

		FHHs' access to local institutions	Enhancement of FHHs adaptation
FHHs access to local institutions	Pearson Correlation	1	.410**
	Sig. (2-tailed)		.000
	N	120	120
Enhancement of FHHs' adaptation	Pearson Correlation	.410**	1
	Sig. (2-tailed)	.000	
	N	120	120

**.Correlation is significant at the 0.01 level (2-tailed).
FHHs stands for farmers' households

However, the correlation being at 41% means that FHHs' access to LIs may not be the only one factor defining the enhancement of FHHs' adaptation to climate change. This can be explained by Antwi-Agyei's findings (2012), where lack of financial resources and poor access to climate information can be obstacles for FHHs' adaptation to climate change.

4.2.4.3 Local Institutions in Bongo District Are more Reactive than Anticipative

As shown by the results (See figure 14 a), local institutions (LIs) in Bongo district are involved mostly in knowledge management (including education and training, awareness raising and climate and weather information) and on farm management (usage of improved varieties, adjustment in planting date and cropping systems, soil and water management, agroforestry, biotechnology, and reducing post-harvest losses, improving marketing and value addition). Through these supports, FHHs' awareness of climate change, its impacts and how to face them is increased helping them to define their planting date, to adjust in their cropping systems, to adopt improved varieties. As an example this year, based on the seasonal forecast FHHs have been advised to plant early. As a result those who planted early had good harvests of Naara (early millet) while those who planted after were not able to get good yield.

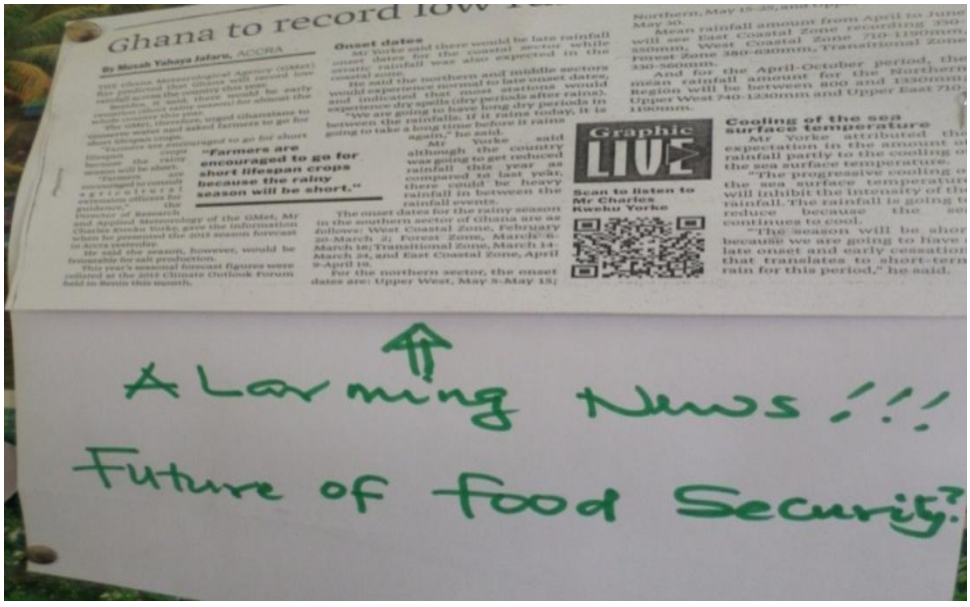

Figure 26: Figure showing how climate information is used by Trax-support to advise farmers' households (Photo credit: Mawulolo YOMO).

In addition, LIs take FHHs into diversification such petty trade, animal rearing, non-timber products extraction (honey, Dawadawa powder, Shea butter) and handicraft , which reduce their reliance on farming activities, then reduce their vulnerability to climate change impacts. In facts, all these activities are hold to minimize any impacts that may result from

changes in the climate, therefore, aim at anticipating these impacts. Thus, the hypothesis 4 (local institutions in bongo district are more reactive than anticipative) is rejected. However, some of these institutions such as Red Cross society and NADMO by intervening particularly in the case of disaster to supply relief items (food, building materials, blankets.....) act as reactive institutions.

4.2.4.4 Local Institutions and Local Farmers' Households Share the Same Perception on Coping Strategies to Adopt under Climate Change and Variability.

Based on the Table 9, only one coping strategy is shared by both local institutions and farmers' households while others are different. Therefore, local institutions and farmers' households do not share the same perception on coping strategies under climate change. Thus, the hypothesis 4 (local institutions and local farm households share the same perception on coping strategies to adopt under climate change and variability) is rejected.

CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Conclusion

Drought, one of the effects of the decreasing trends of climate induced changes in rainfall, is a serious problem to farmers' households in Bongo district in UER, Ghana. In addition to this condition, uncertainty in rainfall pattern in the area misleads farmers in the choice of planting date that results into crop failure, affecting the entire households. Therefore this study assessed the role of local institutions in farmers' household's adaptation to climate change in Bongo district using primary and secondary data.

Primary data used in this study includes data on institutions and data on farmers' households obtained through household interview, semi-structured key informant interview (SSKI), focus group discussion, and role playing games while the secondary data employed includes the profile of development partner working in Bongo district and coping strategies developed by farmers' households under climate change, gotten from published and non-publisher papers.

From focus group discussion several local institutions (formal and informal, public, private and civic) working with the communities have been identified. However, the background of Bongo district reveals that most of these local institutions are not directly involved in climate change adaptation but enable it while intervening in various domains of rural life.

Data from this study has shown that local institutions play an important role in farmers' households' adaptation to climate as they represent local capacities that enable farmers' households' to address the impacts climate change leaves on their farming activities. They facilitate adaptation by mediating and ensuring the flow of resources provided by extra local institutions regarding adaptation to climate change, by shaping farmers' households' vulnerability and by offering a framework of adaptation options. However, they are mostly involved in knowledge and on farm management while diversification, farm financial management and investment in infrastructure are less addressed. In addition, most of farmers' households' respondents in Bongo district access these local institutions through their participation in meeting with few participating in decision making. However, the lack of access to local institutions is mostly due to unawareness or unmet criteria of some farmers' households, unwillingness of others to participate, and the community group delivery nature of some supports.

It has been clear that in Bongo district, the local institutions identified to play the most important roles in farmers' households' adaptation to climate change are public institutions as they intervene in almost all the adaptation classes.

5.2 Policy recommendations

The policy recommendations we can draw from the study could be:

1) Ghanaian government should focus on diversification and farm financial management when building local institutions capacities.

2) As public local institutions represent key actors enabling adaptation in Bongo, Ghana government should allocate more resources (funds and logistics) to the local government for an effective adaptation.

3) The local government should think of investing more in infrastructure development especially irrigation infrastructures (dams and dugouts) as drought is the most recurrent climate event in the area and also equipping the Agriculture Department unit.

4) Incoming (new) non-governmental organizations should coordinate with existing local institutions in order to avoid duplication.

5) Farmers' households should have new farming model (where they have to invest in agriculture).

6) The continuation of this study must explore the linkages among local institutions and between local institutions and extra local institutions but also the impact of local institutions' support on FHHs' adaptation using data on income and agricultural yield.

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ANNEXES

ANNEX I: DEFINITION OF KEY TERMS

Access

Access refers to the extent to which different social groups and households within a certain area have connections to local institutions, including having the ability to benefit from assets and resources of these institutions as a consequence of their connections (Agrawal, 2008).

Anticipatory governance

According to future planners, anticipatory governance is "a system of institutions, rules and norms that provide a way to use foresight for the purpose of reducing risk, and to increase capacity to respond to events at early rather than later stages of their development"(Fuerth, 2009).

Climate change

Represents any change in climate over time, whether due to natural variability or as a result of human activities (IPCC, 2007).

Climate change Adaptation

It refers to the capacity of a system or community to adjust to a particular change in order to reduce the impacts of that change (Burton et al., 2002).

Climate variability

Climate variability refers to the statistical variations of climate system parameters at all temporal and spatial scales which are gradual and slow (IPCC/ SREX, 2012).

Extra Local institution

Are institutions whether public, civil or private organizations and individuals whose accountability and legitimacy is derived beyond the scope of the communities within which they normally operate (Agrawal, 2008).

Formal institution

Any institution with an organizational structure and which has taken steps to be legalized according to Ghanaian law.

Informal institution

Any institution with an organizational structure and which has not taken steps to be legalized according to Ghana law

Institution

Institutions are seen as humanly created mechanisms (formal and informal) that shape social and individual expectations, interactions, and behavior (Agrawal and Perrin, 2008) while Young (2002) defines them as being rules or norms which define the roles, rights and responsibilities of actors. Meanwhile, IPCC (2014: 17) views institutions as rules and norms held in common by social actors that guide, constrain, and shape human interaction. Institutions can be formal (laws and policies) or informal (norms and conventions). However, McGray and Sokona (2012) define institutions as formal and informal organizations through which society structures shared decision-making and takes collective action.

Livelihood outcome

Are achievements or outputs of livelihood strategies, such as more income, increased well-being, reduced vulnerability, improved food security (farm productivity and a more sustainable use of natural resource (GLOPP, 2008).

Local institution

Local institutions are seen as public or civic or private organizations and individuals whose accountability and legitimacy is derived within the scope of the communities within which they normally operate (adapted from Agrawal, 2008).

Social Learning

Social learning is a process of concerted action (or performance) that requires a convergence of understanding and practice among multiple stakeholders leading to agreement on a way progress situation of concern within conductive institutional settings (Wallis et al., 2013).

Vulnerability

According to Adger (2006), vulnerability is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt. Therefore vulnerability is function of exposure susceptibility and adaptive capacity.

ANNEX II: INSTITUTION PERCEPTION MAPPING (IPM) APPROACH

Preliminary

Community assessed.....
Date.....
Participants to the focus group discussion.....
.....

Section1: climate change and its impacts

1. What is the seasonal distribution in your area?

a. 2rainy seasons and 2 dry seasons
b. 1rainy season and 1 dry season
c. Other……

2. Are there any changes in the season distribution these last 10-30 years?

1. Yes 2. No

3. What are the impacts of climate change on farming activities in Bongo district?

a. Increase in agriculture yield
b. Decrease in agriculture yield
c. Shift in the type of crop cultivated
d. Others

……

Section 2: Institutional perception mapping procedure and mapping exercise

STEPS	PROCEDURE
Step1:Welcome all the participants	• Welcome them and make them feel comfortable
Step 2: Provide instruction and explanations regarding the FGD objective	• **Overall objective: Identify local institutions working in the community, their level of importance and accessibility by farmers.** • **Cards** will be used to do this exercise. • The level of importance of the institutions(which institution supports you more) working with you will be ranked using the card numbered from 0 to 5.

	 • Local institutions accessibility by farmers will be ranked using the size of the card(smallest and largest cards) The small card (2) = Difficult access The large card (1) = Easy access The medium card (0) = Medium access • The type of relationship between local institutions and farmers will be ranked using arrows. One way arrow (1) = Mutual relationship Two ways arrow (2) = Unique direction relationship
Step 3: Produce an institutional perception map	Map
Step 4: Analyze the Institutional Perception Map	• Ask the local analysts to explore and explain the basis of each relationship and discuss how these relationships can be changed or improved. • Explore the possible opportunities and constraints to change.
Step 5: **Conclude the activity**	• Check again that the farmers know how the information will be used. • Thank the local analysts for their time and effort.

Section 3: Mapping exercise

1. What are the institutions (Cooperatives, association, government agencies, NGOs) helping you to adapt to climate change impacts on your crops and livelihood.
2. Using the cards (based on the size of the card) indicate the institutions that help you more in this area in terms of advice, training, education, credit, improved seeds….(Use the cards forms).

3. Do these institutions consult (needs, information) you or they only bring information to you (advice, strategies, technology) to help you adapt to climate change

Distribution of local institutions per community in Bongo district

IMPORTANCE SCALE (relevance for adaptation)

Very high = 5, High = 4, Medium = 3, Acceptable = 2, Low = 1, Very low = 0

ACCESSIBILITY SCALE

The small card (2) = Difficult access, the large card (1) = Easy access, the medium card (0) = Medium access

RELATIONSHIP SCALE

2 ways relationship = 2, 1 way relationship = 1

Community 1: AMANGA

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
NADMO	3	2	2
MoFA	2	2	1
Ghana Health Service	4	1	2
NABOCADO	1	2	2
Tree Aid	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 2: SUNABISI

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
WORLD VISION	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 3: LUNGO

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
MoFA	0	2	2
Tree Aid	2	1	2
RADIO	5	2	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	1

Community 4: BOKO

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
WORLD VISION	4	1	2
RESULT	5	1	2
Tree Aid	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 5: VEA

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
WORLD VISION	2	1	2
MoFA	1	0	1
Trade Aid	4	1	2
Real Life Fellowship	3	2	2
Village microcredit	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 6: BALUNGU

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
NADMO	4	2	1
WORLD VISION	5	1	2
MoFA	2	1	1
Red Cross society	5	2	1
SADA	4	1	2
Tree Aid	1	2	1
GSOP	5	2	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 7: TAMOLGA

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
NADMO	5	2	2
WORLD VISION	5	1	2
RESULT	5	1	2
MoFA	5	2	1
Red Cross society	3	2	2
Action Aid	4	2	1
ACDEP	5	1	2
Shea butter extraction Group	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 8: GOWRIE

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
NADMO	3	2	1
WORLD VISION	5	1	2
MoFA	4	1	2
ICOUR	5	1	1
SADA	2	1	1
TRAX	4	1	2
LEAP	4	2	2
ACDEP	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 9: FEO

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
ADRA	5	1	2
WORLD VISION	4	1	2
MoFA	4	1	2
ACDEP	3	1	2
SADA	2	2	2
LEAP	3	1	2

GSOP	1	1	2
Trans-border Onchocerciasis Freed Zone Program	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 10: NYARIGA

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
GSOP	5	0	1
ACTION AID	2	2	2
CRS	5	2	2
LEAP	5	1	2
NADMO	2	2	1
ADRA	1	2	1
WOMEN GROUP	5	1	2
MoFA	2	2	1
WORLD VISION	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community 11: CENTRAL BONGO

LOCAL INSTITUTION	LEVEL OF IMPORTANCE	ACCESSIBILITY	RELATIONSHIP
Tree Aid	5	1	2
WORLD VISION	5	1	2
MoFA	4	1	2
TRAX	4	1	2
ACDEP	3	2	1
RESULT	5	1	2
Naara Rural Bank	3	1	2
Microcredit	5	1	2
ESOKO	0	1	1
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Community12: AWULABISI

Local institution	Level of importance	Accessibility	relationship
GSOP	5	0	1
ACTION AID	2	2	2
CRS	5	2	2
LEAP	5	1	2
NADMO	2	2	1
ADRA	1	2	1
WOMEN GROUP	5	1	2
MoFA	2	2	1
WORLD VISION	5	1	2
RADIO	5	1	2
TRADITIONAL COUNCIL	0	1	2
UNIT COMMITTEE	0	1	2

Centrality Measures of Local institutions in Bongo District

Local institutions	Type	Degree centrality	Betweenness centrality	Closeness centrality
RADIO	Civic	0,444444444	0,251068376	1782
Traditional Council	Public	0,444444444	0,251068376	1782
Unit Committee	Public	0,444444444	0,251068376	1782
MoFA	Public	0,37037037	0,19825641	1890
World Vision	Civic	0,37037037	0,16760114	1998
NADMO	Public	0,222222222	0,055264957	2430
Tree Aid	Civic	0,185185185	0,030461538	2700
ACDEP	Civic	0,148148148	0,027954416	2538
GSOP	Public	0,148148148	0,011760684	2808
LEAP	Public	0,148148148	0,014566952	2808
Action Aid	Civic	0,111111111	0,007390313	2916
ADRA	Civic	0,111111111	0,004911681	2970
RESULT	Civic	0,111111111	0,009823362	2916
SADA	Civic	0,111111111	0,007002849	2916
CRS	Civic	0,074074074	0,000236467	3186
Microcredit	Civic	0,074074074	0,00639886	3078
Red,Cross	Private	0,074074074	0,002091168	3078
TRAX	Civic	0,074074074	0,004831909	2970
Women Group	Civic	0,074074074	0,000236467	3186
ESOKO	Private	0,037037037	0	3240
Ghana Health Service	Public	0,037037037	0	3456
ICOUR	Public	0,037037037	0	3294
Naara,Bank	Public	0,037037037	0	3240
NABOCADO	Civic	0,037037037	0	3456

Real Life Fellowship	Civic	0,037037037	0	3456
Shea butter extraction Group	Civic	0,037037037	0	3294
TOFZP	Civic	0,037037037	0	3294
Trade Aid	Civic	0,037037037	0	3456

ANNEX III: QUESTIONNAIRE FOR SEMI-STRUCTURED KEY INTERVIEW

Introduction

As part of the requirement for the award of MSc. in Climate Change and Human Security, this study is aimed at assessing the role of local institutions in enhancing farmers' households' adaptation to climate change.
The information obtained through this study is not meant for any political nor governmental purposes but for the purpose of MSc. Research of the Researcher.
You are assured of the confidential treatment of the valuable information you supply to me.

Researcher's Name: Mawulolo YOMO

Researcher's Affiliation: West African Science Service Center on Climate Change and Adapted Land Use, University of Lome, Togo.

SECTION 1- Preliminary

Name of the institution……

Year of creation……

Address of the institution……

Name of the interviewee……

Highest education status of the interviewee

Tertiary ☐ License /BScs ☐ MScs ☐ PhD ☐

Post occupied by the interviewee in the institution……

Since when are you employee of the institution?

1 year ☐ 5 years ☐ 10 years ☐ More ☐

Name of the interviewer……

Date the questionnaire is filled……

SECTION 2- Description of the Institution

2.1What are your areas of interest?

2.2 What are your major priorities (goals)?

2.3 What are your specific priorities (goals)?

2.4 What are the measures taken to achieve these priorities (goals)?

In your opinion, did you achieve your goals with regard to these priorities?

1. Yes 2. No

2.5 Is your institution working in Bongo district (Villages in Bongo district)?

1. Yes 2. No

2.6 What are the communities in Bongo district your institution work with (area of coverage in Bongo)?

2.7 Is your institution working under the umbrella of another institution?

1. Yes 2. No

2.8 If yes, give the institution in question

SECTION 3 - Level of Awareness and Understanding of the Institution on Climate Change and Realities in Bongo

3.1 What is the seasonal distribution in Bongo?

a. 2rainy seasons and 2 dry seasons
b. 1rainy season and 1 dry season
c. Other

3.2 Are there any changes in the season distribution these last 30 years?

1. Yes 2. No

3.3 If yes what evidence (proofs) of climate change do you see in the district? Tick as many as applicable

a. High temperature
b. Low temperature
c. Decrease in the rain (drought)
d. More important rain (flooding)
e. Disturbance in the rain distribution
f. Change in seasons length (precise the length)
g. Others

3.4 What are the climate events occurring in the area as a result of changes in the climate? And what are their frequencies? Tick as many as applicable

Climate events	Occurrence	Frequency
Drought	1. No 2. Yes	1. Less frequent 2. More frequent

Flooding	1. No 2. Yes	1. Less frequent 2. More frequent
Storm(strong wind)	1. No 2. Yes	1. Less frequent 2. More frequent
Fire	1. No 2. Yes	1. Less frequent 2. More frequent
Insect invasion	1. No 2. Yes	1. Less frequent 2. More frequent
Others		

3.5 What are the causes of these changes? Tick as many as applicable

a. God will
b. Deforestation
c. Our sin
d. Greenhouse effect (from Greenhouse gases)
e. Nature
f. Abandon of traditions
g. Other

3.6 Are you aware of the impacts of climate change on farming activities in Bongo district?

1 Yes 2. No

3.7 If yes tick these options as many as applicable

e. Increase in agriculture yield
f. Decrease in agriculture yield
g. Shift in the type of crop cultivated
h. Famine
i. Others

3.8 According to you, are farmers able to cope with these impacts?

1. Yes 2. No

3.9 If yes, what are some of the strategies developed by farmers to cope with these changes?

3.10 Where do you get the above climate change information?

a. From farmers
b. From scientific report
c. Institution's assessment
d. From other institutions

If ticked, give the name of these institutions

3.11 Is your Institution helping farmers to address the negative effects of climate change on their crops and their livelihood?

1. Yes 2. No

3.12 Are you aware of any climate change adaptation program?

1. Yes 2. No

3.13 Have you consulted programs on Climate Change Adaptation?

1. Yes 2. No

3.14 If yes, which of the following Climate Change Adaptation document do you use?

a. National Adaptation Programs of Action (NAPA)
b. METASIP (Medium Term Agriculture Sector development program)
c. FASDEP (Food and Agriculture Sector Development Program)
d. District Medium Term Development Plan
e. Others

3.15 How are these documents integrated into your planning and priorities?

1. Yes 2. No

If No, why?

SECTION4 - Support Provided by Local Institutions Regarding Farmers' Households' Adaptation to Climate Change

4.1 Based on recent experience, what does your institution do to enhance farmers' households' adaptation to climate change? Tick as many as applicable

1. Knowledge management
   b. Education and training
      i. On crop storage
      ii. On crop utilization
      iii. On pest and disease management
      iv. Type of crop to sow at a particular
      v. Alternative livelihood program
      vi. Agricultural practices
   c. Awareness raising
   d. Support with climate and weather information
2. Farm financial management
   a. Credit
      i. Cashless (input)
      ii. Cash (to afford input or to enhance the adoption of alternative livelihood)
   b. Improve access to market
   c. Crop Insurance Scheme
3. On farm management
   a. Improved seed (drought resistant seed, insect resistant seed)
   b. Fertilizers and pesticides
   c. Tractors

d. Reduction of post-harvest losses
e. Biotechnology
f. Soil and water conservation
    i. Irrigation scheme
    ii. Fertilizers and pesticides
    iii. Tree planting

4. Investment in infrastructure improvement
    a. Roads
    b. Market sheds and stores
    c. Irrigation infrastructure
        i. Dam
        ii. Dugout
    d. Bridge

5. Diversification

1. On farm diversification
    i. Animal rearing
    ii. Non-timber product extraction (Shea butter, honey.....)

2. Off farm diversification
    i. Petty trade
    ii. Basket weaving

6. Others

4.2 Does the institution currently have projects or initiatives regarding to Bongo's farmers adaptation climate adaptation?

1. Yes 2. No

4.3 If yes, list these projects and their duration

Project	Duration

4.5 If no, why?

4.6 What are the main constraints your institution faces in enhancing farming households adaptation to climate change?

1. Financial constraints

   1. Yes 2. No

How?

2. Human constraints

   1. Yes 2. No

How?

3. Technical constraints

   1. Yes 2. No

How?

4. Others

4.5 Are you aware of other relevant institutions working in the same domain as you?

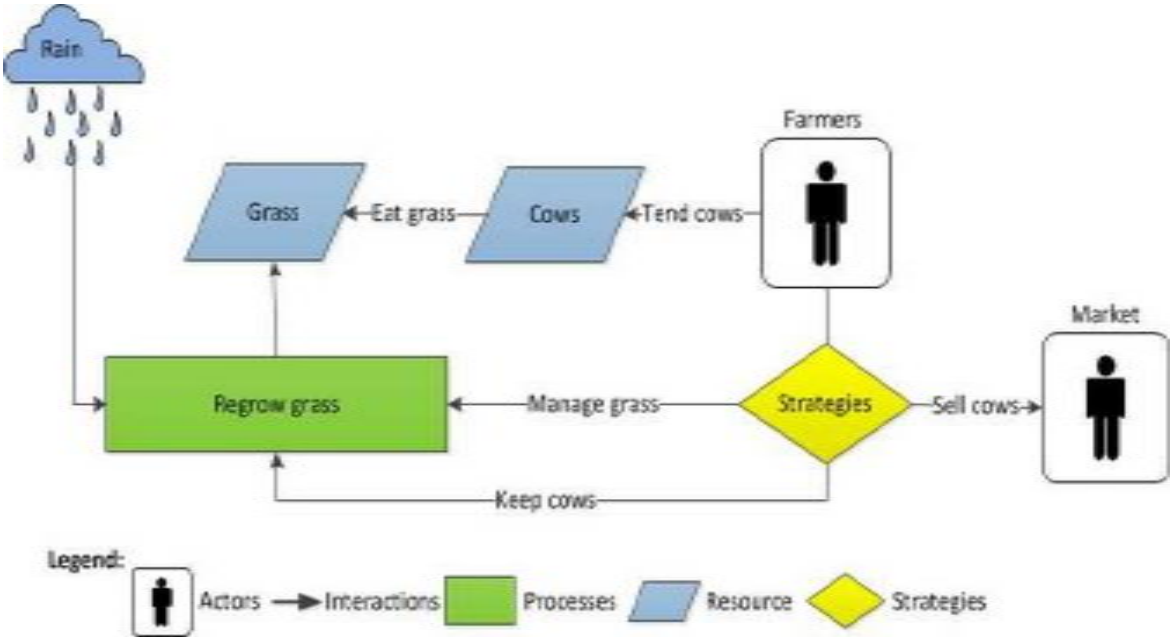
1. Yes 2. No

4.6 If yes, list them and give the relationship between your institution and that institution

List of institutions	Relationship between the institutions

ANNEX IV: GRAZING GAME MATERIAL AND PROCEDURE

1. Grazing game conceptual model



Source: Villamor et al. (Under review)

2. Grazing Game Material

The game board representing all available land is organized by a grid of 8 x 8 cells, each of which measuring 5 x 5 cm, for a total of 64 cells or 'patches' of land on the game board. A total of 16 patches at the center of the game board represent a 'valley', where water is assumed to be available throughout the year.

A six-sided die is used to determine the amount of rainfall and grass production before each round of the game. Herd indicators (e.g., pebbles) are used to represent herds of cows and each herd is composed of five cows.

Land patches are colored-coded according to land cover type; red patches represent desert and green patches represent bush or grass. Colored pins are used to indicate the quantity of grasses and crops. A score sheet is provided to monitor the status of individual players such as the number of cows produced (yield), the number of cow sold and a recorder for cross-checking the conversations of the players.

Game board and die with actors of local institutions during the game in Bongo district

3. Game Rules

3.1 Round/time Step

Each time step or round of the game represents one annual cycle. Each year is divided into two seasons—a rainy season and a dry season. The rainy season begins in April and lasts for a period of seven months. Afterwards the dry season begins in November and ends in March. In northern Ghana, rainy season is also referred to as growing season.

3.2 Rainfall and Vegetation

In dry-land areas rainfall is low and erratic. In the game the die is used to determine the amount of rainfall once a year for each land patch on the board. The amount of grass growth varies along a range from one to six markers. For example, if the die indicates a number one then each field of the board will have a unit of grass during that round of the game.

3.3 Grazing

Every month each cow in a herd requires one unit of grass. The herd can move through two neighboring patches per month. In the seventh month of the rainy season all patches may be

grazed. If the full requirements of the cows are not met, they can be fed at half a ration, but this will affect both reproduction and sale value. If individual cows are not fed at all they perish. The crop residues remaining after the harvest of corn, millet, peanut or groundnut (*Arachis hypogaea*), and rice can be used to feed cows, but only during the month that crops are harvested.

3.4 Reproduction and Sale

At the end of each dry season the cows that have been fed full rations for the past six months give birth to a calf. At the end of each rainy season cows can be sold at the discretion of the player. If cows have not been fully fed over the previous 6 months their value (count) is reduced by one-half. If a herd consists of six cows or more it may be split into two sub-herds that graze separately. Sub-herds must be reunited if they are reduced to less than three cows.

3.5 Regrowth of Vegetation

After the first year there are additional rules for determining the vegetation on the basis of rainfall:

- *If there is no vegetation remaining in a patch of land at the end of each round, nothing will grow (it becomes desert) in the subsequent round.*
- *If the vegetation in a patch of land is reduced to one unit the vegetation will recover slowly. The rainfall determined by the subsequent roll of the die will only produce half (rounded down) of the quantity of grass that would grow under normal conditions(1 = **0** markers; 2 & 3 = **1**; 4 & 5 = **2**; 6 = **3**).*
- *If the vegetation marker for a land patch is six at the end of a round and the next roll of the die results in a six the vegetation changes from grass to bush and no longer had any forage value.*

4. Players

In terms of players, each game included five to 15 players. Each game had a game master, an observer to document the conversation each round, and a recorder to maintain scores and facilitate the process.

5. Session Steps

Before the beginning of each game the players were asked to locate four patches with their choice of crops (e.g., one unit of millet, one unit of corn, one unit of rice, and one unit of groundnut). Each player begins with a herd of five cows that will graze in one of the suitable

patches. The objectives are to manage the herd to maximize the production of cows and avoid desertification. The game master explained the objectives and the rules of the game (section 3), including the score sheets. The score sheets were used to track the indicators (e.g., primary production of grass, amount of grass used, number of calves produced, number of desert patches, number of bush patches, number of sold cows, and number of fertilizer bought) during each round.

A pretest was conducted before each full game trial to make certain that the rules of the game were clearly understood by the players. Each full game consisted of five rounds. Each round was composed of 12 months. Depending on the number of players per game, players rotated turns per month or per year to graze (move) on the game board. Each herd began grazing inside the valley (central 16 patches on the board) for the first month of year/round one before the herd can be moved to graze outside the valley. The game master would score the result after each round and announce the status of achieving the players' goals (i.e., the number of calves produced and the number of desert or bush patches created). During the course of each annual round the game master would also announce the beginning and end of the rainy and dry seasons, and ask whether players if they want to sell cows. At the end of each game a reflection exercise was conducted to clarify and verify the strategies/decisions made by the players and for them to assess the overall game. Typically, we asked multiple choice and open-ended questions regarding the quality of game (i.e., playability, perceived value as a learning tool etc.), reflection of reality, cooperation, role of the government and ways to improve the game.

6. Additional Scenarios

The game master announced scenarios on the following years:

- At the beginning of year 3 a new household with a new herd (i.e., five cows) was added as a population increase scenario. The new household would select four new blocks for the crop production (i.e. millet, corn, rice, and groundnut). The purpose of this scenario is to understand the players' response to competition for available patches of grasses.
- At the beginning of year 4 a fertilizer subsidy was offered to restore grass in desert patches in exchange for a cow. One cow could replenish the units of grasses depending on the rainfall as well. This scenario explored players' perceptions on fertilizer subsidies of the local government in the study area.
- At the beginning of year 5 the game resumed the original scenario.

GAME REFLECTION GUIDE

1. How did you find the game?

☐ Boring ☐ Hard ☐ Easy ☐ Fun ☐ Educational

☐ Other……..

2. Does it reflect the reality?

☐ Yes, what aspect does the game appears to be real?

- Rainfall pattern
- Feeding habits of the animals in the valley
- Neighbors competing for resources
- Fertilizer availability

☐ Others……

No, the game is not real at all

3. If rainfall pattern will be much less in the coming 5 years, what plans or strategies can you do to survive or solve the problem of :

☐ Overgrazing?
.....

☐ Desertification?
.....

☐ Erratic rainfall?
.....

Will cooperation with your neighborhood assist you to survive?

☐ Yes, example of cooperation activities
……

☐ No, why

……
……

What support or assistance can you recommend?

……
……

As institutions, important in farmers' adaptation to the current variability and change in the climate, do you assist farmers with all the supports you recommended?

☐ Yes, give the example of support

……
……

Do you think that the support you have given to them build them up to face and take advantage of these current change and future changes?

☐ No

If No, Why.....

Do you think that the following support recommended by farmers is valid?

Form of support	Frequency	Institution 's opinion
Irrigation services:	**14(35%)**	
Restoring irrigation canals	7(50%)	
Constructing a dam	6(43%)	
Irrigation pump	1(7%)	
Farm input:	**10(25%)**	
Fertilizer subsidies	5(13%)	
Machinery	3(8%)	
New drought resistant varieties	2(5%)	
Financial support	**7(18%)**	
Food support	**5(13%)**	
Create new jobs	**3(8%)**	
No trust	**1(3%)**	

4. Are there other common problems in the area that need to be captured in the game?

.....
.....

5. Would you play this game again?

☐ Yes ☐ No

6. Any suggestion to improve the game

.....
.....

ANNEX V: QUESTIONNAIRE FOR HOUSEHOLD INTERVIEW

You are assured of the confidential treatment of the valuable information you supply to us.

PRELIMINARY

Name of the community…….
Name of the Interviewee…….
Name of the Interviewer…….
Date of the interview……..

Section 1: Socio-Economic Characteristics

Age: 18-25 ☐ 26-30 ☐ 31-35 ☐ 36-40 ☐ 41-45 ☐

46-50 ☐ 51-55 ☐ 56-60 ☐ 60-65 ☐ Above 65 ☐

Gender: Male ☐ Female ☐

Marital Status: (a) Single Mother (b) Married (c) Widowed (d) Divorced (e) Separated (f) Never Married

Household Size……

Education level (a) Primary (b) Secondary (c) Licence/BSc (d) PGD/MSc (e) Illiterate

What is the range of your seasonal income (in Cedis)?

- Less than 600
- 600-700
- 701-800
- 801-900
- 901-1000
- Above 1000

What is the main crop you grow?

- Sorghum
- Millet
- Maize
- Groundnut
- Cowpea
- Rice
- Soya bean
- Bean

Section 2: Climate Change and its Impacts

In the last 30 years, how many years did you live in this district?

Have you noticed any changes in the climate pattern in the past 30 years?

1. Yes 2. No

If yes, how are these changes in climate manifesting in the area?

……
….....

What are the impacts of climate change on your household?

a. Decrease in farm productivity

b. Decrease in household income
c. Decrease in household welfare
d. Others

Section 3: Farmers' Households' Access to Local Institutions

Are some institutions supporting farmers' households in your community to adapt to climate change?

1. Yes 2. No

From which of the following institutions is your household beneficiary?

Local Institutions	Household' access	Type of access	Degree of access	Frequency of intervention	If yes, how did you get connected to the institution? If no, Why?
1. LEAP	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
2. GSOP	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
3. MoFA	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
4. Naara Rural bank	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
5. Bongo Rural bank	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
6. ICOUR	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	

7. NADMO	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
8. Ghana Health Service	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
9. TRAX	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
10. Action Aid	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
11. Tree Aid	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
12. Trade Aid	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
13. Nabocado	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
14. ACDEP	1. Yes 2. No	1. Consultation 2. Resources	1. Participation to meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis	

				3. Weekly basis	
15. World Vision	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
16. Ghana Red Cross Society	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation to decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
17. RESULT	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
18. Traditional council	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
19. Unit committee	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
20. Women Group (Shea butter extraction)	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
21. Abalungu Cooperative	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
22. Gowrie Women group	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
23. Adelewini	1. Yes2. No	1. Consultation	1. Participation in meeting 2. Participation in	1. Yearly basis	

group		2. Resources	decision making 3. Shape local institutions activities and initiatives	2. Monthly basis 3. Weekly basis	
24. Azindoo group	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
25. Anafubisi group	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
26. Asongtaba Nayire	1. Yes 2. No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
27. Edsongobe ngbre	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
28. URA Radio	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
29. Word FM	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
30. Gurune Radio	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
31. Microcredit Group (saving)	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	

32. Religion based group (precise)	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
33. Religion based group (precise)	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
34. Other1 (precise)	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	
35. Other2 (precise)	1. Yes 2.No	1. Consultation 2. Resources	1. Participation in meeting 2. Participation in decision making 3. Shape local institutions activities and initiatives	1. Yearly basis 2. Monthly basis 3. Weekly basis	

Section 4: A**ssessment of the Enhancement in Farmers' Household' Adaptation to Climate Change**

How did /is the institutions you are beneficiary supported (supporting) you?

……

……

Is the support you received from these local institutions enhanced your adaptation to climate impacts?

1. Yes 2. No

Which changes did you observed as a result of the support you received from local institutions?

a. Increased income

What was the range of your annual income (in Cedis) before receiving support?

- Less than 600
- 601-700
- 701-800
- 801-900
- 901-1000
- Above 1000

What is the range of your annual income (in Cedis) after receiving support?

- Less than 600
- 601-700
- 701-800
- 801-900
- 901-1000
- Above 1000

b. Increased farm productivity (Food Security)

What was the yield of the main crop you grow before receiving support?

- 1-2 bags
- 3-4 bags
- 5-6 bags
- 7-10 bags
- Above 10 bags

What is the yield of the main crop you grow after receiving support?

- 1-2 bags
- 3-4 bags
- 5-6 bags
- 7-10 bags
- Above 10 bags

c. Increase in household well-being

How?.....
.....

d. Reduced Vulnerability

- As a result of reduced exposure
- As a result of reduced sensitivity
- As a result of an increased adaptive capacity

How?.....
.....

e. More sustainable use of natural resource base

- Less soil erosion (source of land degradation)
- More trees
- Decrease in rivers siltation (avoid farming along the river banks, planting trees along the banks)

f. Others……
……

Do you trust these local institutions helping you today to help you, if you have a problem in the future?

1. Yes 2. No

Please explain
……
……
……

If yes in what way would one or more of the institutions help you if needed?
……
……

VITA

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