



Climate change adaptation in Semi-Arid Ecosystems: A case study from Ghana



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ABSTRACT

This paper investigated the role of local institutions in facilitating farm households' response and adaptation to climate change impacts on their livelihood. A case study of adapting to drought events associated with crop failure in a Semi-Arid Ecosystems of northern Ghana was taken. A total of 49 semi-structured interviews with key representatives of various local institutions from different sectors were conducted and 120 farm households were randomly interviewed to assess their perceptions about their livelihood outcomes and local institutions accessibility. social network analysis (SNA) has been used to bring into light the institutional framework in the context of adaptation in Bongo district. From our research we noted five salient findings and their implications in effective local level adaptation. First, the public and civic institutions in the study area play a key role in facilitating adaptation. Essentially, institutional performance is inherently local and may vary depending on their mandate as well as availability of resources. Secondly, it has been realised that most of the institutions leading adaptation among the farming community are not directly adaptation related but are those intervening in various domains of households' rural life. Thirdly, it appears that institutional role is not limited to the leading aspect but also the ability of some institutions to channel or extend the available resources to the beneficiaries in the network (known as resources controllers or communicators), and others in controlling the flow of resources in the network (known as bridges or brokers). Fourthly, the results revealed that institutional support is more evident in term of knowledge management, on farm management than farm financial management (insurance, credit, market), livelihood diversification and the investment in infrastructures (dams). Fifthly, it appears that institutional support has at some extend facilitated adaptation within the farming communities by increasing the annual income, farm productivity and well-being while reducing households' adaptation. This paper contributes to the growing knowledge of the role of institutional framework in the facilitation of local adaptation.

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1. Introduction

The high dependence on rain-fed agriculture coupled with low adaptive capacity made Africa one of the most vulnerable regions to climate change and variability (Boko et al., 2007). Based on the Intergovernmental Panel on Climate Change (IPCC) report, a reduction of 8% in the annual crop yield is expected in Sub-Saharan Africa (SSA) by 2050 (Porter et al., 2014). Nevertheless, several studies have highlighted the insufficient character of rural communities' local strategies in dealing with medium to long-term impacts associated with climate change (Adger et al., 2003; Parry, 2009). This situation needs to think ahead of time to build the capacity of communities with high reliance on climate related livelihoods, to enable them to adapt to the impacts associated with climate change.

Ghana, like other countries in West Africa, has been already experiencing considerable variations in temperature and rainfall patterns, observed since 1960s (EPA, 2007). These variations are reported to be associated with increase in some extreme events' incidence especially droughts, floods and bush fires (Boko et al., 2007). In addition, Owusu and Waylen (2009) 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, 2008). Furthermore, based on climate change scenarios, the Inter-Governmental Panel on Climate Change predicted that Ghana is likely to experience greater rainfall variability and higher temperatures in the future. 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). Such changes will shorten the growing season with implications for the agricultural and fisheries sectors (Asante and Amuakwa-Mensah, 2015). As a result, Ghana will be highly challenged by climate change and climate variability for its reliance on rain fed agriculture as the backbone of its economy (i.e., contributes to about 44% of the country GDP and employs about 57% of the population). Northern Ghana has been identified as a particularly vulnerable region to the changing climate. This makes, Ghana a perfect study site for this study (Antwi-Agyei et al., 2014).

The IPCC defines adaptation as a "process of adjustment to actual or expected climate and its effects. Considering human system, adaptation seeks to moderate harm or exploit beneficial opportunities" (IPCC, 2014, p. 118). Adaptation knowledge in SSA has so far focused on the adaptation and coping strategies employed by farming households to reduce adverse impacts of climate change on their livelihoods (Bawakyillenuo et al., 2016; Antwi-Agyei et al., 2014; Codjoe et al., 2012), the role of indigenous knowledge in reducing impacts associated with climate change on farming households' livelihood (Kupika et al., 2019; Nyong et al., 2007; Codjoe et al., 2014; Speranza et al., 2010).

The IPCC (2012) reported that there is evidence of the deliberate efforts made for governance systems that help respond to climatic and other challenges across the continent but highlighted the institutional frameworks insufficiency of the requisite capacity to effectively coordinate implemented initiatives. Local institutions among others have been reported to play key roles in shaping the response to impacts associated with climate change, thus reducing its adverse effects on communities (Agrawal, 2008; Rodima-Taylor et al., 2012; Amaru and Chhetri, 2013; Butler et al., 2013; Mubaya and Mafongoya, 2017). Nevertheless, several studies have highlighted the limited research on roles of institutions or community-based organizations to different forms of Adaptation and in enabling or facilitating climate change adaptation (Aboniyo and Mourad, 2017; Ngonyani and Mourad, 2019). This shows that although the recognition of the role of local institutions in local adaptation facilitation, research in this context seems to still be in its infancy.

Institutions are formal and informal organizations through which society structures share decision-making and take collective actions (McGray and Sokona, 2014). Based on their actions, they can be organized into state/public, private/market and civic/civil society (Agrawal, 2008). Local institutions within the existing government structure is considered public institutions. The private or market institutions are organizations that work for their own, including service organizations and private businesses while the civic institutions are more about non-governmental organizations and any hybrid organizations such as cooperatives (Agrawal, 2008). 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 while extra-local institutions 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). In the context of this study, a formal institution is any institution with an organizational structure and which has taken steps to be legalized according to Ghanaian law while an informal institution represents any institution with an organizational structure and which has not taken steps to be legalized according to Ghana law (Adapted from Brown and Sonwa, 2015).

Institutional linkages are recognized to be critical to adaptation because of the many ways they affect resources flow among others. These linkages encompass institutional access and institutional articulation, which sometimes become an obstacle due to the share responsibilities (Jama and Mourad, 2019). Institutional access represents the connected (degree and links) of that institution by communities while the institutional articulation refers to linkage existing among local institutions and between local institutions and extra-local institutions (Agrawal, 2008).

The Adaptation, Institutions and Livelihoods (AIL) Framework, is developed by Agrawal (2008) as an approach to assess the role of local institutions in climate change adaptation. The framework uses the typology of public, private and civic institutions to propose a linkage framework of local institutions emphasizing on the role of their partnership in facilitating climate change adaptation as well as their influence on resources access for different vulnerable social groups. 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 South Asia (Agrawal, 2008) and Kenya (Ochieng, 2014).

For this study, we have modified the AIL (Fig. 1) and employed some of its concepts to assess the existing local institutions and how they promote adaptation under changing climate among the farming communities in semi-arid ecosystem of northern Ghana.

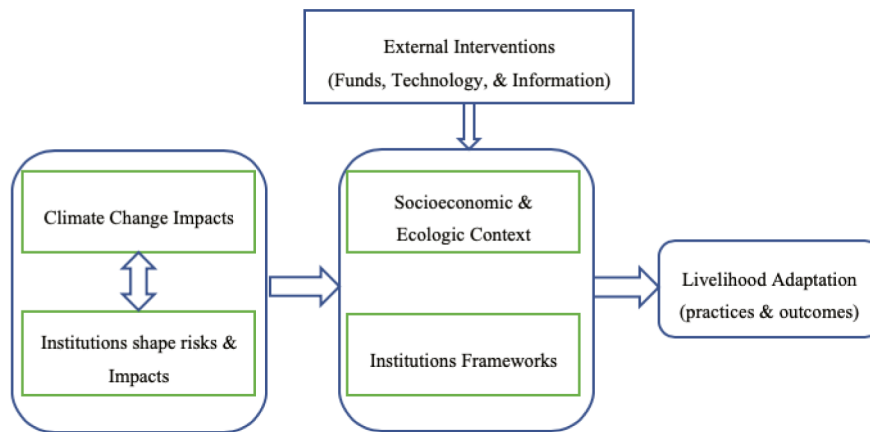


Fig. 1. Adaptation, Institutions and Livelihoods (AIL) Framework (Adapted from Agrawal, 2008).

This article investigates the role of local institutions in enabling farm households to respond and adapt to climate change impacts on their livelihood in Bongo district in the Upper East region (UER) of Ghana. In this paper, we adapted a conceptual framework of analysis in which we considered: (1) institutional framework that characterises the study area within the context of climate change adaptation (institutional landscape, institutional accessibility), (2) the institutional support/function (adaptation options), and (3) communities' perceptions on the existing framework for livelihood opportunities (institutional impact). Following the framework, findings of this study in the context of institutional support/function is discussed as proposed by Agrawal (2008): (1) Reduce farm households' vulnerability to climate change impacts, (2) influence communities' response to these impacts and (3) mediate resources from extra-local institutions for efficient/effective adaptation while the institutions impact findings are discussed considering the (GLOPP, 2008) livelihood outcomes (farm households' income, farm productivity, farm households' well-being, farm households' vulnerability and the use of natural resource base). After this introduction, the study area and the data collection methods will be presented, then the results and discussions; and we conclude with lesson learnt and some conclusions.

2. Materials and methods

2.1. 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 1–5 scale, with level 5 being the worst (Owusu, 2012). Within the UER region, Bongo district is reported to be the most vulnerable district because of its particularly high poverty level and low literacy rates (Antwi-Agyei, 2012: 98), making it a suitable study field in evaluating the role of local institutions in enabling adaptation to climate change.

One of the 13 districts of the Upper East Region (UER) in Ghana, Bongo district lies between longitudes 0.45° W and latitude between 10.50° and 11.09° N with a total land area of 459.5 square kilometres according to the Ghana Statistical Services (GSS, 2014). The district 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 inhabitants (as of 2010) from which approximately 94% are rural with an average household size of six (06) (GSS, 2014). Twelve (12) communities namely, Boko, Feo, Soe Awukabisi, Soe Sanabisi, Soe Tamolga, Amanga, Balungu, Lungu, Vea, Nyariga, Gowrie and Bongo central were selected for the assessment (See Fig. 2). The ecological and socioeconomic characteristics of Bongo district are summarized in Table 1.

Generally, the rainy season in the UER is relatively short and marked by variations in its onset, duration and intensity (Villamor and Badmos, 2015). The amount of rain 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). In addition, Bongo district is reported to have experienced already an increase in temperature between 1 °C and 5 °C compared to the temperature that prevailed in 2007 (min 21 °C and max 40 °C) associated with high variability in the rainfall pattern.

2.2. Research method and sampling procedure

Focus group discussion (FGD), semi-structured key informants interview and household survey were used in a step-wise approach. Quantitative information was obtained through households' survey and key informants interview while Focus group discussions have been used as a mean to access qualitative data. A multistage procedure of sampling was used for the study.

We first purposively sampled the Bongo district, as the district with the most vulnerable crop production (especially millet and

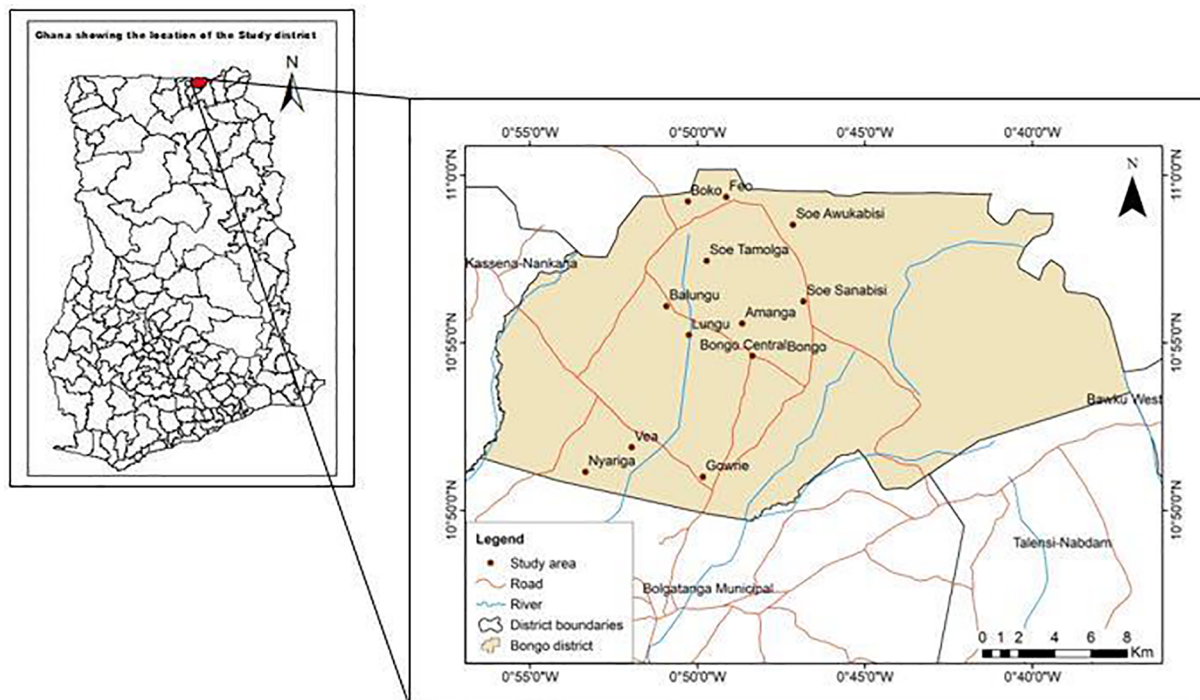


Fig. 2. Study site map of Bongo district, Upper East Region of Ghana. Source: WASCAL-MRP CCHS (Google/Field work, 2015).

Table 1
Key ecological and socioeconomic characteristics of Bongo district.

Characteristics	Bongo district
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 2010)
Climate	Tropical continental/interior savanna climate
Agroecological 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 in a year)
Temperature	Min 21 °C, Max 40 °C

Source: Data compiled from Ministry of Food and Agriculture (MoFA, 1998) and Ghana Statistical Services (GSS, 2014).

sorghum) to climate change impacts in the whole country (Antwi-Agyei, 2012).

The stage two consisted in selecting randomly 12 communities within five area councils of the district. As the result, 12 FGDs (a FGD in each community) have been conducted to identify relevant institutions in the study site through the Institutional Perception Mapping (IPM) approach (Brocklesbury, 2002), but also how these institutions contribute to their adaptation (collected as narratives). The use of this approach for data generation is based on its ability to bring out key relationships and factors affecting those relationships (Brocklesbury, 2002). Thus, the approach allowed local farm households to identify institutions working with them, their relevance/importance and accessibility to households but also the existing relationship between these institutions and farm households/communities. Previous to institutional perception mapping sessions, research questions were developed and include “What are the institutions (Cooperatives, association, government agencies, NGOs) helping you to adapt to climate change impacts on your crops and livelihood.”, “how accessible are they?”, “how relevant is each institutions to the your adaptation (have they really helped you, please explain how)”, “Do these institutions consult you or they only avail resources to help you adapt to climate change”. At the beginning of the discussion, notions such as climate change, climate change adaptation, local institution, the perceived institutional relevance, institutional accessibility were explained, then the group were asked to name all the institutions intervening in the area with regards to their adaptation to climate change. The name of the identified institutions was written on a



Fig. 3. Focus Group discussion with farm households in Bongo.

large paper, then various colour of marker and different sized cards were used to mark institutions relationship (2 ways relationship = a 2 ways arrow, 1 way relationship = one way arrow), their perceived institutional relevance (Very high = 5, High = 4, Medium = 3, Acceptable = 2, Low = 1, Very low = 0) and their accessibility (The small card (2) = Difficult access, the large card (1) = Easy access). The mapping process was associated with the recording of narratives (arguments as well as the explanations) provided by the gathered households. The approach allowed local farm households to identify related institutions with their level of importance and their accessibility to their community (See Fig. 3). Thus, a total of 12 FGDs was applied.

The discussion during FGDs was conducted in local dialect (Gurunee). Each FGD lasted for two hours and was carried out between June and August 2015. A total of 28 institutions (as intervening in the study area and enabling adaptation among farmers households) were identified during the FGDs, of which 49% are involved in agriculture, 35% in community development, 6% in forestry and natural resources management, 4% in banking, 4% in disaster management and prevention and 2% in environment protection. Twenty-five of the identified institutions are formal while three are informal. Out of the 25 formal institutions, nine are public, two are private and 14 are civic institutions.

For the third stage, we interviewed key representatives (e.g., Director, Monitoring/Evaluation Officer, Project manager/leader, chiefs, unit committee leaders) of the institutions identified by farm households using a semi-structured questionnaire. The interview explored questions on 1) local institutions' areas of interest and 2) the adaptation options provided to farm households (institutional support) but also constraints encountered.

For the fourth stage, we randomly selected 10 households from each of the 12 communities previously selected. Thus, a total of 120 farm households (of which 75 were male headed households and 45 were female-headed households, purposively selected) were surveyed using a semi structured questionnaire. The questionnaire covered questions on farm households' awareness on climate change and its impacts, institutional accessibility (type, degree, frequency), perceived changes in their farm households livelihood outcome (annual income, farm productivity, vulnerability and use of natural resources), and if they count on these existing institutions for future adaptation.

The overall data used for the study was collected between June and August 2015.

2.3. Data analysis

The data were analysed in two ways:

1. The data on adaptation options provided, institutional accessibility and farm households' livelihood outcome (based on farm households' perceptions) were analysed using simple descriptive statistics of the SPSS software version 16.0.

2. The local institutions classification based on their perceived institutional relevance in adaptation using Social Network Analysis (SNA) techniques of the Network Visualization Software or Net DRAW (Borgatti et al., 2002). The collected data through the IPM approach were used for analysis (network standards and statistics calculation) and network visualization. The choice of Net Draw in the context of this study is based on tree criteria including 1) the available stable version of the packages (mainly the graphical user interfaces) at the time of the study (SocNet, Gephi, UCINET/Netdraw, NodeXL, Graph-tool, Pajek, Graphviz, AutoMap, Tulip, Cytoscape), 2) the purpose of the package (only the student purpose is considered and includes SocNet, Gephi, UCINET/Netdraw, Graphviz, GraphChi, Meerkat, NetWorkit, NetWorkX, Visone) and the functionality (mainly to analyse and visualize the network, thus the UCINET/Netdraw) (Jokar et al., 2016). The study considered the three most widely used centrality measures such as the degree centrality, closeness centrality, and betweenness centrality (Freeman et al., 1991; Borgatti et al., 2009) for the analysis. These measures reveal whether there are institutions (in terms of nodes) that act as core to adaptation, that act as mediators or brokers between others who have no direct relations with each other, and finally those acting as communicators or resources controllers. The degree of centrality reveals the local institutions (agents/nodes) that hold more influence or authority in the network based on the number of direct links maintained with communities (other agents/nodes) (Cambridge Intelligence, 2014). It helps to spot possible enablers for change. Thus, institutions with high degree score are considered to be the most important in the network, therefore marked as core institutions. Unlike the degree of centrality, closeness centrality indicates the proximity of an institution (node/agent) to the rest of the network (Cambridge Intelligence, 2014). This gives to these institutions the ability to pass or extend resources through the network more quickly than other institutions. Institutions with high closeness scores are marked as resources controllers

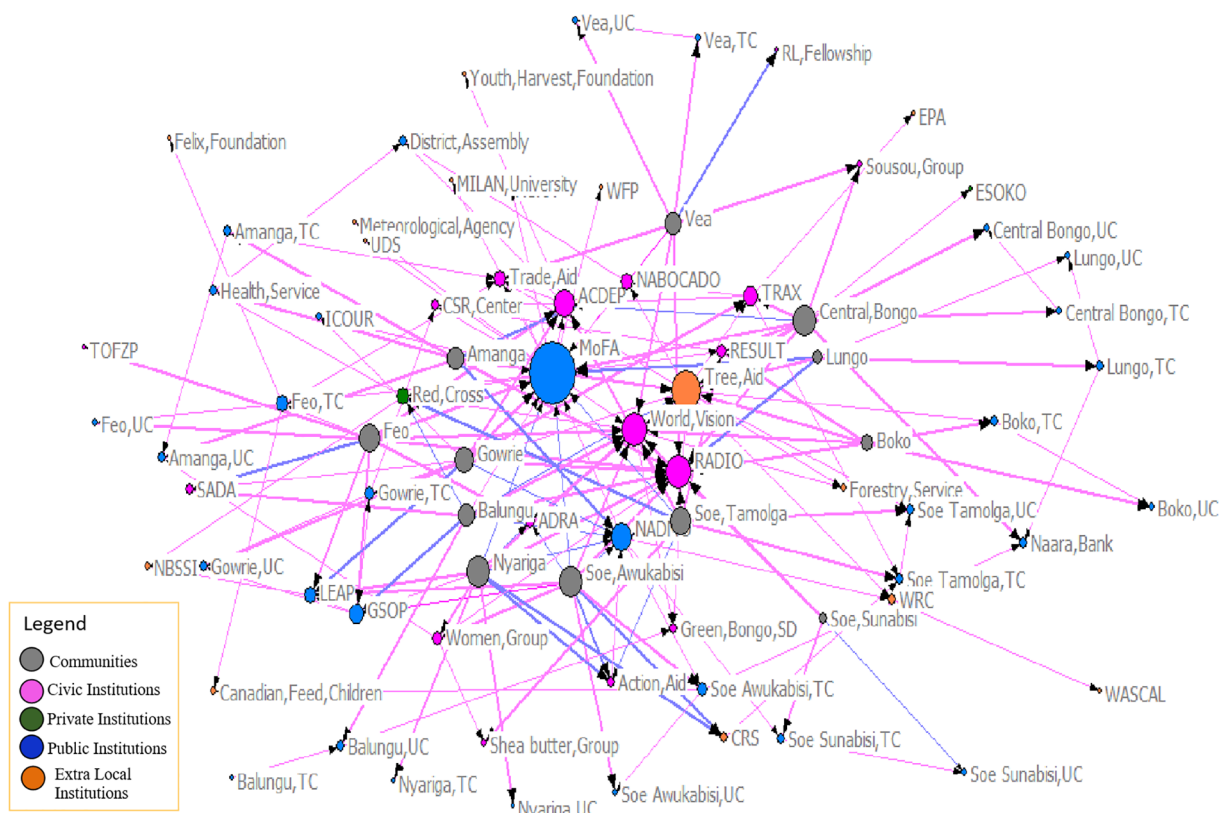


Fig. 4. Institutional articulation network in the context of climate change adaptation in Bongo district.

or communicators. On the other hand, the betweenness centrality reveals how an institution (node) controls flows between other institutions (node) within a network (Matas et al., 2017). Thus, these institutions may cause most disruption to resources flow if removed. Institutions (nodes) with high betweenness scores in a network can be considered as “bridges” or “brokers” connecting nodes (Jaja et al., 2016).

3. Results and discussion

This study aimed to evaluate the role of existing local institutions in climate change adaptation efforts with a focus on the institutional framework that characterises the study area within the context of climate change adaptation (institutional landscape, institutional accessibility), the institutional support/function (adaptation options), and communities’ perceptions on the existing framework for livelihood opportunities (institutional impact). Annex 1 summarizes these local institutions (social action-based classification) and their areas of interventions.

3.1. Institutional framework

3.1.1. Institutional landscape

Fig. 4 gives an over view of institutions working with both district (local and extra local institutions) in helping them adapt to the impacts associated with climate change. Colours are used to represent the nature of the actor (nodes). Lines (ties) with different arrow head size represents the link between actors (collaboration, support). The size of the arrow head between actors show non-reciprocal and reciprocal relationship while the size of the lines, the strength of the relationship. On the other side, the size of the nodes indicates the degree score pd each actor while the colour of the lines give an idea of the institutions accessibility. As shown by the figure, MoFA shows the highest.

The Ministry of Agriculture (MoFA) shows the highest degree centrality followed by Tree Aid, world Vision, Radio and ACDEP (See Table A2 in Annex 1). The leading/core role of MoFA in the context of communities’ adaptation to climate change in Bongo district concurs with the reality on the ground. The institution has been entrusted with the mandate to accompany farming households in the area to improvement of food production system. The centrality of institutions such as by Tree Aid, world Vision, Radio and ACDEP need to be looked from another angle, as these institutions although not directly mandated to enable climate change adaptation, intervene in various domains of farm households rural life (including alternative rural livelihood initiatives, families’ welfare and investment in infrastructures). In brief, adaptation in Bongo district is enabled by public and civic institutions contrary to several findings (See Table

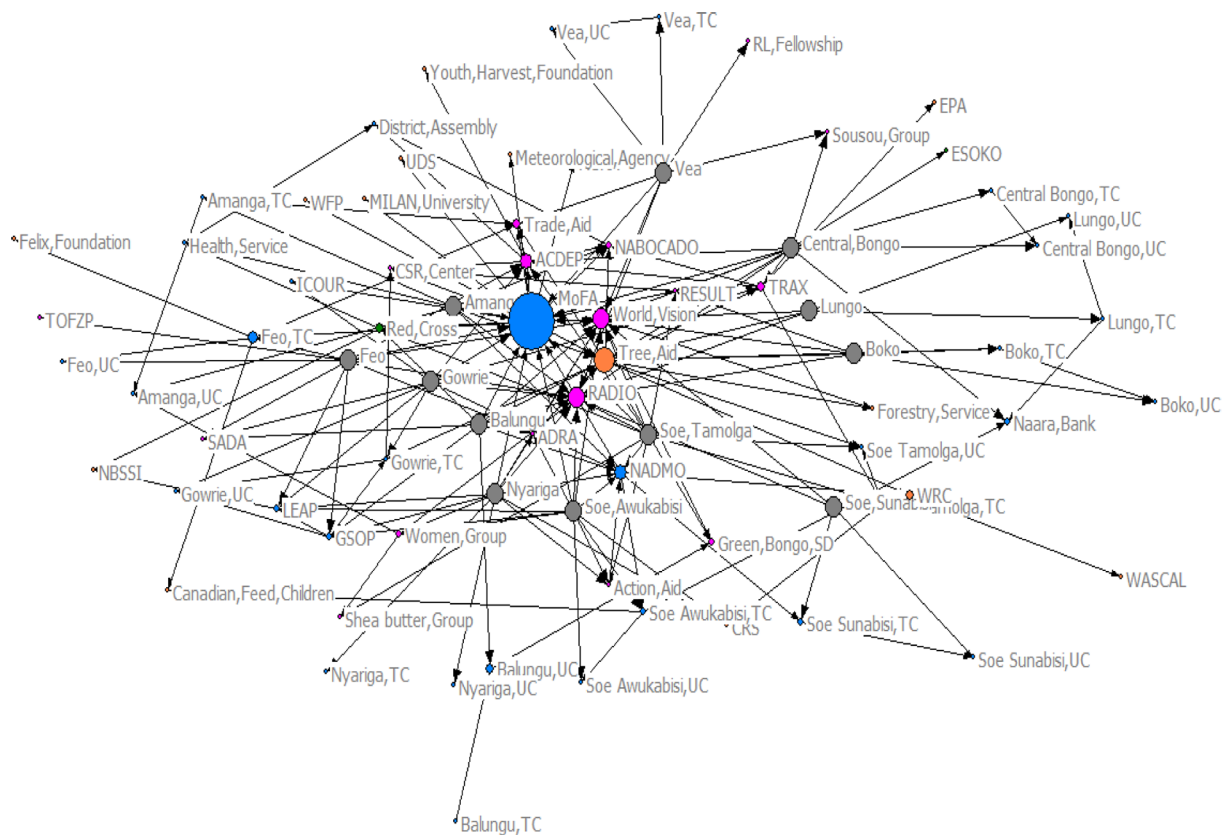


Fig. 6. Institutional network based on the betweenness centrality.

in this context as institutions whose accountability and legitimacy are derived beyond Bongo district. These interactions, in the form of cooperation, collaboration and partnership are reported to result in the acquirement of resources such as climate information (from Bolgatanga Meteorological agency, WASCAL, ESOKO), funds (from Canadian feed the children, Felix foundation, Tree aid), and technology (Ministry of Food and Agriculture, Forest resource division, water resource commission, SARI, UDS) which are later used by local institutions to support local farmers. By doing so, local institution in Bongo district acts as resources mediators to farm households’ adaptation to climate change. Table 2 summarizes all extra-local institutions working in the context of climate change adaptation in Bongo district.

3.1.2. Institutional accessibility

Fig. 4 shows that each community is connected to at least one local institutions. Nevertheless, institutional accessibility is found to be structured in the area.

As a matter of fact, some institutions are connected to only one community (example of Trade Aid which is accessible only to Veal community) while other institutions are connected to more than one (See MoFA, Tree Aid) (Fig. 7). In fact, the connectedness

Table 2
Summary of extra local institutions intervening in the study area.

Regional and National Government Agencies	International Organisations/Research Centres
Export Development Investment Fund (EDIF)	United Nation Development Program (UNDP)
National Board for Small Scale Industries (NBSSI)	World Food program (WFP)
Water Resource Commission	Felix Foundation
Meteorological Agency	Catholic Relief Services (CRS)
Environmental Protection Agency (EPA)	Tree Aid
Forestry Service Division	Canadian Feed the Children
	West African Science Service Centre onClimate Change and Adapted Land Use (WASCAL)University of Development Studies (UDS)
	MILAN UniversitySavannah Agricultural Research Institute (SARI)

Table 3
A crosstab of local institutions functions in Bongo district by type of institutions.

Key intervention	Function	Local Institutions Respondents (N = 49)					Examples of institutions involved
		Frequency			Percentage		
		Civic	Private	Public	Total	(%)	
<i>Knowledge management, network, and governance</i>	Education and trainings	11	1	20	32	65	MoFA, Radio, Esoko
	Awareness raising	6	1	9	16	33	
	Provision of climate and weather information	3	0	5	8	16	
<i>On-farm management and technology</i>	Provision of storage bags and bins (Reduction of post-harvest losses)	2	0	2	4	8	MoFA, ICOUR, ACDEP, World Vision
	Supply of improved crop varieties	4	0	3	7	14	
	Provision of agricultural inputs and tools (Soil and water management)	6	0	7	13	27	
<i>Livelihood diversification (on and off farm)</i>	Off-farm diversification (includes animal rearing, petty trade, aquaculture, and basket weaving and soap production)	5	1	0	6	2	World Vision, RESULT, ACDEP, Community Self-Reliance Center, and Trax-support, NADMO
	On-farm diversification (e.g., extraction of non-timber product such as honey, Dawadawa powder and oil)	1	0	0	1	12	
	Credit provision	0	0	1	1	2	
<i>Farm: Financial Management</i>	Improvement of the access to market	1	0	0	1	2	Financial institutions (Naara rural bank and Bongo rural bank), insurance companies (AR promising), ICOUR, Trade aid, and RESULT
	Provision of insurance scheme	1	0	0	1	2	
<i>Government Assistance in Infrastructure, Health, and Risk Reduction</i>	Infrastructure development (Road; and Dugouts)	1	0	1	2	4	GSOP, Bongo district assembly, ICOUR, Tree Aid
	Infrastructure rehabilitation (e.g. dams)	0	0	1	1	2	

Source: Authors' Analysis (2015).

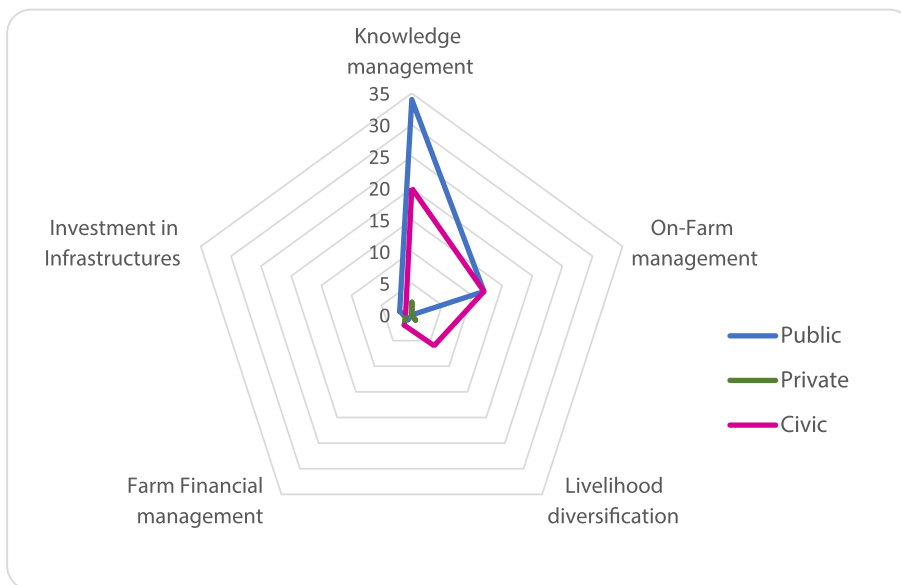


Fig. 8. Adaptation options by type of local institutions. Source: Authors’ analysis.

agricultural inputs and tools, 14% in the provision of improved crop variety seed and 8% in the provision storage bags in bins) with limited support in farm financial management, investment in infrastructures and livelihood diversification.

A close look at the Table 3, indicates that knowledge management interventions are essentially led by public institutions (34 public institutions against 20 civic institutions and 2 private institutions) while diversification are initiated essentially by civic institutions. In addition, leadership when it comes to on. farm management is found to be commonly carried by both civic and public institutions (12 civic institutions against 12 public institutions). A summary of institutional support by type of local institutions is illustrated in Fig. 8.

Based on the Table 3 and Fig. 8, contrary to the findings in Zimbabwe (Mubaya and Mafongoya, 2017), adaptation in Bongo district, Ghana is facilitated by civic and public institutions as the private institutions are quite absent. This shows that when it comes to adaptation to climate change, the institutional framework is contextually formed. In addition, the findings ring the bell on encouraging private institutions in getting involved in adaptation process especially in setting where they are not or less involved.

3.3. Institutional impacts: farm households’ livelihood outcomes

3.3.1. Farms’ households’ socio-economic characteristics

Local institutions accessibility and farm households’ perceived livelihood outcome are obtained from a sample (n = 120) which socio-economic characteristics are described below (Table 4). From a total of 120 households, results have 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 households. These female households’ heads are in most of the cases widowers or divorced. In addition, the average households’ size in the area is 8 with a seasonal income averaging 1043 Ghana Cedis (273 USD\$ at the time of writing). Most households’ heads assessed have no formal education (79%) while those who obtained primary and

Table 4
Farms’ households’ socio-economic characteristics.

Variables	Characteristics		
Male headed households	N	Percentage (%)	
	75	63	
Female headed households	45	37	
Total households	120	100	
Household’ size (# of persons)	Minimum	Maximum	Average
	1	20	8,411765
Households’ seasonal income	600 GHS (157 USD)	2000 GHS (524 USD)	1042,8 (27 3 USD)
	Frequency	Percentage (%)	
No formal education	95	79	
Informal education	3	3	
Primary	10	8	
Secondary	12	10	
Total	120	100	

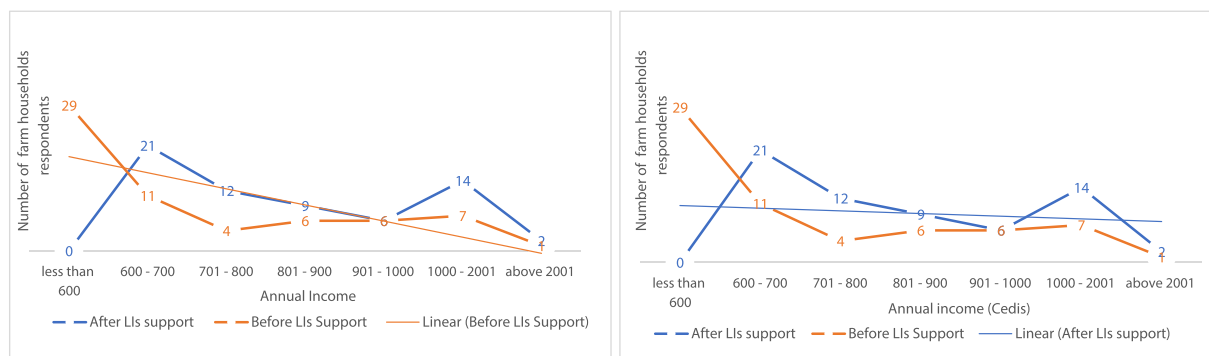


Fig. 9. Charts depicting changes in farm households' annual income.

secondary education constitute about 8% and 10% respectively. Besides, most of these household' heads assessed are within the category of 41–65 years, which represents an experienced range, aware of the impacts of institutional support on their adaptation level.

3.3.2. Institutional impact: insight from farm households' livelihood outcomes

As the result of their interaction with local institutions, farm households' have reported to benefit both tangible and intangible resources including financial resources (in form of credit or loan), farm inputs (fertilizers, seed, pesticide), alternative livelihood (aquaculture, extraction of nontimber product, petty trade, animal rearing), irrigation scheme, insurance scheme, weather information and agricultural advice. At the question of whether farm households have perceived any change in their livelihood outcome as the result of the support provided or resources availed by the local institutions, majority of farm households' respondents expressed positive answers (73%); whereas, 27% of the farm households' respondents did not see any change. The institutional impact was translated in following livelihood outcome indicators (GLOPP, 2009) as perceived by these farm households:

1. **Farm households' income:** Out of the 73% farm households' respondents who perceived an enhancement in their adaptation capacity to climate change, 64% experienced an increased annual income. A comparative analysis of the changes in farm households' annual income (See Fig. 9.) have shown an increasing trend in farm households income as the result of local institutions support. As a matter of fact, these figures show a decrease in the number of farm households with low income (especially farm households with an annual income less than 600 Cedis) and the increase in the number of farm households with an annual income equal or above 600 Cedis. This pattern has been mainly attributed to the alternative livelihoods introduced by local institutions and access to on-farm management resources (irrigation schemes and improved seeds). As a matter of fact, farm households have reported to be taken into alternative livelihoods such as animal rearing, aquaculture production, basket weaving, extraction of non-timber product (honey, Shea butter, Dawadawa powder) and petty trade. Actually, Bongo district sensitivity to climate change impacts (drought) lies in its high dependence on crop production (about 95.7% of the population as of 2010), which is mainly rain-fed. This crop production being recorded to be subject to the highest level of land degradation (level 4 in the 1–5 scale with 5 being the worst) (Owusu, 2012) but also being the most vulnerable (for millet and sorghum) in the whole country (Antwi-Agyei, 2012), making farming activity in the area initially subject of frequent crop failure. The introduction of alternative livelihoods has given to these household other sources of livelihood while on-farm management resources like irrigation schemes have given them the possibility to still farm even when there is drought and even to go into dry season farming, thus, contribution to their annual income.

2. **Farm productivity:** Around 62% farm households respondents viewed that the support increased their farm productivity. Fig. 10 shows an increasing trend in farm households annual yield. Like the case of the annual income (Fig. 9), the number of respondents having low farm yield (1–2 bags) have tremendously reduced while the number of respondents with farm yield above 4 bags have greatly increased. Accordingly, the increase in farm productivity was linked mainly to their access to availed resources

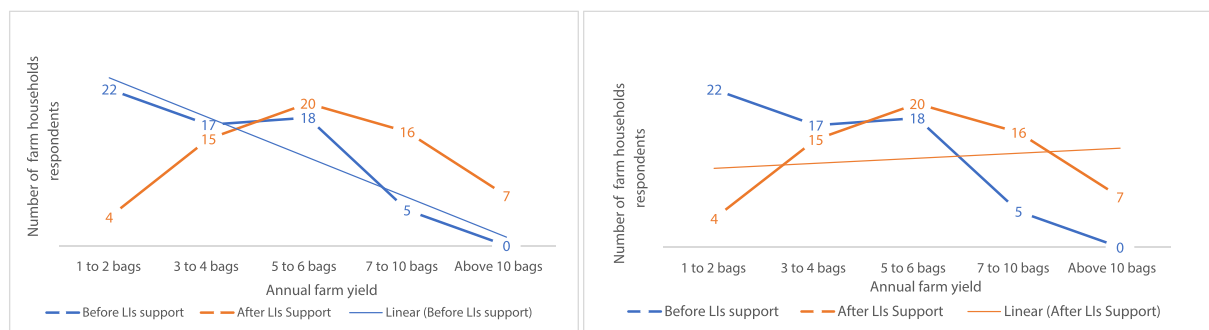


Fig. 10. Charts depicting changes in farm households' farm productivity.

(including the technical and agricultural advice, climate information, improved seeds, fertilizers and irrigation scheme, credit) but also and capacity to afford some adaptation options (...). Farm households have reported climate information helped them while planning agricultural activities (especially the planting date) with more precision or the type of crop to grow to avoid crop failure. As an example, during the 2015 crop farming period, farm households have been advised to plant early based on the seasonal forecast. As result, those who planted early had good harvests of early millet (Naara) while those who planted late were not able to get good yield. These farm households reported also that their interaction with existing institutions increased their understanding on subjects such as climate change (its impacts and the available adaptation options), crop storage techniques (to reduce post-harvest losses), organic farming (manure and compost), which have raised their awareness, stimulated and brought them to perceive changes, and thus to invest in some adaptation strategies as reported by Maddison (2007). In brief, farm households' likeliness to manage risk of crop failure (using resources such as irrigation scheme and improved seeds, climate information-based farming activities planning) and their awareness on climate change impacts and adaptation have improved their farm productivity.

3. Farm households' well-being: Farm household respondents in the study area viewed well-being mainly as the availability of food for the households (59%) and the ability for the households to ensure children's education (20%). The increased households' well-being experienced is reported by the respondents to be mainly linked to the farm productivity and annual income. According to them, financial empowerment through alternative livelihoods and improved farm productivity have increased their annual income but also made available food, in most of the cases till the next harvest.

4. Farm households' vulnerability: About 73% of the farm household respondents perceived a reduction in their vulnerability to climate change. For these respondents the reduced vulnerability experienced is the result of a decreased reliance on agricultural activities (47%), awareness on climate change and its impacts on framing activities (32%) and the access of agricultural inputs (21%). Farm households' involvement in other livelihood activities reduces their reliance on agricultural activities and in some cases enables them to invest in the available adaptation options. In addition, respondents acknowledged that the use of early crops (59%), improved seeds (14%), and irrigation scheme (16%), fertilizer and manure (11%) have helped them to manage crop loss risk associated with climate change in the area. The vulnerability reduction pattern through decreased reliance on agricultural activities, awareness on climate change and its impacts on framing activities and the access of agricultural inputs in the study area is confirmed by Antwi-Agyei (2012) findings where the presence of irrigation scheme (Vea dam) and the availability of diverse livelihood opportunities has been source of the low vulnerability of Vea community compared to Adaboya and Ayelbia in 2012.

5. Use of natural resource base: Based on farm households respondents view, the benefits resulted from the support provided by the local institutions were of great importance for the environment itself. As the result of the support, up to 83% of farm households highlighted a decrease of soil erosion occurrence in the area. This improvement is attributed to the adoption of good agricultural practices such as planting of Vertivar grasses and ploughing across the slope.

In brief farm households' respondents agreed that local institutions support have had an impact in their livelihood outcomes in terms of adaptation. However, they have reported that their interaction with existing local institutions is mainly limited to their participation in meetings (55%) with very few going beyond like participating in decision making. Based on the above, a move in the level of participation of beneficiary farm households from simple participation to decision making level may help in integrating their experienced impacts and challenges, key in shaping these institutions activities and initiatives. This will increase their effectiveness, knowing that up to 62% of the farm households' respondents confessed their trust in these institutions for their adaptation to the impacts that will be associated with future changes in the climate.

4. Lesson learnt and limitation of the study

The combination of focus group discussion, households' survey, and key informants interview involving both local institutions and farm households (done in a cross-checked way) have given a clear picture on how local institutions are facilitating climate change adaptation among local farmers but also the relevance of each existing local institution in local farmers adaptation efforts. The household survey and key informant (developed based on the AIL framework) gave an overview on adaptation options provided (institutional support), institutional accessibility to farm households' and farm households' livelihood outcomes (institutional impact) while the FGDs have helped to classify the existing institutions based on their relevance. The FGD has been a platform where farm households expressed their opinion based on the trust, they have on the institutions helping them to adapt while key informant interview helped to highlight barriers (internal mainly financial, human and technical barriers and external mainly loans reimbursement) encountered by local institutions in being productive in adaptation efforts but also their dependence on each other in those efforts. These lessons learnt have helped to understand that the role of local institutions turns around their ability to mediate resources (from other local institutions or/and extra-local institutions), that in turn enable them to shape the risk/impacts of climate change on farm households and avail adaptation options which together contribute to improved livelihood. Finally, the social network analysis gave insight on the leading institutions in adaptation efforts in the study area, essential in resources allocation. However, no matter their domains of intervention, all the existing local institutions contribute in one way or the other in farm households' adaptation to climate change.

In farming communities like Bongo district adaptation options like mobility although existing was found to be less desirable (households' members moving down to the southern regions for wage labour or other jobs during off season) compared to options like diversification and storage. The diversification in the area was mainly in terms of (1) livelihood diversification where farm households go into various activities (such as dry season farming of vegetable, non-timber product extraction, petty trade, aquaculture, basket weaving, animal rearing and soap production among others), (2) changing in the eating habits (reduction of the number of meal per day), and (3) crop and seed diversification (introduction of crops such as water melon, maize and white sorghum in the

cropping system and the adoption of drought resistant seeds and insect resistant seeds). Storage in this context includes water storage, food storage, pest (for animal) and insect (locust and caterpillars as result of dryness) control. The experience of Vea, Gowrie and Nyariga communities in Bongo district put light on the adoption of storage in farm households' adaptation to climate change. Farm households in those communities benefit from irrigation scheme provided by the Irrigation Company of Upper Region (ICOUR), enabling them to go into irrigated farming during raining season (rice growing) but also in dry season farming of vegetable (tomatoes, pepper). Aquaculture is another activity that benefited farm households as the result of the presence of the dam. These activities have been reported for their contribution in reducing risks associated crop failure (because of water stress) but also providing other source of income to the involved households. Although few institutions are taking farm households through options such as diversification and storage, these two have been highlighted by farm households as a great asset in communities' adaptation, this based on the impact of these options on their overall livelihood outcome.

Besides all, one thing different learnt with the communities is that knowledge reduces vulnerability.

5. Limitations of the study

This study did not explore deeply the linkages among local institutions and between local institutions and extra local institutions, this because of the short time allocated to the research. Therefore, the continuation of this study regarding these aspects will be of great benefit as most of farm households' respondents have trust in these institutions for their adaptation to the impacts that will be associated with future changes in the climate.

6. Conclusions

Institutional framework that characterises the study area within the context of climate change adaptation (institutional landscape, institutional accessibility), the institutional support/function (adaptation options), and the communities' perceptions on the existing framework for livelihood opportunities (institutional impact) analysis showed how local institutions facilitate adaptation among farming communities in semi-arid ecosystems. From our research we noted five salient findings and their implications in effective local level adaptation. First, the public and civic institutions in the study area play a key role in facilitating adaptation. Essentially, institutional performance is inherently local and may vary depending on their mandate as well as availability of resources. Secondly, it has been realised that most of the institutions leading adaptation among the farming community are not directly adaptation related but are those intervening in various domains of households' rural life. Thirdly, it appears that institutional role is not limited to the leading aspect but also the ability of some institutions to channel or extend the available resources to the beneficiaries in the network (known as resources controllers or communicators), and others in controlling the flow of resources in the network (known as bridges or brokers). Fourthly, the results revealed that institutional support is more evident in term of knowledge management, on farm management than farm financial management (insurance, credit, market), livelihood diversification and the investment in infra-structures (dams). Fifthly, it appears that institutional support has at some extent facilitated adaptation within the farming communities by increasing the annual income, farm productivity and well-being while reducing households' adaptation.

These findings suggest that collaboration between other local institutions and the leading institution (MoFA) be fostered in order to avoid potential maladaptation. It is vital, that the private sector is encouraged to step in the adaptation settings, especially in enabling diversification, farm financial management and investment in infrastructure in the context of study area. Finally, for the leading institutions, there is need for empowerment of the local office of Ministry of Food Agriculture (MoFA) and the encouragement for great engagement of the institutions with high legitimacy (World Vision, etc). This paper contributes to the growing knowledge of the role of institutional framework in the facilitation of local adaptation.

Author contributions

Mawulolo Yomo and Grace B. Villamor designed the study, developed the methodology and wrote the manuscript. Mawulolo Yomo performed the fieldwork, collected the data, and conducted the analysis while Grace B. Villamor, Mawuli Aziadekey, Felix Olorunfemi, and Khaldoon A. Mourad supervised and edited the work.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Annex 1

Table A1

Summary of local institutions working in the study area: areas of intervention.

Type	Form	Institutions	Role in adaptation/areas of intervention
Public	Formal	Ministry of Food and Agriculture (MoFA), National Disaster Management Organization (NADMO), Ghana Social Opportunities Project (GSOP), Irrigation Company of Upper Region (ICOUR), Naara Rural bank (Naara, bank), Ghana Health service (Health, Service), Livelihood Empowerment Against Poverty (LEAP) Traditional councils (TC) Unit committees (UC)	Headed by the District assembly chief executive, these institutions are involved in activities that promote the development of the district such as infrastructure building (dams, roads, and dugouts), health scheme, disaster management, improvement of food production system and social wellbeing Headed by the local chiefs, this institution oversees the implementation of laws (laws against bush fires and cutting of trees) and the provision of authorization for any development initiative (from local institutions) in the community. They ensure stability and peace in the community and intermediate access to land Headed by the assembly man, the unit committees work in collaboration with traditional councils in ensuring the implementation of laws (bush fires, cutting of trees) and other related activities. They are also involved in some activities of the community such as the protection of community members' crops during cropping seasons
Civic	Formal	Trax-support (TRAX), Association of Church Development Project (ACDEP), Adventist Development and Relief Agency (ADRA), Navrongo-Bolgatanga Catholic Agricultural Development Office (NABOCADO), World vision international (World, Vision), Tree aid (Tree, Aid), Trade aid (Trade, Aid), Radio, Community self-reliance center (CSR, Center), Catholic Relief Services (CRS), Socio-Economic Program for the Trans-border Onchocerciasis Freed Zone (TOFZP), Resilient and Sustainable Livelihoods' Transformation (RESULT)	Institutions are involved in the following activities: <ul style="list-style-type: none"> • Alternative rural livelihood initiative • Food security achievement (through gender mainstreaming or poor empowerment or advocacy, credit for livelihood, Shea butter production, food aid, trainings on the reduction of post-harvest losses and the good use of inputs and pest and disease management, and provision of farm inputs). It helps farm households in reducing their reliance on agriculture with some by providing improved seed, therefore reducing the risk of crop failure as a result of drought • Families' welfare (through education, training, awareness rising, technical and financial support.) • Tree planting, tree aid contributes to climate change mitigation (microclimate, reduced soil erosion, reduced inundation) • Infrastructure development (building of dugouts) to alleviate the impacts of drought on livestock. Trading and improvement of the access to the market (for basket weavers) through the value chain • Involved in information (climate and weather, good agricultural practices) broadcasting and awareness rising on climate change and other issues • Disaster management (intervention in emergencies with the supply of health care and food
	Informal	Women Group (Women, Group) and Shea butter extraction Group (Shea butter, group)	Mainly made up of women and formed based on their interest in improving self-financial capacity. It is involved mainly in basket weaving business, Shea butter production and common labour activity that act as secondary source of income reducing their reliance on agricultural activities. It supports its members in case of disaster or crisis through loans
Private	Formal	Ghana Red Cross Society (Red, Cross) and ESOKO Ltd (ESOKO)	Institutions are involved in the following activities: <ul style="list-style-type: none"> • Disaster prevention and response, their actions reduce the impacts of disaster on the community • Youth development • Provision of weather information to farm households (helping them in defining the planting date, therefore, reducing the risk of crop failure) • Provision of price of commodities

Table A2
Centrality measures scores.

Institutions	Type	Degree scores	Betweenness scores	Closeness scores
MoFA	Public	26	969	133
Tree, Aid	ELIs	16	389	161
World, Vision	Civic	14	297	155
RADIO	Civic	13	296	159
NADMO	Public	11	218	166
GSOP	Public	7	46	208
TRAX	Civic	7	107	195
Feo, TC	Public	6	144	193
LEAP	Public	6	34	212
NABOCADO	Civic	6	39	184
Red, Cross	Private	6	81	184
Trade, Aid	Civic	6	74	180
Gowrie, TC	Public	5	23	204
RESULT	Civic	5	19	188
Soe Awukabisi, TC	Public	5	52	212
Women, Group	Civic	5	40	204
CSR, Center	Civic	4	8	197
Soe Tamolga, TC	Public	4	14	224
Amanga, TC	Public	3	5	239
Amanga, UC	Public	3	5	241
Balungu, UC	Public	3	77	245
Boko, TC	Public	3	14	228
CRS	ELIs	3	11	233
District, Assembly	Public	3	6	235
Gowrie, UC	Public	3	1	231
Green, Bongo, SD	Civic	3	28	205
Health, Service	Public	3	8	237
Lungo, TC	Public	3	5	250
Naara, Bank	Public	3	27	229
SADA	Civic	3	3	227
Soe Sunabisi, TC	Public	3	25	232
Soe Tamolga, UC	Public	3	7	214
Boko, UC	Public	2	0	274
Central Bongo, UC	Public	2	0	246
Central Bongo, TC	Public	2	0	246
Feo, UC	Public	2	0	246
ICOUR	Public	2	0	201
Lungo, UC	Public	2	0	259
Shea butter, Group	Civic	2	2	239
Soe Awukabisi, UC	Public	2	0	244
Soe Sunabisi, UC	Public	2	0	281
Sousou, Group	Civic	2	6	237
Vea, TC	Public	2	0	263
Vea, UC	Public	2	0	263
ESOKO	Private	1	0	247
Nyariga, TC	Public	1	0	249
Balungu, TC	Public	1	0	321
Nyariga, UC	Public	1	0	249
RL, Fellowship	Civic	1	0	264
TOFZP	Civic	1	0	252

Annex 2

Table B1
Communities Based Institutional Importance.

Type	Form	Institutions	Institutional Importance (Score/5)												
			AMANGA	SANABISI	LUNGO	BOKO	VEA	BALUNGU	TAMOLGA	GOWRIE	FEO	NYARGA	CENTRAL BONGO	AWUKABISI	
Public	Formal	MofA	2	N/A	0	N/A	1	2	5	4	4	2	4	2	
		NADMO	3	N/A	2	N/A	N/A	4	5	3	N/A	2	N/A	2	
		GSOP	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	5	N/A	5	
		ICOUR	N/A	N/A	N/A	N/A	4	N/A	N/A	5	1	N/A	N/A	N/A	
		Naara, bank	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		Health,	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		service													
		LEAP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	3	5	N/A	5
		TC	0	0	0	0	0	0	0	0	0	0	0	0	0
		UC	0	0	0	0	0	0	0	0	0	0	0	0	0
Civic	Formal	TRAX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	N/A	N/A	4	N/A	
		ACDEP	N/A	N/A	N/A	N/A	N/A	N/A	5	5	3	N/A	3	N/A	
		ADRA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	1	
		NABOCADO	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		World, Vision													
		Tree, Aid	5	N/A	N/A	4	2	N/A	5	5	4	5	5	5	
		Trade, Aid	5	N/A	N/A	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		Radio	5	5	5	5	5	5	5	5	5	5	5	5	
		CSR, Centre	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		CRS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	5
Informal	Group	TOFZP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	
		RESULT	N/A	N/A	N/A	5	N/A	N/A	5	N/A	N/A	N/A	5		
		Women,													
		Group	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	5	
		Sousou,													
		Group	N/A	N/A	N/A	N/A	5	N/A	N/A	5	N/A	N/A	N/A	N/A	
		Shea butter,													
		group	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		Private	Formal	Red, Cross	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	N/A
		ESOKO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A
Leading institutions	Informal	Ghana													
		Health	N/A	World	Radio	World	ICOUR,	NADMO,	MofA, NADMO,	MofA,	TOFZP,	Women	Trax, Sousou	Women Group,	
		Service, Tree	N/A	Vision,	Vision,	Vision,	Trade Aid,	GSOP, World	ACDEP, World	ICOUR,	Radio,	Group,	Group, RESULT,	CRS, Radio,	
Aid and	N/A	Radio	Trade Aid,	Trade Aid,	Radio,	Radio,	Vision, Radio,	LEAP, Trax,	World	Radio, CRS,	Radio, Tree Aid,	World vision,			
Radio	N/A	Radio and	Radio and	Radio and	Sousou	Red Cross	RESULT, Sousou	ACDEP,	Vision,	World Vision,	World Vision,	LEAP, GSOP			
		RESULT	RESULT	RESULT	Group	Group	Group	Group	Radio	MoFA	MoFA	MoFA			

N/A = Not Available in the community.

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