Climate Change and Sustainable Livelihoods Adaptation

user perspectives on community managed irrigation schemes in North-Eastern Ghana

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BY
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DENMARK

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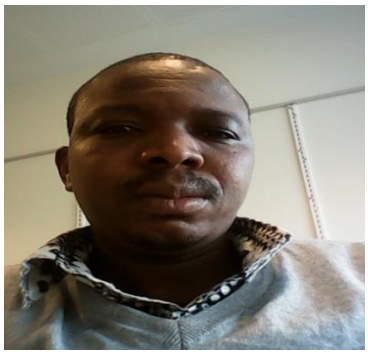

CV

Jonah Amosah holds a Master of Science Degree in Development Planning and Management (SPRING Programme) from the Department of Planning, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi in 2009 courtesy an In-country DAAD scholarship obtained in 2007. The SPRING Programme is a unique International joint Master of Science in Regional Development Planning and Management between KNUST and TU Dortmund University in Germany. Jonah holds a Bachelor of Art Degree in Integrated Development Studies (IDS) from the University for Development Studies (UDS), Tamale in 2005 and a Professional Teachers' Certificate A from Bagabaga College of Education, Tamale in 2001. As a trained teacher, Jonah taught briefly in Tamale.

After postgraduate studies he was appointed as a lecturer in the Department of Social, Political and Historical Studies, at the UDS in 2010 and taught courses in Fundamentals of Planning, Political Economy of Ghana, Globalization and Development, Project Design and Implementation and Comparative Studies of Agencies in Development among others.

In September 2014, Jonah received a grant from the department of Culture and Global Studies, Faculty of Humanities, Aalborg University, Denmark to pursue a PhD programme in Interdisciplinary Discourse Studies. In his thesis, he explores climate change as a global concern and examines how community managed small-scale irrigation scheme farmers are sustaining their livelihoods by adapting to the impacts of climate change using their indigenous knowledge. The thesis draws inspiration from Fairclough's critical discourse analysis and Gee's illustration and labelling of discourses.

ENGLISH SUMMARY

Research has shown that climate change is affecting many developing countries and the livelihoods of many small-holder farmers; however few studies have explored and assessed the impact of climate change on the livelihoods of small-scale irrigation farmers in rural communities including Tanga in North-Eastern Ghana. This study investigates the issue of climate change and sustainable livelihood adaptation in North-Eastern Ghana with a focus on how small-scale irrigation scheme farmers rely on their indigenous knowledge to adapt to the impacts of climate change. Research has demonstrated the significant role discourse plays in shaping opinion and perceptions of climate change, and the manner in which climate change is perceived and constructed discursively has major implications for the responses chosen for climate change mitigation and adaptation. Anchored on the complex phenomenon of climate change, the PhD thesis explores the perceptions of the causes of climate change, with a focus on the impacts of climate change on livelihoods of farmers and the role of indigenous knowledge systems for adaptation to climate change. To achieve the objectives, the study employs a case study to analyse issues of climate change in the field study area, Tanga, that is the focus of the study. The research employs a mixed methods approach in which both qualitative and quantitative research methods and techniques were used for data collection and analysis.

The PhD thesis is inspired by Fairclough's version of critical discourse analysis (CDA). However, the discourses that emerge in this study are not analysed by way of a typical linguistic analysis. Instead, the analysis draws on Fairclough's version of CDA which assesses and interprets societal phenomena on the basis of different discourses derived from the social actors during interviews and discussions with a starting point in social constructionism. The analysis is based on the notion that interactions between people and their environment create social reality. In addition to Fairclough's version of CDA, the study draws on Gee's discourse analysis approach to categorize and label discourses into big D Discourses and small d discourses.

Data for the study was collected from primary sources using questionnaire, in-depth interviews, focus group discussions and observation within the Tanga community in the Bawku West District of the Upper East Region.

Findings of the study reveal that farmers are aware that the climate of the area has changed in the last three decades. This is based on their lived experience and local environmental knowledge and relates climate change to rising temperatures, unpredictable rainfall, droughts and floods and changing wind conditions. The farmers also associate the causes of climate change to science-based natural phenomenon, spiritual and religious beliefs and anthropogenic causes, with religious beliefs being the dominant Discourse on the causes of climate change. The findings also show that farmers are conscious of the effects of climate change on their livelihoods and have taken a number of measures and strategies based on their indigenous knowledge to adapt to climate change.

The study concludes that indigenous knowledge is a powerful resource used by farmers to overcome their vulnerabilities to climate change and recommends or advocates for the involvement of local farmers and their indigenous knowledge in climate change adaptation strategies, practices and policies, which seek to deal with the challenges of climate change at the sectoral, local and national levels.

DANSK RESUME

Megen forskning har vist, at klimaforandringerne rammer mange udviklingslande hårdt og har stor indflydelse på livsvilkårene for mange småbønder. Imidlertid er der kun få studier, der har undersøgt klimaforandringernes indflydelse på livsvilkårene for småbønder, der har mulighed for at benytte kunstvanding i landdistrikterne, herunder i Tanga provinsen i det Nordøstlige Ghana.

Dette studie undersøger spørgsmålet om klimaforandringer og bæredygtig klimatilpasning i det nordøstlige Ghana, herunder i hvilket omfang småbønder med adgang til et kunstvandingssystem anvender traditionel viden for at tilpasse sig virkningerne af klimaforandringerne. Forskning har vist, at diskurserne spiller en vigtig rolle for dannelse af holdninger til spørgsmålet om klimaforandringer, og den måde hvorpå klimaforandringer opfattes og konstrueres diskursivt har store konsekvenser for de handlinger, der vælges med henblik på afbødning af og tilpasning til klimaforandringerne.

Med udgangspunkt i denne komplekse problemstilling undersøger ph.d.-afhandlingen forskellige opfattelser til og fortolkninger af klimaforandringer og årsagerne hertil, herunder hvordan sådanne opfattelser og fortolkninger indvirker på livsvilkårene samt hvordan traditionelle videns systemer inddrages. For at besvare disse spørgsmål anvendes et casestudie, der afgrænses til feltundersøgelsesområdet, Tanga, der er undersøgelsens fokus. I studiet anvendes en tilgang der kombinerer kvalitative og kvantitative forskningsmetoder, hvilket afspejles i de metoder der er valgt til dataindsamling og analyse.

Ph.d.-afhandlingen er inspireret af Faircloughs version af kritisk diskursanalyse (CDA). Diskurserne i undersøgelsen analyseres imidlertid ikke ved hjælp af en typisk sproglig analyse. I stedet trækker analysen på en version af CDA, som vurderer og fortolker samfundsmæssige fænomener på baggrund af forskellige diskurser som de anvendes af de sociale aktører i interviews og i fokusgruppe diskussioner med udgangspunkt i social konstruktionisme. Analysen er baseret på forestillingen om, at interaktioner mellem mennesker og deres miljø skaber sociale virkeligheder. Sammen med Faircloughs version af CDA trækker undersøgelsen på Gees diskursanalysetilgang med henblik på at kategorisere diskurserne som store D-diskurser og lille d-diskurser.

Data til undersøgelsen blev indsamlet fra primære kilder ved hjælp af spørgeskema, dybdegående interviews, fokusgruppediskussioner og observation inden for Tanga-samfundet i Bawku West District i Upper East Region. Resultaterne af undersøgelsen afslører, at landmænd er opmærksomme på, at klimaet i det undersøgte område har ændret sig gennem de sidste tre årtier. Dette baseres på interview-personernes livserfaring og deres lokale viden om miljøet. Svarene fra spørgeskemaet relaterer klimaforandringer til stigende temperaturer, uforudsigelig nedbør, tørke og oversvømmelser samt skiftende vindforhold. Svarene fra interview og fokusgruppediskussioner forbinder desuden årsagerne til klimaændringer med naturfænomener/ naturvidenskab, åndelige og religiøse overbevisninger samt menneskeskabte årsager. Af disse udgør de åndelige og religiøse overbevisninger den dominerende diskurs om årsagerne til klimaforandringer. Resultaterne viser også, at landmænd er opmærksomme på klimaforandringernes indvirkning på deres levebrød, og at de har truffet en række foranstaltninger og klimatilpasningsstrategier baseret på deres traditionelle viden.

Undersøgelsen konkluderer, at traditionel viden er en stærk ressource, der bruges af landmænd til at overvinde deres sårbarhed over for klimaforandringer, og den anbefaler at lokale landmænd og deres traditionelle viden inddrages i policy-arbejde med strategier, med henblik på at løse udfordringerne med klimaforandringer, på lokalt såvel som på nationalt niveau.

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CHAPTER 1: CONTEXTUAL BACKGROUND AND PROBLEM STATEMENT

According to the UN World Water Development Report 2 (2006: V), "Water is an essential life sustaining element. It pervades our lives and is deeply embedded in our cultural backgrounds". It is required for the survival of all living creatures and to spur social and economic development, and at the heart of the challenge of socio-economic development in relation to water is the issue of climate change (UN, 2006). To highlight the above challenge of climate change the IPCC (2007) predicted that present environmental variability precipitated by climate change is likely to cause an increase in global temperatures, changed weather patterns, rise in sea levels and lead to more recurrent and severe weather events. Africa is seen as one of the continents which are most vulnerable to environment and climate variability and change because of multiple stress and low adaptive capacity (Parry et al., 2007). Brown and Crawford (2008) also suggested that a lot of doubts exist about the long-term patterns of climatic and environmental variability and their likely effects on the livelihood activities of the poor. They are also of the opinion that the poor face considerable challenges in dealing with the effects of climate change, and this could reduce their livelihood choices. According to Stern, (2007) the likely effects of environmental variability and climate change are many. The many consequences of climate change projections on sub-Saharan Africa are that it will have a major effect on agricultural production by the end of the 21st century, and this could hamper the hope of reducing poverty in sub-Saharan Africa, a region where the majority of the population live in rural areas and rely on smallholder agriculture as their main source of livelihood (Slater et al. 2007; Assan et al. 2009; Yanda and Mubaya, 2011).

West Africa is considered to be one of the regions likely to be most affected by climate change. Its vulnerability is as a result of its geographical and climatic features. The region has five main bio-geographical features with the savannah, which is vulnerable to little changes in climatic features, occupying about 60% of the surface of tropical Africa (Laube, 2007). This therefore makes the assertion of Jain (2014:1) very relevant in this part of the region, where the Upper East Region (UER) is located when she said in her PhD thesis that:

> *"Variability is inherent to any living system, and adaptation, or changing one's behavior in response to variability, is an important way to reduce or eliminate possible adverse consequences of change. Adaptation is particularly important to consider in the face of contemporary climate change, as individuals and communities may be able to adapt their behavior in response to weather variability and reduce or possibly eliminate predicted adverse impacts".*

In the UER the rainfall pattern is erratic and irregular and is sometimes characterized by extreme drought and flooding resulting in insecure livelihoods. This is amply displayed in the fact that the region is considered as one of the poorest in Ghana with 8 out of 10 people considered poor (GSS, 2010). This adverse situation in the region has led to migration from the rural areas in the north to the areas in southern Ghana where the weather conditions are suitable for agriculture as well as in the urban areas where commercial activities are brisk to engage in menial jobs. There is therefore the need to address this unfavourable situation which has an impact on the development of northern Ghana including the UER. Identifying the adverse impacts of climate as outlined above will also help build the adaptive capacity of individuals and communities to respond to future climatic changes.

In an effort to improve rural livelihoods in the UER the government of Ghana commissioned the construction of 104 dams in the region in 1957 to enable all year farming, for watering livestock as well as for domestic purposes. The dams were fixed with irrigation infrastructure and the Ghana Irrigation Development Authority (GIDA) was given the authorization to manage the dams. The authority made efforts to engage local farmers in the practice of irrigation. The success of the irrigation schemes were mixed, as small-scale farmers were not wholly interested and GIDA's management approach was also authoritative and this deterred many farmers from engaging in irrigation farming (Gyasi, 2005; Faulkner, 2008).

The apathy displayed towards the use of these schemes led to the development of Small multi-purpose reservoirs managed by communities themselves through the Water User Associations. This was seen as one the solution for curtailing the higher incidence of poverty and a means of improving the living standards of the people through improved smallholder irrigation and also as a means to adapt to climate change. However, these small schemes themselves are now subject to the effects of climatic variability, high population growth and increased demand in water for domestic uses thereby putting additional demand for water meant for irrigation purposes (Neilsen et al., 2001). This is amply captured by a study

conducted by Green WaterHut in 2012 and other partner institutions to assess the vulnerabilities of communities in Northern Ghana with regard to evapotranspiration. The study concluded that climate change is one of the major causes of shortfalls in water levels in the reservoir of irrigation schemes in the Vea catchment area in the Bongo District and invariably in many parts of northern Ghana, thereby affecting the availability of water for domestic and irrigation use (Green WaterHut et al., 2012). Coupled with this is the fact that the UER with a population density of 118.4 per km2 is the highest exceeding the national density of 103.4 per km2 thereby increasing pressure on existing irrigation infrastructure (GSS, 2013; Limantol et al. 2016). It is in the light of this that the study seeks to find out how users of community managed irrigation schemes are able to adopt strategies to sustain their livelihoods from the use of the schemes in the light of climate change so as to mitigate the impacts the change has on the small scale irrigation schemes and farming.

1.1. RESEARCH OBJECTIVES AND QUESTIONS.

1.1.1. RESEARCH OBJECTIVES

The main research objective is to gain an understanding of how community managed irrigation schemes in the UER are contributing to sustainable rural livelihoods enhancement and explore the strategies adopted by users of the irrigation schemes to sustain their livelihoods from the use of the schemes in the face of climate change. Specifically, the study examines the discursive constructions of user perceptions about climate change and the causes of climate change. Moreover, the study explores how users of the irrigation schemes relate the impact of climate change to their livelihoods. Lastly as an important part of the project, the study examines discursive constructions of farmers' indigenous/local knowledge on climate change and how this knowledge base has been used by farmers' to evolve adaptation strategies so as to continue to sustain their livelihoods.

1.1.2. RESEARCH QUESTIONS

The main question for this study is: what are the adaptation strategies adopted by users of Community Managed Irrigation Schemes to sustain their livelihoods from the use of the schemes in the light of climate change?

The study seeks to answer the following questions:

1. How do users of the scheme perceive climate change and its causes and how are these perceptions constructed discursively?

2. To what extent do users of the schemes in the UER relate the impact/changes on their livelihoods to climate change?

3. How has indigenous/local knowledge on climate change stimulated and diversified farmers' adaptation strategies to climate related shocks?

1.2. CLIMATE VARIABILITY AND LIVELIHOOD ISSUES

The issue of livelihood has gained global attention in recent academic and development discourse. Humans all over the world in their quest to meet their needs have engaged in various economic ventures including agriculture as a source of livelihood. The agricultural sector is the foremost economic activity in Africa. The sector is the most important source of employment and largest contributor to many countries' GDP. The sector's contribution to employment and GDP varies but all point to the same fact that it is the main source of livelihoods on the continent. For instance the sector employs between 70%-90% (Nyong, 2005), 70% (Challinor et al., 2007) and 60% (Collier et al.,2008) of the total labour force and its contribution to export earnings is about 40% and accounts for one-third of national income (Nyong, 2005), contributes between 10%-70% of GDP (Boko et al. 2007) and 50% of GDP (Collier, 2008). Nyong (2005) pointed out that agriculture provides up to 50% of both household income and food requirements in Africa as well as being the highest-exchange earner in sub-Saharan Africa, accounting for about 70% of total revenue. This means that Africa's development largely depends on the agricultural sector; therefore climate change risks are a real concern for the livelihoods of people in the region where the climate is already too hot.

According to NDPC (2005), agriculture is the largest contributor to GDP in Ghana, contributing about 28.3% per annum and providing employment for over 60% of the population. Agriculture remains the engine of growth in most developing countries as a producer of food, raw materials and employment to majority of its citizenry. Notwithstanding this significant role of agriculture to developing economies, food production has come under threat due to rainfall variability. In fact the agricultural sector is believed to be the sector most prone to climate change. The sector (agricultural) is influenced directly by temperature and precipitation which are the two most important variables for agricultural production

(McCarthy et al., 2001; Arnell, 2004; IPCC, 2007; Funk et al., 2008). In the dry regions of sub-Saharan Africa irrigation schemes have played significant roles in providing productive lands for off-season agriculture. To sustain rural agricultural livelihoods, many governments in the sub-region over the years have embarked on massive irrigation development drives to enhance rural livelihoods.

The government of Ghana identified agricultural modernization and community-based irrigation as key to alleviating poverty and enhancing livelihoods especially in the driest savannah (NDPC, 2005). The NDPC document recognizes the fact that rain-fed agriculture cannot adequately meet the demands of providing food, employment and sustainable income to people in the savannah areas. The government therefore sought to develop a systematic policy to conserve and utilize rain water in all parts of the country by following the example of Burkina Faso, through the use of simpler and cheaper technologies for the harvesting and use of rain water for irrigation purposes. The Ripple Briefing Paper (2010), in a study conducted in the Ethiopian highlands noted that small-scale irrigation can advance rural food security, alleviate poverty and improve adaptation to climate change. This is because it enables households to create additional income, increase their resilience to climate shocks and, in some cases, may be able to transform their livelihoods. They were of the view that even though Irrigation has the potential to stimulate rural growth and generate new employment opportunities, it must be done in conjunction with investment in market infrastructure.

Globally, irrigation has contributed significantly to agricultural production in the world. About 40% of the entire world food crops are produced through irrigation farming undertaken on only 17% of the total agricultural land in the world (Upton, 1996; IPTRID, 1999; Inkoom and Nanguo, 2011). Irrigation enhances agricultural production by ensuring that farming takes place throughout the year through the artificial supply and application of water to crops. Irrigation has the capability to regulate water supply to crops, particularly at periods that the crops need the water most and also provides drainage facilities for the disposal of excess water, which is not possible when it comes to rain-fed agriculture (Rydzewski, 1987; Inkoom and Nanguo, 2011).

According to various statistics, three quarters of the world's extremely poor people live in rural areas and rely on agriculture and related activities for their livelihoods (IFAD, 2008; Glennie, 2012; Alkire et al., 2014). These are the people who will face the negative impact of

climate change. These people apart from food production have limited alternative livelihood opportunities outside the rural economy.

This explains why IFAD (2008) noted that agricultural production and access to food in many regions may be severely compromised by climate variability and change. Under climate change, the area appropriate for agriculture, the length of growing seasons and the yield prospect of some crops in the mostly arid areas may decrease. Under such circumstances, the prospects of achieving food security may be severely hampered. The findings of IFAD are also characteristic of the agricultural sector in Ghana where agriculture is opened to the vagaries of the weather and its performance is threatened.

Agriculture is also the main economic activity of the people of the UER of Ghana and about 80 percent of the people who are economically active are engaged in this sector (GSS, 2013). Agriculture in the region is largely rain fed and the low rainfall pattern makes it impossible for all year round agriculture, hence the need for the establishment of these irrigation schemes so that people can engage themselves in income generating activities during the dry season. Successive governments of Ghana in their quest to promote agricultural development in the three Northern Regions of Ghana have developed numerous irrigation schemes to promote all year production. Irrigation is, therefore, seen as an avenue to mitigate and adapt to the impact of climate change and variability in North-Eastern Ghana. The UER has recorded some of the largest irrigation schemes in Ghana such as Vea and Tono irrigation schemes which are managed by government agencies, mainly the Ghana Irrigation Development Authority (GIDA). Despite the provision of irrigation schemes by successive governments to serve as a source of livelihood through dry season farming in order to reduce poverty and bridge the north-south gap in development, poverty is still endemic in the UER[1] (IFAD, 2006; GSS, 2008) and the north-south seasonal migration is still on-going. This situation could be attributed partly to the failure of these large irrigation schemes in the UER.

The failure of these large irrigation schemes is seen as mainly a result of non-performance as a result of institutional weakness, high maintenance cost, deteriorating position of governments in terms of fiscal position, poor maintenance culture and inability to raise revenue from collection of water fees to meet operational expenses. This is evidenced by the inability of irrigation schemes to perform adequately in economic terms with Nigeria and

[1] UER is used as an abbreviation for Upper East Region.

Kenya being typical examples (Adams, 1991, 1992; Moris, 1987; Moris and Thom, 1990 in Adams, 2001). For instance in Kenya, by 1982, the Bura irrigation was two years behind schedule and costs were 187 per cent of those predicted in 1997 (Adams and Hughes 1990). Similarly, in Ghana after the construction of 22 public schemes in the 1960s and 1980s, the management was entrusted to the Ghana Irrigation Development Authority (GIDA). The unit made use of government subsidies and public funds to cover staff costs. However, with the commencement and acceptance of the Structural Adjustment Programme by the Ghanaian government in the 1980s, the authority had to reduce their staff strength. This made it difficult for the authority to effectively manage the 22 schemes because of the drastic cut in their budget and their inability to generate the needed revenue to continue paying the staff and managing the schemes. In fact personnel expenses for the management of the schemes accounted for 82 per cent of total expenditure (Miyoshi and Nagayo, 2006 in Namara et al., 2011).

The failure of these schemes provided the impetus for subsequent governments in Ghana to adopt the Community Managed Irrigation Scheme System as a way to ensure efficiency in the management and use of water resources in Ghana, especially Northern Ghana. This is buttressed by Liebe et al., (2005) and Van de Giesen et al., (2010), when they indicated that the UER alone has about 160 water reservoirs. The majority of these are small schemes used for irrigation farming and managed by the communities themselves. The reason for the adoption of this system is to devolve management responsibilities of the schemes to the local level so as to reduce the size and cost to government in irrigation scheme management (Shah et al., 2002). The community members therefore became stakeholders in the management of water resources in their communities (Obeng and Agyenim, 2013).

In view of the above and to manage these schemes, communities are encouraged to form Water User Associations (WUAs). The formation of these WUAs was often facilitated by external agencies including the Ministry of Food and Agriculture (MoFA) and some Non-Governmental Organizations (NGOs) (Derbile 2011). The formation of these User Associations is informed by the idea that the communities may be able to effectively manage the resources to ensure efficiency, equity and sustainability (Meinzen-Dick et al., 1999, 2002). The idea of the community managed irrigation schemes also lies in the principle that ‘small is beautiful’ which has been a guiding principle of most donor policies on small reservoirs as a response to the increasing cost of developing large-scale dams coupled with

under performance of the large schemes (Turner, 1994; Vaishnav, 1994; Postel, 1999; Keller et al., 2000; Shah et al., 2002; Swatuk, 2008 cited in Nkhoma, 2011). The functions of the WUAs included protection of the catchment area of the dams, resolving conflicts among members, revenue generation to carry out regular maintenance of irrigation facilities, scheduling the use of irrigation water and offering members the chance to enjoy services provided by development agencies such as the district assemblies and NGOs (Obeng and Agyenim, 2013).

The UER lies within the Guinea Savannah belt of the West African semi-arid area and the climate is characterized by one rainy season from May/June to September/October. The mean annual rainfall during this period is between 800 mm and 1-100 mm. The rainfall is erratic spatially and in duration. There is an extended spell of dry season from November to mid-February, characterized by cold, dry and dusty *Harmattan* winds. Temperatures during this time of the year can be as low as 14 degrees centigrade at night, but can go to more than 35 degrees centigrade during the daytime. However, humidity is very low, making the daytime temperature high and very uncomfortable. The Sahel climate of the UER makes it even more prone to climate change and this has dire consequences on its irrigation potentials. Invariably, with this situation, poverty reduction is impaired. Since poverty is basically a rural problem (IFAD, 2007) and the majority of the Ghanaian rural economies are agriculturally based, climate change puts rural livelihoods under risk.

Laux et al., (2008 cited in Laube et al. 2012), in their statistical analyses of rainfall patterns in the last 60 years have also indicated that the onset of the rainy season has shifted from April to May with increased dry spells during the rainy season in West Africa. This invariably has an impact on the level of water available in the small irrigation schemes and the livelihood of users is therefore threatened. Laube et al., (2012) also said regional climate model projections developed from the results of global climate change models indicate that climatic patterns have become more erratic and unpredictable than before in West Africa. This situation increases the likelihood of the incidence of severe events such as floods and droughts, and for that matter the danger of more harvest and food insecurity in the region. This was particularly the case in 2007 when the three northern regions of Ghana- the Northern, Upper East and Upper West Regions witnessed torrential rainfall leading to flooding. The rains followed two months of below average rainfall that had already impacted on the farming activities in the northern part of the country. The flooding caused a humanitarian situation, the scale of which

the country had not experienced in many years. This caused damage to crops, assets and livelihoods. The flooding together with the environmental effects of stagnant and receding water provided the impetus for a potential disaster for a population that was already vulnerable, placing them at further risk (UNDP 2009; Adu-Boateng and Oppong, 2011). This catastrophe also affected a number of small-scale irrigation schemes which had their infrastructure destroyed thereby affecting the livelihoods of users of the scheme. The destruction of irrigation infrastructure in northern Ghana according to Akudugu and Alhassan (2012), sometimes leads to violent conflicts between crop farmers and herdsmen who compete for the limited amount of water thereby worsening social insecurity, which impacts negatively on economic activities.

The impact of climate change is not only peculiar to West Africa and Ghana; its impacts are global. As noted by Oliver-Smith (2009a) the reality of climate change is widely accepted, but its impact in terms of actual and projected effects is still debated in the scientific and political arena. Climate change impact, though global in nature, has regional and sectoral variations depending on location, adaptive capacity as well as socio-economic and environmental factors. For instance, the semi-arid and arid regions are more vulnerable to the impacts of climate change due to decline in fresh water and river water availability as a result of low rainfall, increasing temperatures and precipitation whilst in mid to high latitude regions, moderate warming will benefit agricultural production, especially in cereal production and pasture yields (IPCC, 2007). Much in the same vein, many climate models are forecasting that the agricultural sector in the northern hemisphere and temperate areas in North America, Northern Europe, and parts of Northern Asia could profit from climate change due to the carbon fertilization effect and the warming climate. This will enable the expansion of potential agricultural farmland and enable longer growing seasons, thereby resulting in increasing yields (McCarthy et al., 2001; IPCC, 2007). On the other hand, the predictions for regions such as Africa, South-East Asia and Latin America paint a rather melancholic picture for the agriculture sector. The reason is that climate-induced changes such as floods, droughts, increasing soil degradation and shift in marginal agriculture systems will have negative consequences for the agricultural sector since it will lead to massive crop failures leading to livelihood disruptions in the regions (McCarthy et al., 2001; IPCC, 2007; Collier, 2008).

The tropical regions are mainly those affected by climate change (FAO, 2008). Also developing countries will be most affected by climate change, 11% of arable land could be

affected by climate change, leading to a reduction of cereal production in most countries by up to 16% of agricultural Gross Domestic Production (GDP) (FAO, 2005).

Africa, a continent which contributes insignificantly to GHGs emission (accounting for only 2-3% of the world's CO_2 emissions) is the worst affected by climate change (UNFCC, 2007). Africa is by far one of the most vulnerable continents to climate change. Africa's vulnerability is as a result of low adaptive capacity, multiple stresses, marginal climate and over-reliance on agriculture (Boko et al., 2007; Challinor et al., 2007). Africa's economic sectors are also vulnerable to climate related sensitivity. This is made precarious by existing developmental and socio-economic challenges. The combined effect of these is a reduction in adaptive capacity, thereby increasing the continents vulnerability to climate change. The day-to-day economic development of Africa especially at the local and household levels is influenced by the climate (Boko et al., 2007). In Africa by 2020, an estimated number of people between 75 and 250 million are projected to face more severe water shortage as a result of climate variability and change. It is also likely to reduce the supplies of water for irrigation. Climate variability and change is likely to compromise agricultural production and food security with a reduction of crop yields by up to 50% and crop revenues by as much as 90% by 2020 and 2100 respectively and small-scale farmers will be the most affected (Boko et al., 2007).

Although, Africa's production systems and infrastructure are vulnerable to climate variability and change, its impacts are not spread evenly. The impact is much stronger in sub-Saharan Africa, negatively at 56%. The most notable areas are the semi-arid regions which experience unreliable rainfall, causing severe impacts to crop production (Kurukulasuriya and Rosenthal, 2003; Boko et al., 2007). For instance, the Sahel was the spotlight of the international community in the 1970s and 1980s because of the devastating droughts and famine that hit the region leading to the deaths of thousands of people including a greater number of cattle due to lack of forage. Many families in their tens of thousands were also dislocated and left destitute (West et al., 2008). Much in the same vein, increase flooding could also lead to the spread of water related diseases such as cholera and malaria and rising temperatures could also trigger meningitis in many African countries (Dixon et al., 2003; Nyong, 2005; Boko et al., 2007).

Climate change has also been reported to have some benefits. It is predicted that the Sahel of West Africa could benefit from rising temperatures as evidenced in the re-greening of the

Sahel due to increasing rainfall in some parts of the area coupled with investment in environmental, economic and social capital (Sendzimir et al., 2011), but largely the negative impacts are weighty.

In view of the impact of climatic variability on livelihoods globally and in Africa, especially, in the UER, people adopt new strategies to adapt to the changing environmental conditions. Among some of the adaptation mechanisms are the adoption of the Shallow Ground Water Irrigation System (Laube et al., 2012), animal husbandry and intercropping of different crop varieties (Laube, 2007) and Craftsmanship[2] (Apusigah, 2009), whilst others in the wake of rainfall variability coupled with resource scarcity and low retains on agriculture engage in circulatory seasonal outmigration to find jobs in the mines and cocoa growing areas and major cities, mostly Accra and Kumasi being the preferred cities of destination (Agyei and Ofosu-Mensah, 2009). The studies of these adaptation strategies tend to be very general in nature and conducted on households in the UER. This study, therefore, will focus primarily on the activities of users of CMIS, but information will also be sought from non-users who are stakeholders to understand the dynamics of climate adaptation based on their local/indigenous knowledge.

1.3. IDENTIFYING A RESEARCH GAP

Climate change is considered to be one of the major threats to sustainable development because of its impacts on health, infrastructure, settlements, agriculture and above all food security. The vulnerability of sub-Saharan Africa to climate change impacts and the region's inability to deal with anticipated climate change scenarios has been highlighted through a number of global appraisal reports, such as the Millennium Ecosystem Assessment of 2005, the Stern Review of 2007 and the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2007 (IFAD, 2008).

The above assertion is a reflection of the situation in the Upper East Region (UER) which is a semi-arid area and the vegetation is largely of the Sahel savannah type, consisting of open savannah with fire swept grassland. The Sahel savannah is a major reason for the low rainfall pattern, which makes the development of community managed irrigation schemes a necessity in the region. The region also faces the problem of droughts and floods depending on the season; a clear example was the floods of 2007. This means that irrigation scheme

[2] http://www.ghana.gov.gh/index.php/about-ghana/regions/upper-east.

development in the UER where majority of the populace depend on agriculture is paramount for their livelihoods. Hussain, et al., (2003) supported this view in their five key interrelated areas of the irrigation/poverty alleviation relationship. This includes production, employment, vulnerability/food security, income/consumption, and overall welfare.

Though small-scale irrigation schemes have been developed in the region, many of these schemes are also affected by the incidence of climate variability which sometimes reduces the availability of water for irrigation purposes thereby stimulating competition among users of the schemes; this generates conflicts among users which has an impact on the livelihoods of the users. The situation often generates problems for officials of the WUAs who are to ensure that there is equity in the distribution of water.

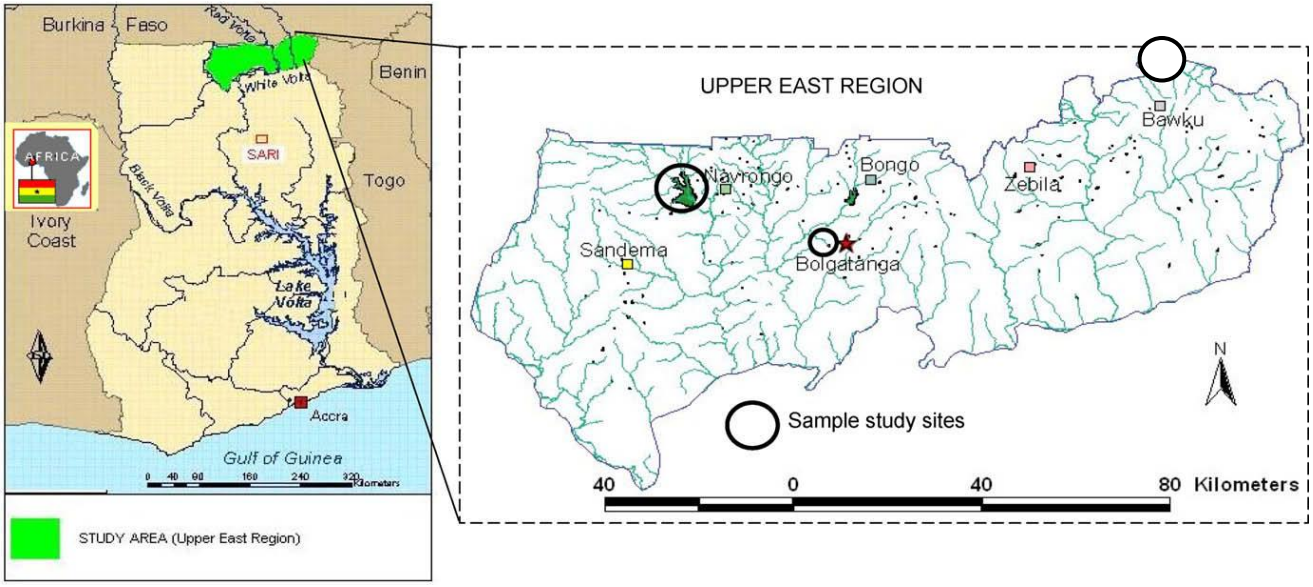
Following the key role irrigation plays to sustaining agricultural productivity in the Sahelian regions of Ghana, several research works have been undertaken covering varying aspects. Over the years, studies in the UER have centered largely on irrigation scheme management, water use and productivity (Faulkner, 2005; Faulkner et al., 2008; Mdemu et al., 2009), typology of irrigation schemes (Namara et al., 2011), irrigation and migration (Schraven, 2010), water resource allocation and management (Obeng-Asiedu, 2004; Eguavoen, 2007) and the impact of small scale irrigation scheme development on poverty reduction (MOFA, 2011; Inkoom and Nanguo, 2011). Even though, these studies have highlighted how small-scale irrigation have impacted on the wellbeing of the people, not much has been highlighted on the ability of these schemes to still be a source of secured livelihoods for small-scale dry season farmers, in the face of climatic change and variability. Moreover, they have not highlighted how users of community managed irrigation schemes are able to adapt their livelihoods to the changing natural environmental conditions that might have an impact on the schemes. This study therefore seeks to examine the performance of community managed irrigation schemes in enhancing sustainable rural livelihoods under climatic variability in the UER as well as assess how users of the irrigation schemes are able to adapt sustainable livelihood strategies to enhance their wellbeing and sustain the schemes.

1.4. FIELD STUDY AREA

This study focused on the assessment of how community managed irrigation schemes has fared as a source of sustainable livelihoods under climate change in Ghana. This is necessary to understand and better situate irrigation schemes amidst climate change. The research was conducted in the Bawku West and Bongo Districts of the Upper East Region, where small irrigation systems are common and management tasks are performed by the farmers themselves and a small Water Users' Association (Faulkaner et al., 2008). The region has about 160 water reservoirs (Van de Giesen et al.,2010, Liebe et al.,2005), many of which are community based irrigation schemes used for irrigation farming but the most notable two are the Tono and Vea irrigation projects in the Kessena Nankana Municipal and Bongo district respectively which are used for commercial irrigation farming. The irrigable land in the community based schemes are lands that belong to farmers in the community and through an agreement between the district assemblies and the landowners, the lands are ceded to the WUAs who allocate land to interested farmers who register with the association and pay a fee determined by the association.

The Bawku West District, which also commands a large number of the community managed small reservoirs, and the Bongo District have purposively been chosen because a lot of studies on water management and livelihood choices have been conducted in the area through the Global Change in the Hydrological Cycle (GLOWA) Volta Project. The ethnic spread of the study area too will be taken into consideration to ensure that findings are balanced and reflect to a great extent the socio-cultural settings of the region. In the Bawku West District the majority is from Kusasi ethnic group, but it is also home to several ethnic groups including the Mamprusis and Basaris from the northern region. The district is one of driest parts of the region, which makes the study imperative. The people of Bongo District are of the Grusi ethnic stock and call themselves Boosi, and the area is also under the threat of desertification. Another factor taken into consideration is the type of crops grown in the area, mostly onions, water melons and tomatoes respectively for Bawku West and Bongo Districts and their socio-cultural set up. This can give a good understanding of the nature of the livelihood adaptation strategy adopted by the users of the irrigation schemes in the two districts.

Figure 1.1 Map of Ghana indicating Area (Upper East Region)



Adopted from Mdemu et al., (2009)

1.5. SIGNIFICANCE OF THE STUDY

The study falls within the realm of community and rural development and seeks to find out how rural communities are able to sustain their livelihoods despite the impacts of climate change. The research will provide both quantitative and qualitative data on how users of community managed irrigation schemes in the UER perceive climate change and the factors that cause such changes. This would help them to better adapt their livelihoods within such a context as well as bring to the fore how these schemes contribute to sustaining rural livelihoods in the UER, especially in the area of food security, household income and ability to guard against shocks by overcoming their vulnerabilities.

The study therefore brings to the fore the challenges faced by communities in their use of these schemes that prevent households from meeting daily needs. This will provide a starting point for the development of programmes that target vulnerable communities, which rely on community managed irrigation schemes. The research also offers an insight on the daily stresses households go through in their quest to expand their assets and also spread their risk so as to improve upon their standard of living under climatic change and variability. It will therefore provide a platform for users of the schemes to provide recommendations that can help policy incorporate indigenous knowledge and expertise in their planning, especially with regard to environmental change due to climatic variability in the UER. Also, useful data will

be generated from the study which can equip policy makers to roll out mechanisms to enhance the participation of vulnerable groups such as farmers in the process of community development especially in the area of small scale irrigation schemes sustainability.

The study also highlights the important role indigenous/local knowledge (knowledge handed down from generation to generation through socialization) plays in every development effort and to highlight that indigenous knowledge in conjunction with other knowledge systems (scientific knowledge farmers learn from experts) can enhance sustainability of livelihoods. Finally, the study expands the current knowledge on factors that contribute to sustainable rural livelihood. It will serve as basis for further research by students and researchers in the academia into issues of water management and its impact on sustainable livelihood.

1.6. ORGANIZATION OF THE THESIS

The thesis is organized into eight chapters. As outlined above, chapter one is the introduction which identifies a research gap and establishes the research problem and research questions. Chapter two presents the theoretical perspectives and conceptual framework. The chapter elaborates on the concepts of climate and climate change, perceptions of climate change, vulnerability, livelihoods and sustainable livelihood approach. The chapter also extensively discusses issues on adaptive capacity and adaptation as well as indigenous knowledge. In this chapter I also outline the conceptual framework which draws on vulnerability, adaptive capacity and indigenous knowledge to explain livelihood sustainability.

Chapter three discusses the methodology of the study. This includes a discussion of the research approach and design, the philosophical foundations of the research, the sampling procedure, the sample size, the data collection techniques, that analysis of data and ethical issues.

The next chapter presents a brief outline of the study region. The chapter highlights the background of the study region, the geophysical characteristics of the region which makes it susceptible to climate related changes as well as the socio-economic issues that make the area vulnerable as well as having an impact on the livelihood of individuals and households.

Chapters five, six and seven make up the analytical chapters. Chapter five presents a highlight of the socio-demographic characteristics of the study area. In this chapter the integral characteristics were age, sex, ethnicity, religion, marital status, educational level of

respondents, and the number of years a farmer has been involved in irrigation scheme farming was considered. Some of these issues were cross-tabulated to provide a comprehensive understanding of how they influence farmers' access to land, which is a source of power in the study area, perceptions of climate change, the causes of climate change and the adaptation strategies employed.

Chapter six discusses how people perceive climate change and the factors that cause climate change and how these perceptions are constructed discursively. This chapter gives an insight into the factors that might account for how people perceive climate change and the factors responsible for climate change since climate change perception is a prerequisite to adaptation.

Chapter seven sheds light on how farmers relate the impact of climate change to their livelihood especially in the area of food production, incomes and access to some social services. The chapter also deals with the adaptation strategies adopted by farmers and their households to deal with rainfall variability, high temperatures and soil infertility through the use of indigenous knowledge since adaptation is a response to livelihood vulnerability. Issues discussed in this chapter include the conservation of water and how to deal with short falls in water supply from the schemes, how to enhance soil fertility and how to deal with the effects of high temperatures so as to enhance food crop production. The chapter also discusses local mechanisms employed by scheme users to sustain the schemes.

The next and final chapter (8) discusses the major findings that have been identified and summarized after each analysis chapter. The chapter therefore links the discussion of the findings of the study to the research questions and discusses the various identified discourse orientations and their implications for climate change adaptation. The chapter also highlights the contributions of the study to knowledge on climate change and variability and further provides an overall conclusion that can be drawn from the findings of the study. The chapter ends with suggestions for future research so as to further the debate on the central theme of the problem of the study.

1.7. LIMITATIONS OF THE STUDY

I envisage that the research will be largely successful but a study of such magnitude also came with some challenges. First and foremost there was a challenge with regards to the conceptual issues underpinning the research. The concept of climate change as an evolving contemporary concept was interpreted differently by various respondents; this was because

the ‘local’ equivalent of the term climate change was a daunting task to convey to respondents. To overcome this I had to use a whole phrase or sentence to explain it to their understanding, I particularly used climatic factors such as rainfall and temperature to make them understand what I meant by climate change. Another conceptual challenge is the concept of livelihood which was an integral part of this research. This is because pinning a precise definition to the concept was difficult. This therefore required a lot of tact in explaining the concepts to the respondents, so that they could relate it to current living conditions.

Another challenge was the inability to collect data over a long period of time. A research of this nature required the collection of data over a period of more than one year because of the climatic element. The limited time available for the research since the study is time bound means that much of the data on climatic issues was based on the memory of respondents and comparing it to existing secondary data.

Finally, a scenario that I will describe as a delimitation also affected the analysis. Though data was gathered in Tanga and Bongo in Bawku West and Bongo Districts, the analysis dwelled only on Tanga. This is because the data sets in both the quantitative and qualitative data did not show any marked differences to make a comparative analysis of the two districts, hence the need to concentrate on Tanga to do a thorough analysis rather than to repeat and duplicate information. Tanga was chosen over Bongo because it is more diverse in terms of its ethnic and religious composition than Bongo.

1.8. SUMMARY

The major issues pointed out in the introduction are that current environmental variability and climate change are predicted to have an impact on temperatures and other weather patterns leading to extreme events. The discussions highlighted the fact that there is uncertainty about long-term patterns of climate variability and their likely impacts on the activities of people especially the poor. In this chapter, I also pointed out that irrigation schemes development commenced in 1957 when the government commissioned the construction of 104 dams and management entrusted to GIDA but the failure of GIDA led to the construction of small purpose reservoirs managed by communities through the formation of decentralized WUAs who were charged with the day-to-day management of the schemes. I also drew attention to the problem that small-scale irrigation schemes, which have been constructed as a response to

unfavourable climatic conditions, have also been impacted negatively by climate change. This was noted by Green WaterHut and other partner institutions who concluded that climate change is one of the major causes of shortfalls in water levels in the reservoir of irrigation schemes in the Vea catchment area in the Bongo district and invariably in many parts of northern Ghana, thereby affecting the availability of water for irrigation and domestic use.

A considerable part of the chapter shed light on the issues of climate variability and livelihoods. The discussion indicated that agriculture is the largest contributor to GDP and contributing about 50% of household food supply and the highest exchange earner. Irrigation schemes are also seen as important to the economies of African countries through its ability to stimulate rural growth and generate new employment opportunities by enhancing all year round farming. I also pointed out that despite the importance of irrigation schemes, large scale irrigation schemes in Africa have failed to achieve the aims for which they were constructed, due to high maintenance cost, institutional weakness, inability to raise revenue to meet operational cost and poor maintenance culture among others.

Finally, I drew attention to various studies that have been carried out on irrigation scheme management and productivity, irrigation scheme and migration, impact of small scale irrigation schemes development and poverty reduction and water allocation and management. Through this preliminary review of literature, I found that not many studies have focused on how users of community managed irrigation schemes are able to adapt indigenous strategies to sustain their livelihoods within changing climatic conditions. It is therefore within this context that the study seeks to examine how users of community managed irrigation schemes in the Upper East Region of Ghana are able to evolve strategies based on their indigenous knowledge to sustain their livelihoods in the face of climate change.

CHAPTER 2: THEORETICAL PERSPECTIVES: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1. INTRODUCTION

This chapter entails a comprehensive review and discussion of the theoretical and conceptual issues that underpins the problem under study. The discussion in this chapter is divided into four parts. The first part deals broadly with the concept of climate change and perceptions of climate change taking into cognizance global and regional change scenarios as well as the factors that causes climate change and the evidence of climate change. It is important to dwell on climate change because of its strong linkage to livelihood issues which has a strong impact on development. This is followed by an inquiry into the perceptions of climate change from the global, regional and national levels. This will entail a discussion on both the physical and social perceptions of change. This is important because people's perception about climate change will inform the nature of adaptation employed by resource users to safeguard their livelihoods and curtail the impact of climate change.

In the second part the discussion focuses on livelihood. The discussion highlights the concept of livelihood and the components of a livelihood and how this is related to vulnerability. The discussion will also highlight the sustainable livelihood approach and framework and link it to a framework to understand adaptation of livelihoods to climate change. The discussion highlights the importance of assets as a buffer to guard against climate change so as to reduce the impact of climate related stress on the activities that enable them to make a living.

The third part of the discussion centres on vulnerability analysis. In this section the discussion sheds light on vulnerability as both a physical, social, institutional and economic phenomenon which makes people susceptible to impacts of climate change. The discussion highlights vulnerability as a double structure with an internal and external side. The fourth part of the literature review elaborates on adaptation and adaptive capacity, highlighting adaptation processes by resource users to climate change to enhance their livelihoods as well as a discussion on the fact that low adaptive capacity of the vulnerable makes it difficult for them to adapt appropriately to climate change. The discussion also sheds light on the local adaptive capacity framework as an approach developed to enhance the capacity of local resource users to enable them deal with the impact of climate change and the various capitals

and resources available for them to overcome their vulnerabilities as related to climate change.

The fifth part deals with a discussion on indigenous knowledge as an important resource to enhance sustainable livelihood and ensure development in the light of climate change. Based on the above discussion I embed the study in a conceptual framework that draws on climate change, livelihood vulnerability, adaptive capacity and indigenous knowledge to adapt to climate change. This will integrate the sustainable livelihood approach, local adaptive capacity and indigenous knowledge for an integrated conceptual framework for reducing livelihood vulnerability to climate change.

2.2. CLIMATE AND CLIMATE CHANGE

Climate change has gained widespread attention since the establishment of The Intergovernmental Panel on Climate Change (IPCC) jointly by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1998. Since then the IPCC have produced a series of reports on climate change issues with the recent one produced in 2014. The international impact of the phenomenon has given birth to various international agreements and protocols on the environment such as the Earth Summit in 1992 And the Kyoto Convention which culminated in the Kyoto Protocol in 1997.

According to Konrad and Thum (2014:32) much of the debate about climate change has centered on questions such as whether climate change is already on its way, whether climate change is man-made, what the likely consequences of climate change are, and whether climate change can be avoided by a reduction in greenhouse gas emissions. Sokona and Denton (2001) however contend that the idea that the climate is changing is no longer in contention but there is still scientific uncertainty in terms of timing, scope and magnitude of climate change.

Literature published on the topic of “climate change” during 1970–1990 focused primarily on changes in the physical climate system and how these changes affected other aspects of the Earth’s physical environment (IPCC, 2013). However, the IPCC report indicates that though the body of scientific knowledge about climate change and its impacts has grown tremendously, future conditions cannot be predicted with absolute certainty. The report noted that climate change impacts will rely on past and future socioeconomic development, which

influences emissions of heat-trapping gases, the exposure and vulnerability of society and ecosystems, and societal capacity to respond (ibid).

According to IPCC (2001), "Climate" refers to the average weather in terms of the mean and its variability over a certain time period within a particular geographical area. Climate is not uniform and varies from geographical areas, depending on latitude, distance to the sea, vegetation, presence or absence of mountains or other geographical factors. Climate also varies over time ranging from shorter periods to decades or much more over longer time periods. Statistically, significant variations of the mean state of the climate or of its variability, usually persisting for decades or longer, are referred to as "climate change".

Similarly, the IPCC (2007) describes climate as the overall long-term characteristics of the weather experienced at a place. The ecosystems, agriculture, livelihoods and settlements of a region are very dependent on its climate. Climate can therefore be described as a long-term summary of weather conditions, taking into cognizance average conditions as well as the variability of those conditions. The fluctuations that occur from year to year, and the statistics of extreme conditions such as severe storms or unusually hot seasons, are part of the climatic variability. Some changing climatic phenomena can last for whole seasons or even years without being noticed. The most common of these phenomena is called the El Niño phenomenon (IPCC 2007).

Climate change in IPCC usage refers to a "change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity". This definition differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC 2007). The UNFCCC therefore makes distinguishes between climate change attributable to human activities changing or altering the atmospheric composition, and climate variability attributable to natural causes, whereas the IPCC attributes climate change to be caused by both natural variability and human activities.

The main cause of climate Change is increased concentrations of Greenhouse Gases (GHGs) in the atmosphere resulting from human activities. The main GHGs that lead to climate change are carbon dioxide, methane, nitrous oxide and sulphur hexafluoride. The major contributor to the emission of carbon dioxide are exhaust fumes from industrial production and car use, while methane comes from cows and intensive cattle breeding, and nitrous oxide from agricultural land/animal manure management. These gases are responsible for the GHG-induced changes to the atmosphere, through the process known as the "Greenhouse effect" but Africa's role in the emissions of carbon is minimal and her past economic activities and future projections suggestion that it will continue to be minimal and insignificant (IPCC 2001, Collier et al 2008).

According to IPCC (2001), "climate variations and change, caused by external forcings (This "refers to forcing agent outside the climate system causing a change in the climate system". The changes include solar variations, volcanic eruptions and anthropogenic changes in the composition of the atmosphere and land use change which may be partly predictable, particularly on the larger, continental and global spatial scales, (IPCC, 2001). This is due to the fact that human activities contributing to the emission of greenhouse gases or land-use change, result in external forcing thereby making large-scale aspects of human-induced climate change partly predictable. The IPCC acknowledges that the ability to predict with certainty human-induced climate change is limited, due to population change, technological advancements, economic change and other important future human activities that cannot be predicted accurately by human beings. The IPCC therefore advocated that, people should rely on carefully constructed scenarios of human behaviour and determine climate projections on the basis of such scenarios.

On factors contributing to climate change the report of the IPCC (2007) indicated that human beings, like other living organisms, have always influenced their environment. The report noted that the Industrial Revolution in the mid-18th century gave sufficient evidence to the impact of human activities on global climate change. The human activities during this period that have contributed to climate change include the combustion of fossil fuels for industrial as well as domestic use. These fossil fuels generate greenhouse gases and aerosols which alters the composition of the atmosphere. The report acknowledges that the emission of chlorofluorocarbons (CFCs) and other chlorine have had an impact on the depletion of the stratospheric ozone layer.

This era where it was widely accepted that human activities impacted on the earth's ecosystem has been described as the anthropocene, a term first used by Biologist Eugene F. Stoermer in the 1980s and formalized by Paul Crutzen (Revkin, 2011). The anthropocene has been argued by several authors as a new epoch in Earth History and has been in use informally in the global research community. For instance Steffen et al. (2011) argue that the advent of the industrial revolution during the 1800 serve as a reasonable start for the anthropocene epoch. To them the anthropocene suggest that the earth is now moving out of its current geological epoch known as the Holocene and that human activity is mainly responsible for the exit from the Holocene because humankind has become a global geological force in its own right.

The IPCC (2007) report also referred to Land-use change as a major contributor to climate change. According to the report it is now recognized that land-use change as it is now may contribute significantly to changing the local, regional or even global climate and have an important impact on the carbon cycle. The physical processes and feedbacks as a result of land-use change that may have an impact on the climate include changes in albedo and surface roughness, and the exchange between land and atmosphere of water vapour and green house gases. This is generally referred to as anthropogenic climate change.

The seriousness of climate change has been acknowledged by several authors. The IPCC assessment report in 2007 for instance pointed out that that all regions may warm in the 21stcentury. However, the warming in all parts of Africa may be greater than the global annual mean warming throughout the continent and in all seasons, in the drier subtropical regions the warming will be more than the moister tropics (Christensen et al. 2007). They noted that extremely wet seasons, high intensity rainfall events and flooding are expected to increase by 20% in West Africa over the next decades.

Narrowing down the focus to West Africa, Brown and Crawford (2008) noted that climate change is not new in West Africa but has become pronounced in the twentieth century. The changes in climatic conditions in the region have been observed in the past decades resulting in a decrease in rainfall amounts leading to extreme droughts during the 1970s and 1980s resulting in the displacements and death of human beings and animals (West et al. 2008; Gordon et al. 2013). According to Gordon et al (2013) the climatic conditions during the 1970s and 1980s which saw a decrease in rainfall amounts and severe droughts led to a shift of the climatic zones in a southerly direction. According to them the impact of this shift in the

climatic zones has led to instability in the rainfall pattern leading to many rivers drying up, degradation of large tracts of land cover and the water table drawing down. A consequence of this is that pressure on water resources for farming will be highly affected.

Climate change issues in West Africa and the Sahel existed long before the droughts of the 1970s (Hulme, 2001; Derbile, 2010). In West Africa climate change scenarios show that temperatures have increased in the Sahel but climate models are in disagreement with regards to change in precipitation, while others suggest increases in rainfall (Paeth and Hense, 2004; Haarsma et al, 2005) others predict decrease in rainfall (Held et al. 2005; Biasutti and Gianni, 2006; Laux et al. 2008). Paeth and Hense (2004) are of the view that a future wetter Sahel seems possible. They point out that recent precipitation recovery in the Sahel can be due to a warmer North Atlantic propelled by increased GHG concentrations, which are going to rise continually in the 21st century. Similarly Haarsma et al. (2005) suggest that with the heating over the Sahara, they expect that a decrease in Mean Sea Level Pressure (MSLP) over the Sahara will lead to an increase in Sahel rainfall. With regards to decreasing rainfall in the Sahel, Held et al. (2005) and Biasutti and Gianni (2006) are of the view that emission of GHGs and aerosols, solar variability and volcanic eruptions have contributed to reproduce a drying of the Sahel in the late 20th century and temperatures across African countries increased by 0.5°C. They used simulations models to predict a drier Sahel in the 21st century. The disagreements with regard to precipitation in the Sahel is buttressed by the forth assessment report of the IPCC when they said that it is uncertain how rainfall in the Sahel, the Guinean Coast and southern Sahara will evolve (Christensen et al. 2007).

The seriousness of climate change is corroborated by Brown and Crawford (2008 citing EPA, 2007:7-8) who projected a steady rise in temperature and reductions in rainfall in Ghana over the next decades. They said that, “Historical data across the country from the year 1960 to 2000 shows a progressive and discernible rise in temperature and a concomitant decrease in rainfall in all agro-ecological zones in the country.” Based on this data, they estimate an average temperature rise of 0.6°C, 2.0°C, and 3.9°C; a rainfall decrease of 2.8 per cent, 10.9 per cent and18.6 per cent; and a sea-level rise of 5.8 cm, 16.5 cm and 34.5 cm by 2020, 2050and 2080 respectively (EPA, 2007:7–8 in Brown and Crawford 2008).

In a similar vein and addressing the issue of irrigation, Turner (2006) noted that climate change coupled with population increase will contribute to water scarcity globally thereby limiting its availability for irrigation. This therefore makes it imperative for farmers who rely

on irrigation to find solutions to the effect of climate change since agriculture is a major sector through which climate influences economic development. Nyong (2005) suggested that to respond to climate change there are two strategies thus mitigation and adaptation. According to him mitigation deals with the controlling of greenhouse gases to stabilize climate change at an acceptable limit, it is aimed at reducing the amount of future climate change and adaptation is adjustments to the impact of climate change given existing levels of greenhouse gasses in the atmosphere. It is aimed at reducing the vulnerability of a system so as to increase its resilience to change. He however noted that adaptation is the only feasible means for Africa to deal with the negative or adverse impact of climate change. Derbile (2010) noted that sustainable adaptation should be based on the contribution of a shift in paradigm for understanding natural disasters and livelihood interactions. In this study perception of climate, its causes and adaptation were my main focus to explore how small scale irrigation scheme users adapt to the changing climate to sustain their livelihoods.

2.3. PERCEPTIONS OF CLIMATE CHANGE

In this section I will review studies on the perception by people about climate change and how they understand and interpret climate change. The review will primarily centre on the perception of farmers since they are the crust of the study. Perception deals with views and interpretation based on beliefs and understanding (Wolf and Moser, 2011). Perceptions of climate change importance lies in the fact that it enables people form their own opinions about climate change and ultimately develop ways to adjust to its effects. This is in line with Fish (2010: 2) argument that, "perception is the primary source of our knowledge about the world in which we live. "It is therefore a basis on which we socially construct climate change based on our own realities". Maddison (2007) in studying climate change impacts on adaptation of agro-ecological zones in eleven (11) countries compared farmers perception and adaptation based on caparison of experience of farmers, level of education of farmers, access to extension information and so on. Maddison used ecocentric investigations to indicate that perception of climate change is an important prerequisite to adaptation due to the fact that perceiving that climate change has taken place enables farmers decide whether to adapt a particular measure or not. Similarly, Deressa et al. (2011) also in a study on farmers' perception and adaptation to climate change in the Nile basin in Ethiopia noted that continued climate change calls for the need to understand how farmers perceive climate change and adapt to climate change. They are of the view that such information is necessary to aid future

adaptation so as to reduce the adverse impact of climate change. Climate change is expected to have an adverse consequence on agricultural production in Africa, thereby compounding food and livelihood insecurity as well as income in the region and therefore a better understanding of how farmers perceive climate change, on-going adaptation measures. The factors influencing the decision to adapt farming practices is needed to craft policies and programmes aimed at promoting successful adaptation of the agricultural sector (Bryan et al. 2009). This is important because several factors influence why farmers adapt to climate change, including for instance wealth, access to extension, credit, government farm support, access to fertile land and information on climate change. These therefore need to be considered in adaptation policies (ibid).

Studies in Africa and Ghana indicate that farmers have adequate knowledge about the climate and have stated their views on changes in temperature, rainfall and winds (West et al 2008, Mertz et al. 2009a; Speranza et al. 2010; Fosu-Mensah et al. 2010; Yaro 2013). This means that any policy or strategy to address farmers concerns on the impact of climate change and variability on their livelihood should take into consideration the knowledge of farmers about their local climate to ensure that the strategy becomes acceptable to them. Their knowledge could also be linked to improve farmers' adaptation practices to climate change to improve upon their agricultural production. Most of the studies conducted on perception of farmers on climate change in many African countries including Ghana reveals that large numbers of farmers already perceive that the climate has become hotter and drier (Maddison, 2007; Gbetibouo, 2009) and the rains are less predictable and shorter in duration (Maddison, 2007). According to Yaro (2013), farmers' perception of climate change and variability cut across all categories of social groups and locations. This means that no one group or geographical area is insulated from the impact of climate variability and change, therefore in climate research the views of categories of people residing in different locations should be taken into consideration.

Several studies on the perception of farmers about climate change in developing countries are based on comparing farmer responses to meteorological data obtained from meteorological stations (Ovuka and Lindqvist, 2000; Thomas et al. 2007; West et al. 2008; Deressa et al. 2011). However, Deressa et al. (2011), said although this approach is informative in relation to understanding the level of awareness of farmers and using the data to validate farmers claims of perception of change against meteorological records, the method does not explicitly

identify the underlying factors influencing the level of awareness of climate change. In view of this other authors have conducted studies to indicate other underlying factors which influence the awareness of climate change in Africa. Gbetibouo (2009) in studies on perception of farmers on climate change in South Africa's Limpopo Basin indicated that perception of climate change differed slightly between farmers with more than 30 years of farming experience than those with less number of years. Similarly Maddison (2007) also noted that farming experience, age, gender and marital status of farmers play vital roles on how farmers perceive climate change. Also, the level of education of farmers, access to extension services and soil types affects how farmers perceive climate change (Maddison, 2007; Deressa et al. 2011). These factors have a strong impact on how farmers may adopt to or not to one or more adaptation strategies. For instance Maddison (2007) noted that experienced farmers in Africa are more likely to perceive that the climate is changing but those who are more likely to respond by adopting at least one adaptation strategy are the educated farmers and those with access to extension services.

Deressa et al (2011), in referring to Semenza et al (2008), added an economic dimension to how people perceive climate change when they indicated that individuals with higher incomes are more likely to be aware that the climate is changing than individuals with lower incomes. They are of the view that higher income influences positively public perception of climate change since they have access to other sources of information such as the print and electronic media. Much in the same vein they reiterated that higher farm and non-farm income also positively affect farmers' perception of climate change. It is therefore important to consider income levels farmers in studying climate change perception since it may have an influence on farmers' ability to access information about the climate.

To narrow the scope I will henceforth concentrate on studies conducted in West Africa and Ghana on how farmers perceive climate change. West et al. (2008) indicated that in their studies in Burkina Faso, most farmers contended that there is a long-term decline in rainfall as well as an increase in its variability contradicting the views of Nicholson (2005) that indicate that the Sahel is experiencing a recovery in rainfall. The perceptions of the farmers are grounded in local history, regional history and culturally significant events (West et al. 2008). This assertion indicates a need to accommodate indigenous knowledge in studies of farmers' perception. Speranza et al. (2010) supported this assertion when they recommended incorporation of indigenous knowledge in educational programmes and climate change

research. Berkes and Jolly (2001) also asserted that indigenous knowledge is relevant to adaptation because it is at the local level that people have to adapt to climate change impacts and indigenous knowledge will therefore serve as the first source of adaptive capacity to do so.

In Ghana several studies point to the fact that farmers perceive change using changes in climatic factors such as temperature, rainfall and precipitation. In several of the studies, farmers perceived a long-term change in temperature and noted that temperature is rising while rainfall and precipitation are declining (Fosu-Mensah et al. 2010; Kemausuor et al. 2011; Yaro, 2013).

On the causes or reasons for climate change, Mertz et al (2009a) in studying sedentary farmers in the savannah zone of central Senegal in the Sahel, indicated that households and in this case farmers have a good knowledge about climate change. For instance, they were aware of climate variability when they identified wind and occasional excessive rainfall as the most destructive climate factors. However, they noted that when questions about land use and climate change were not asked directly in a climate context, they tended to assign economic, political and social rather than climatic factors as the main reasons for change. In this respect, when exploring the perception of individuals or household on climate change, it is important to situate it in the climate context. Kumausour et al. (2011) also noted that peoples' understanding of the factors that cause climate change varies a lot and they asserted that while some take a more scientific view, others perceive climate change in religious terms. The unscientific perceptions may be a result of many subsistence farmers being often poorly educated and mainly rely on superstition to explain natural events since that is their only source of information (ibid). Yaro (2013), in a study on farmers perception of climate change among small scale farmers and commercial farmers in Ghana showed that small scale farmers attributed changes in climate to social and religious/moral reasons while commercial farmers noted environmental reasons for the causes of change in line with scientific observations for the causes. From the literature reviewed, any policy that seeks to tackle effects of climate change especially on farmers, the perception of farmers on climate change should be taken into consideration since perception will indicate the sort of adaptation strategies that households and farmers will employ. In this study the focus will be on how small irrigation scheme farmers perceive climate change, how they perceive its impacts on

their livelihoods and the adaptation strategies that they have adopted to deal with the adverse impacts of climate change.

2.4. LIVELIHOODS AND THE SUSTAINABLE LIVELIHOOD APPROACH

I this section I would centre the discussion on the sustainable livelihood approach as an integral part of the conceptual framework. The approach is an integral tool to assess people's livelihood activities and strategies and to understand the stores of resources at the household level which ensures well-being of its members. The discussion will dwell on livelihood components, activities and strategies which is a major thrust of this study.

The concept of livelihood and sustainable livelihood date back more than 20 years (Solesbury, 2003:1) and gained widespread attention in the late 1980s and early 1990s. The sustainable livelihood approach emerged strongly in the early 1990s as a reaction to wider changes in the general thinking of development during the 1980s. The Brundtland Commission Report of 1987, which gave birth to the modern sustainable development concept, offered the first appearance in policy debate about sustainability, which was later conceptualized as the sustainable livelihood approach. The work of Robert Chambers in the late 1980s and early 1990s and particularly the work of Chambers and Conway in their pioneering work in 1992, titled "Sustainable Rural Livelihoods: Practical Concepts for the 21st Century" developed and contributed significantly to the concept and analysis of sustainable livelihoods. Their work served as the basis and intellectual inspiration for modern livelihood studies and provided a general understanding of the lives of poor people (de Haan and Zoomers, 2005). Since the pioneering work of Chambers and Conway, the concept of sustainable livelihoods has been adopted and used by development agencies such as the Department for International Development (DFID) and NGOs notably OXFAM and CARE (Solesbury 2003:3).

The definition of livelihood and sustainable livelihood as propounded by Chambers and Conway in 1992 was slightly modified by Carney when she defined livelihood as something that:

…. "*Comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base*" (Carney, 1998:2).

This means that issues of livelihood should consider the ability of future generations if it is to be sustainable such that future generations can still earn a living from the environment in which they find themselves.

According to de Haan and Zoomers (2003:352), a livelihood should be seen as holistic in nature. It is also more than just income (Ellis 1998). This nature of livelihood is espoused by Ellis (1998:4) when he said " a livelihood encompasses income, both cash and in kind, as well as the social institutions (kin, family, compound village and so on), gender relations, and property rights required to support and to sustain a given standard of living. A livelihood also includes access to, and benefits derived from social and public services, provided by the state such as education, health services, roads, water supplies and so on". See also Lipton and van der Gaag (1993) and Blackwood and Lynch (1994). For instance rural people may not have income but have other assets such as knowledge, skills, natural resources and other human relations such as family and friends which they can rely on as a means to survive and enhance their wellbeing and living conditions (Soh and Omar, 2012).

From the above assertion the concept of livelihood goes beyond just a man-land relationship which has been the focus of past studies, the scope has been widened to include non-environmental and non-economic aspects. Though, the sustainable livelihood approach has influenced many development efforts since the work of Chambers and Conway. Appendini (2001:24 in de Haan and Zoomers, 2005:30), noted that the central objective of the livelihood approach was "to search for more effective methods to support people and communities in ways that are meaningful to their daily lives and needs, as opposed to ready-made interventionist instruments". Livelihood approaches as noted by de Haan and Zommers (2005), in this era rather took an optimistic household approach that showed how people are able to survive which is a departure from previous household studies that showed a rather pessimistic picture of the exclusion and marginalization of households from the benefits of economic growth in the 1990s. Livelihoods can be defined at different hierarchical levels but the commonest descriptive level is the household and it is considered as the most important unit of analysis (Chambers and Conway, 1992, de Haan and Zoomers, 2003). It is through the household that livelihoods are handed down from generation to generation through the creation of new households. Chambers and Conway (1992) based on their insights from previous works on food security and agro-ecological sustainability points out people's survival capabilities through their livelihoods, they indicated that people's livelihood may be determined in a number of ways. A livelihood could be determined through ascription, that is

by accident of birth, as in the caste system in India when an assigned role is given to a child when s/he is born. It could also be gender as socially defined which could also be an ascriptive determinant of livelihood activity and finally, through socialization and apprenticeship as an inherited livelihood activity for example as a cultivator of land with tools or a pastoralist who keeps animals. A livelihood is therefore determined by the social, economic and ecological environment, in which people find themselves.

Chambers and Conway (1992) indicated that securing a livelihood comprises a system of interrelated parts. In their analysis, they categorized household livelihoods into four, thus: 1) people, with their livelihood capabilities, 2) activities, indicating what they do, 3) assets, consisting of tangible (resources and stores) and intangible (claims and access) which provide material and social means, and 4) gains or output, thus the living they gain from what they do.

In the livelihood framework the most complex is the portfolio of tangible and intangible assets. The tangible and intangible assets provide the basis on which people construct and contrive a living, using physical labour, skills, knowledge and their creativity. The acquisition of the skills and knowledge may be within the household, handed down from generation to generation as indigenous technical knowledge, or through apprenticeship, or more formally through education or extension services, or through experiment and innovation (Chambers and Conway, 1992).

The various assets categorized under tangible and intangible assets are explained briefly below:

Tangible assets of the household:

- Stores: these are tangible assets such as food stocks, gold, jewellery and woven textiles as a store of value and cash savings.
- Resources: these include land, water, trees and livestock. Farm equipments, tools and utensils (domestic).

Intangible assets of the household:

- Claims: these are referred to as demands and appeals made for material, moral or other practical support or access. This is often made at times of stress or shock, or when other contingencies arise. The support may take many forms, ranging from food to issues of work as well as loans. Claims may be made on individuals or agencies, on relatives, neighbours, patrons, chiefs, social groups or communities, or on NGOs,

governments or the international community, including programmes for poverty alleviation or drought relief. These are often contingent on combinations of right, precedent, social convention, moral obligation and power.

- Access: this is the opportunity offered in practice to use a resource, store or service or to obtain information, material, technology, employment, food or income including rights to common property resources (CPRs). . Transport, education, health, shops and markets constitute the services. Information includes extension services, radio, television and newspapers. Techniques of cultivation and new seeds constitute the technology. Employment and other income-earning activities include rights to common property resources (CPRs) such as fuel wood or grazing on state or communal land.

Therefore at the household level assets available constitute a stock of capital which can be stored, accumulated, exchanged or depleted and put to work to generate a flow of income, resources and other benefits (Rakodi 1999:316).

From the literature reviewed, an important aspect mentioned in the sustainable livelihood approach are 'assets' or 'capitals' which Ellis (2003) referred to as 'resources' that people own. Chambers and Conway (1992) indicates its centrality in the livelihoods of people but only used two categories (tangible and intangible assets) but subsequent authors building on this divided the assets further between five or more capitals (Scoones, 1998; DFID, 2001; Ellis, 2003). DFID (2001) and Ellis (2003), grouped these assets or capitals into five types owned or accessed by family members and households. These are; a) human capital (skills, education, knowledge, health and ability to labour to enable people pursue different livelihood strategies), b) social capital (networks, associations and connections based for example on kinship relations that aid people in building their livelihoods), c) physical capital (capital investment, goods and basic infrastructure to support livelihoods, for instance, irrigation canals, implements etc.), d) natural capital (land, water, trees etc., this is the natural resource base) and e) financial (cash, loan access and savings). The quantity and quality of these assets make a big difference in the viability of rural livelihoods. These assets jointly indicate the asset status as wells as the robustness of the household livelihood survival strategies (Ellis, 2000:296). The overall aim of the sustainable livelihood approach is to increase sustainably the asset base and strengthen the capabilities of people to utilize these assets (Butler and Mazur, 2007)

I will at this point turn the discussion on livelihood strategies and activities. Livelihood activities simply put refers to the things that people do in pursuit of a living. The definition of livelihood strategies draws on the concept of assets (DFID, 2001); it describes the processes in which people combine the different assets at their disposal to ensure that they meet their various needs and enable them reach their desired livelihood outcome (ibid). Livelihood strategies can also be said to be the combination of activities pursued by people so as to achieve their livelihood goals at the household level. Livelihood strategies that exist for the poor may include investing in securing more of an asset, hedging against unforeseen circumstances as a way of generating more inflows or substitution of an asset for another (Rakodi, 1999:318). Scoones (1998:9) also indicated that livelihood strategies available for the household could be agricultural intensification or extensification, livelihood diversification and migration. People's ability to pursue different livelihood strategies is determined by the basic material and social, tangible and intangible assets (capitals) at their disposal (ibid).This indicates that building the asset base of poor people who are mostly the vulnerable is a way to help them achieve their livelihood goals.

According to chambers and Conway (1992), rural livelihood activities often comprises one, or more several activities ranging from agricultural activities, artisanal work, agro-processing and social service provision. Scoones (1998) identified a number of elements in the sustainable livelihood framework which influence livelihood outcome; these include institutional processes and organizational structures, livelihood strategies, livelihood resources, conditions and trends of livelihood outcomes. In all of these elements the institutional processes are the most important in determining the outcome of livelihood due to the fact that they mediate access to natural resources and ability to carry out livelihood strategies as well as providing the social context within which livelihoods are constructed and the power to carry out livelihood adaptation.

Modern livelihood studies based on the sustainable livelihood approach have put people at the centre of development and emphasise human well-being and participation of local people in activities that support their livelihoods (Solesbury 2003:5). de Haan and Zoomers (2003:353) argued in the same vein that by "putting people on the centre stage, research in livelihood has helped to open the 'black box' of the household". By this assertion modern livelihood studies and practice makes it possible for researchers and practitioners to know what happens and constrains people at the household level from achieving desirable

livelihood outcomes, therefore any approach to solve the bottlenecks that hampers people's well-being should first of all take into consideration concerns of the people.

This notwithstanding, Scoones (2009:182), pointed out some shortcomings of the livelihood approach. Central to this study is the fact that the sustainable livelihood approach has an inherent lack of a robust attempt to solve long-term secular change in environmental conditions due to the likely impacts of climate change especially in poor parts of the world because the impact of climate change has been ignored by the originally conceived livelihood approaches. He also observed that the livelihood approaches did not integrate livelihood thinking with an understanding of the local context taking into consideration concerns for global environmental change. His concern was that with respect to the new challenge of climate adaptation, support for past livelihood strategies that seek to support local strategies will not be enough. In spite of these concerns, the sustainable livelihood approach still remains one of the best approaches that seeks to understand activities taken by the poor to safeguard their well-being taking into consideration their assets. As noted by chambers (1987:14), the attraction of the sustainable livelihood approach (SLA) is that it combines the different modes of thinking about sustainability namely environment, development and livelihood thinking. It also has the following characteristics of social equity, economic efficiency, ecological integrity and resilience and builds on the systems the poor possess and the adaptive strategies they use to sustain their livelihoods when they are faced with economic and environmental pressures (Helmore and Singh, 2001; Butler and Mazur, 2007).

2.5. VULNERABILITY

In this section, I focus on vulnerability by putting out the evolution of vulnerability. Secondly, I explain the concept of vulnerability and the seeming difficulty in conceptualizing and pinning a definition to the concept of vulnerability. Thirdly I explain the 'double structure' associated with the concept and the analytical framework developed by Watts and Bohle in an attempt to bridge the 'theoretical gap' based on the fact the concept does not rest on a well-defined theory and finally I discuss some of the root causes of vulnerability.

It is clear and rational that research and analysis of climate change adaptation should begin with vulnerability analysis. The concept of vulnerability emerged in the 1970s from the discourse on natural hazards and disaster (Okeefe et al. 1976).

In most of the literature, the concept of vulnerability has been defined differently by different authors, based on their theoretical orientations, but my interest is not to dwell on the various approaches espoused by different authors but to link vulnerability to the household as a basis for understanding how livelihoods are vulnerable especially at the household level. In line with this Ribot (1996) asserted that by looking at vulnerability at the household level, climatic and other environmental phenomena can be understood socially.

In the past three to four decades, the concept of vulnerability emerged strongly in the social sciences following the publication of Amartya Sen on famine (1981) and thereafter Robert Chambers (1983; 1989; 2006). Vulnerability as a concept was mostly used in the literature on risks, hazards and disaster (Hewitt, 1983; 1995, Gilbert, 1995, Cutter, 1996) but its use is now prominent in areas of global change and environment and development studies (Cutter, 1996). Vulnerability emerged as a concept to explain how natural hazards[3] impacts on people's livelihood. Early proponents of this theory focused on hazards and entitlement failure to explain vulnerability. Among the theorists of entitlement failure and to explain how famine and hunger occur are Sen (1981; 1989), Watts and Bohle (1993), Adger (2000), Kelly and Adger (2000) and Bohle (2001). The concept was also a response to the purely hazard-oriented perception of disaster risk management in the 1970s (Schneiderbaur and Erhlich, 2004:13 in Birkmann 2006:11). The analysis of vulnerability is therefore torn between the risk-hazard and the entitlement and livelihoods approaches (Ribot 2010:51, see also Fussel and Klein, 2006, Adger, 2006, O'Brien et al. 2007).

Several authors (Cannon 1990; Blaikie et al. 1994; Wisner et al. 2004; van der Geest, 2004; Oliver-Smith, 2009a) have acknowledged that for a great many years, 'natural' hazards was seen as the cause of 'natural' disasters among human populations and this was the belief for decades. However, as noted by (Cannon, 1990:1, van der Geest, 2004:8) it is now

[3]The natural hazards theorization has contributed to an understanding of vulnerability that simultaneously incorporates biophysical (biophysical vulnerability) and social (social vulnerability) constructs. Biophysical vulnerability is a concept developed from global environmental change research and is generally used to describe the extent to which a system is vulnerable to adverse effects of climate change and to what extent it is unable to adapt to such impacts (WBGU, 2005:33). It's a function of exposure, sensitivity and adaptive capacity. Social vulnerability on the hand deals with the susceptibility of humans and the conditions necessary for their survival and adaptation within a social system (WBGU, 2005:33). It focuses on human drivers of vulnerability namely the economic, social and political that generates unsafe conditions as a result of climate change. It is a social dynamic embedded in class, gender, ethnicity, culture, nationality, age and other power relations (Enarson et al. 2006).

increasingly accepted that not all 'natural' hazards result in disasters; they are trigger events. Hazards do not affect people evenly, even though it can lead to damage, loss and suffering, some groups are more prone to hazards than others, and as such it does not affect people's livelihoods evenly (Wisner et al. 2004). This was made clear by van der Geest (2004:8) when he said that "a drought does not have to result in a famine" and "when an area is affected by floods, for one family this can result in a tragedy from which it might take years to recover, while for a neighbouring family, it might be a mere disturbance of daily life". This means that there are other factors that determine vulnerability of households to disasters, apart from the hazard itself. Disasters are not caused by a single factor such as a natural hazard but by a complex interaction of both environmental and social features and forces (Oliver-Smith, 2009a). The root causes of disasters are therefore embedded in ideological, social, economic, environmental and political systems. These develop, often over centuries, and have contributed to the formation of patterns that over long periods of time produce unsafe conditions (ibid). This is a departure from the traditional view in which vulnerability was seen as either a pre-existing condition or a potential exposure to risk (biophysical) or as a social situation predisposing some response to an external threat (Cutter 2006:537). A natural hazard becomes a disaster when it affects vulnerable people (Blaikie et al. 1994, van der Geest 2004:8). Hazards cease to be hazards if society can absorb all of its impact without effect (Oliver-Smith, 2009b:14). In such a situation it does not result into a disaster since society can deal with its impacts through adaptation.

Vulnerability as a concept is multifaceted in nature and has been defined differently by various scholars. Similarly, Birkmann (2006:11) noted that the different approaches propounded by different authors to analyze vulnerability do not clearly show what vulnerability stands for as a scientific concept. In the same vein, Adger (2006:269), said that different traditions and disciplines ranging from economics to engineering use the term to mean different things, he intimated that "it is only in the human-environment relationships that vulnerability has common, though contested, meaning". It is the area of human geography and human ecology that have attempted to theorize vulnerability to environmental change. It is in these disciplines that socio-ecological systems are related to insights into entitlements grounded vulnerability analysis (ibid).

From a natural hazard perspective, Wisner et al. (2004:11, see also Blaikie et al. 1994:9), defined vulnerability as "the characteristics of a person or group and their situation that

influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard (an extreme natural event or process). It involves a combination of factors that determine the degree to which someone's life, livelihood, property and other assets are put at risk by a discrete and identifiable event in nature and in society". They further argue that vulnerability "is a measure of a person or groups exposure to the effects of natural hazard, including the degree to which they can recover from the impact of that event". The definition indicates that people's vulnerability is a measure of their ability and capacity to adapt to as well as respond to stress. Wisner et al. (2004) therefore argue that households with access to resources and social networks are less vulnerable to the impacts of natural hazards. For example even though a drought or flood can have an impact on people's livelihoods in Northern Ghana, resource-rich households are more likely to recover quickly from the loss of crops than less endowed households. Kelly and Ager (2000:328), drawing from Blaikie et al. (1994), defined vulnerability as "the ability or inability of individuals or social groupings to respond to, in the sense of cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being". This definition suggests that there are already some innate weaknesses which may limit the ability of individuals and groups to respond to stresses placed on their livelihoods independent of future threats. The definition also depicts the social aspects of vulnerability and is often used to explain social vulnerability. A more human centered view of vulnerability was expressed by the UNDP. The UNDP (2004:11) sees human vulnerability as "a condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard. Human vulnerability includes within it the vulnerability of social and economic systems, health status, physical infrastructure and environmental assets". To them it is possible to look at these subsets of vulnerable systems in isolation, but in this instance they are concerned with the broad picture of human vulnerability (ibid). In relation to climate change, the IPCC defines vulnerability as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" (Parry et al. 2007:6). To the IPCC, "vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system" (ibid). The definition of the IPCC is focused more on technical technology issues of a system rather than people but the principle is largely in line with the human-centered definitions. The IPCC widens the definition to include both natural and human systems. The definition also shows how communities are susceptible to harm due to their lack of capacity to cope and adapt to hazards, it is therefore related to the

lack of adaptive capacity of individuals, households and communities due to their vulnerability. In the context of changing climate and increased hazards, Wisner et al. (2004:12) noted that vulnerable groups comprises those who find it very difficult to reconstruct their livelihoods in the wake of a disaster and this in turn makes them more vulnerable to the effects of subsequent hazard events. Vulnerability is often equated to poverty, but they are not the same, the determinants and dimensions of poverty are complex, poverty is considered as one of the factors which cause and aggravate vulnerability but not vulnerability itself.

In the literature reviewed a common theme that runs through is that 'vulnerability' is a dual process and having a dual structure involving exposure to risk, stress and shocks and a lack of adaptive capacity (Chambers, 1989, 2006; Bohle, 2001, van Dillen, 2002, 2004; Birkman 2006; Lucini, 2014). According to Chambers (1989:1; 2006:33), vulnerability has "two sides: an external side of risks, shocks, and stress to which an individual or household is subject; and an internal side which is defencelessness, meaning a lack of means to cope without damaging loss". The loss may be in the form of being physically weak, impoverished economically, socially dependent and humiliated or psychologically harmed. Much in the same vein Bohle (2001, cited in Birkmann 2006:19) also acknowledges the double face of vulnerability as having an external and internal side, the internal side of vulnerability deals with the capacity to anticipate, cope with, resist and recover from the impact of a hazard whiles the external side comprises the exposure to risks and shocks. In the social sciences the distinction according to van Dillen (2004), between the exposure to external threats and the ability to cope with them is what is termed as the 'double structure' of vulnerability. See also Derbile (2010). Bohle (2001), based on perspectives of social geography and his research on famine intimated that vulnerability is the result of the interaction between the exposure to external stressors and the coping capacity of the household, group or society. Fussel and Klein (2006:306), based on insights from the IPCC definition of vulnerability also acknowledged vulnerability as having "an external dimension, which is represented by the 'exposure' of a system to climate variations, as well as an internal dimension, which comprises its 'sensitivity' and its 'adaptive capacity' to these stressors". They indicate that the IPCC makes a distinction between the external aspect and internal aspect of vulnerability separate from each other. Ribot (2010) however noted that the idea of external and internal aspect of vulnerability depends on how the boundaries of the system under analysis are drawn. The double structure of vulnerability forms the core components of vulnerability

frameworks (van Dillen, 2002). To deal with the boundary problem and to analyze the double structure of vulnerability, Watts and Bohle (1993) adopted an analytical framework based on an extension by Dreze and Sen's (1989) analysis of entitlement. The purpose was to explain the causal structure of hunger and famine in what they called the 'space of vulnerability', to explain why a given individual, household, group, nation or region is at risk due to exposure[4] and how they are able to cope.

The conceptual framework will be drawn on for this study to help explain how households' livelihoods are vulnerable to the impact of climate change and vulnerability. Watts and Bohle (1993) pulled together different strands of vulnerability analysis to model the space and causal structure of vulnerability. The framework hinges on a triad of entitlement, empowerment and political economy. Ribot (1996) noted particularly that the addition of the political economy approach introduces a household perspective on vulnerability which has been largely ignored and replaces the "ecocentric" approaches to environmental change. Also see van der Geest (2004:12). The framework espoused by Watts and Bohle (1993) will be incorporated in conceptual framework to explain how irrigation scheme users are able to adapt to the impact of climate change based on available resources that the users own in order to sustain their livelihoods.

The significant contribution of this approach is that it focuses on the vulnerability of individuals and social groups (Olmos, 2001). Vulnerability within this framework is determined by access to resources, thus specifically by individuals' 'entitlement' to call on these resources (Adger and Kelly, 1999 in Olmos, 2001). Among the commonest of these approaches is the entitlement approach. With regard to the entitlements, Sen's work on hunger and famine provided the inspiration for the entitlement approach. According to Ribot (1996) Sen's analysis of vulnerability to hunger and famine in the 1980s begins at the household level with what he terms entitlements. Sen's entitlement[5] approach to analyze vulnerability to hunger and famine (food security) in the 1980s is still important and relevant

[4]Exposure is employed to refer to the presence (location) of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage.

[5] Entitlements are the total set of rights and opportunities with which a household can command-or through which it is 'entitled' to obtain-different bundles of commodities. They are the set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that s/he faces (Sen, 1984; Adger, 2006; Ribot, 2014).

presently. Sen argues that hunger and famine is not caused by a decline in the availability of food (i.e. production failure), but by a failure of people to bring to bear their command over food (i.e. exchange failures or entitlement failures). A household's food entitlement includes the food that the household can obtain through production, exchange, or extra-legal legitimate conventions which include reciprocal relations or kinship obligations (Dreze and Sen, 1989; Ribot, 1996). Famines and hunger is a result of entitlements failure leading to large group of people going hungry, thus a person will go hungry if his/her entitlement does not include a commodity bundle with enough food (Sen 1987: cited in van der Geest 2004:9).

In relation to climate change, the entitlement approach views vulnerability as a lack of sufficient means to protect or sustain oneself in the face of climate events where risks is shaped by society's provision of food, productive assets, and social protection arrangements (Adger 2006:70, Ribot 2010). Households are vulnerable to shocks if they are not able to acquire food through a combination of production, exchange (of goods, services, cash, sale of labour) and assets both tangible and intangible as well as investment. The reverse makes households relatively secured (van der Geest, 2004). Vulnerability in the entitlement approach is therefore the possibility that the household's alternative commodity bundles may fail to buffer them against hunger, dislocation, or other losses (Downing, 1991; Ribot, 2010).

From the above analysis the entitlement approach is more ecocentric focusing more on mans ability to derive benefit from the environment to guard against vulnerability. It is therefore nature-centered. To show that other processes or factors can shape vulnerability several authors (Dreze and Sen, 1989; Watts and Bohle, 1993; Ribot, 2010, 2013, 2014) added a human-centered approach to analyse vulnerability and to indicate how these process they termed as empowerment shape entitlements. The empowerment approach is based on political or social power seen in state-civil society relations. Empowerment is therefore "the ability to shape higher-scale political economy that in turn shapes entitlements" (Dreze and Sen, 1989; Watts and Bohle, 1993; Ribot, 2013:16) and this is made possible through media articulation (Dreze and Sen 1989). Empowerment therefore broadly implies that resistance, class-struggle, protests, civil-society, civil- movements, union and so on shapes the broader political economy that shapes household entitlement (Ribot, 2014). The approach emphasizes that limited command over food resorts from limited rights and power in three political realms. These are, the domestic- referring to intra-household politics; production politics

referring to the realm of work and the state politics which is the public-civil sphere domain (Watts and Bohle 1993, van der Geest 2004).

The political economy[6] approach draws on historical-structural class based patterns of social reproduction to explain patterns of entitlement and empowerment processes in a society that creates inequality and vulnerability through marginalization within a specific political economy as a result of surplus appropriation. The 'space of vulnerability' is configured by the mutually constituted triad of the entitlements, empowerment and political economy. The intersection of the triad process is what produces the space of vulnerability which is defined in terms of exposure, capacity and potentiality, which is explained as the risks associated with exposure to stress and crises, inadequate capacity to cope with stress and the severe consequences of stress and the related risk of slow recovery (Watts and Bohle, 1993; Cutter, 1996). The approaches are interlinked in that empowerment is the ability to shape the higher-scale political economy that in turn shapes entitlements (Ribot, 1995; 2010). In essence, the space of vulnerability is based on the interaction between the 'external' side of vulnerability, which is the external stressors to which a system is exposed taking into account external socioeconomic factors as studied by human ecology, political economy and entitlement theory and the 'internal' side which deals with the internal factors that determine the impact of the stressors on a system and its ability to cope or adapt as investigated in access-to-asset models, crisis and conflict theory and action theory approaches (Fussel, 2007; see also Bohle, 2001).

The above analysis of the approach adopted by Watts and Bohle (1993) and its application to the study of famine over space and time in Africa and Asia provided a framework that significantly narrowed the 'theoretical gap in vulnerability analyses'. This is important because "vulnerability as a concept does not rest on a well-developed theory; neither is it associated with widely accepted indicators or methods of measurement" (ibid: 45, Bohle et

[6]The political economy and political ecology perspective has expanded on the social construction of vulnerability. It underlines the significance of addressing the vulnerability of rural livelihoods as a function of both: (a) external exposure to stresses and shocks; and, (b) the internal capacity to cope and/or adapt to those stresses and shocks (Adger 2000; Bohle 2001; Eakin 2005). Similarly (Oliver-Smith, 2009b) is of the view that vulnerability is basically a political economy concept which integrates both political economy and environmental forces in terms of biophysical and socially constructed risk. It links the relationship that people have with their environment, the social forces and institutions as well as cultural values that sustain or contest them. It emphasizes vulnerability resulting from social inequalities and conflicts in societies as well as on power relations in society.

al. 1994:38). In terms of measuring vulnerability, Wisner et al. (2004:11), advocated that if vulnerability is to be measured, then the measurement should be in terms of the damage to future livelihoods, and not what happens to life and property at the time of the hazard.

In relation to climate change and vulnerability, van der Geest (2004:15), noted that with respect to vulnerability natural factors have always been relegated to the background when looking at causes of limited entitlements and therefore vulnerability. The factors often considered as acting together to cause vulnerability are social, economic and political. The entitlement approach overlooks the importance of the natural environment for people's livelihood. van der Geest stressed that natural factors are crucial because they act as both triggers of events which cause vulnerability such as low rainfall (drought) or floods or favourable rainfall. In agricultural settings such as in my study area van der Geest observed that natural factors such as arable lands, economic trees, favourable rainfall and temperature greatly determine people's entitlement to food and livelihood, in normal years their prospects for creating a surplus and their ability to accumulate assets that reduce vulnerability depends on these factors. Therefore people in rural areas who live in areas that are endowed with high quality natural resources and a favourable climate have a more reliable set of entitlement than those in risky areas with low quality soils and little wild natural resources (ibid). Ribot, (1996:16), is of the conviction that environmental issues including climatic variability and change should be incorporated in the social framework of vulnerability. He said, "Vulnerability occurs at a junction of physical, social and political-economic processes and events. Hence, complete climate impact analysis must include this multi-causal perspective, placing climate as one causal agent among many".

In the literature reviewed, the core issue that runs through is that vulnerability of the poor, who command few resources, will find it extremely difficult to shield themselves from both climatic and non-climatic stresses and events. This places their livelihoods at risk, which will be different from that of the rich, who can move to safety and draw insurance to help rebuild their livelihoods (Ribot, 2010:62). Vulnerability has no single cause, it is a product of intersecting social processes that result in inequalities in socioeconomic status and income as well as in exposure, it is therefore caused by, social, economic, ecological, demographic, technological and political factors; inequality is therefore the root cause of vulnerability (Ribot, 1995; IPCC, 2014). In the long run, this complex interplay of a chain of vulnerability causes produces a specific set of unsafe conditions that may produce a disaster, if combined

with a natural hazard (Wisner et al 2004; Oliver-Smith 2009b). The IPCC further intimates that people who are socially, economically, culturally, politically, institutionally, or otherwise marginalized in society are more vulnerable to climate change (IPCC, 2014). Farming households therefore face three main sources of vulnerability, thus, a) shocks (unexpected extreme events including extreme weather events), b) seasonal variations (including variations in periodicity and amount of rainfall) and, c) long term trends (such as increases in input prices, or long term changes in mean temperature and rainfall) (Ellis 2000). Though I have discussed the double face of vulnerability and the framework by Watts and Bohle (1993) to bridge the theoretical gap in vulnerability analysis, vulnerability to climate change should be seen as complex (Kelly and Adger 2000), multi-faceted (Bohle, 2001) and specific to a particular exposure, location and social group (Kelly and Adger 2000). In this study therefore vulnerability will be conceptualized as an exposure to climate change effects and the adaptive capacity to deal with the shocks and stresses as a result of the changing climate.

2. 6. ADAPTIVE CAPACITY AND ADAPTATION

The issue of climate change and its impact on development has gained widespread attention in current discourse in the development landscape. The threat posed by climate change has led to the issue of adaptation gaining centre stage in dealing with the impact of climate change. Adaptation to climate variability and change has being taking place since life began on earth. Schnipper and Burton (2009), however noted that adaptation gained widespread attention among scientist and policy makers in the last two decades, resulting in policy makers explaining how society may adapt in a planned and strategic manner to the changing climate that life depends on. The capacity of people to adapt to climate change depends to a large extent on their level of vulnerability and asset base. This section looks at the concept of adaptation, adaptive capacity and their relationship or linkage to vulnerability.

Developing countries have need for adaptation due to its high vulnerabilities as well as carrying the greatest global cost of climate change despite contributing insignificantly to GHGs emissions (Mertz et al. 2009b). Adaptation is a global necessity, it is also a potential force widening inequalities in the world and fuelling social justice (Müller-Kuckelberg, 2012). The need for adaptation due to the impact of climate change was amply captured by the former UN Secretary-General Kofi Annan when he said:

''The impact of climate change will fall disproportionately on the world's poorest countries, many of them here in Africa. Poor people already live on the frontline of pollution, disaster,

and the degradation of resources and land. For them, adaptation is a matter of sheer survival.''[7]

Developed countries are better able to cope with and adapt to climate change than less developed countries. This is due to the fact that they have adequate resources in terms of wealth and opportunity for human development, as opposed to the developing countries, which face the immediate burden and adverse impact of climate variability and change and lack the necessary technical, monetary and human capacities to respond to the risks of climate change (Müller-Kuckelberg, 2012). Reducing vulnerability to climate change by building the adaptive capacity of people who are likely to be affected by climate change is therefore imperative. Adaptation takes place when households have to respond to more permanent changes in their environment or to changes in the households entitlement base (van de Geest, 2004:11).

Adaptation as a concept has its origins in the natural sciences; its usage in human systems traces its roots to anthropology through the works of Julian Steward who used the term 'cultural adaptation' to describe the adjustment of cultural cores to the natural environment through subsistence activities (Smit and Wandel, 2006). Adaptability or adaptive capacity was originally defined in biology as the ability of organisms to adapt to, survive and reproduce, to a certain range of contingencies or change (Gallopin 2006; Folke, 2006; Brown and Westaway, 2011). See also Smit and Wandel (2006). In socio-ecological system adaptive capacity involves the enhancing or maintaining the viability of social and economic activities and the quality of human life (Gallopin 2006; Brown and Westaway, 2011). Gallopin (2006) defined adaptive capacity as the capacity of any human system to increase or maintain the quality of life of its individual members in a given environment or range of environments. In relation to climate change adaptive capacity is defined as "the potential or capability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with consequences" (Smit et al. 2001). From these definitions adaptive capacity can be conceptualized as the ability of a system to adapt to shocks or stress and adaptive capacity is a function of resources or assets that a system has or can access.

[7]Opening speech delivered by Kofi Annan at COP 12 (12th Conference of the Parties to the UN Framework Convention on Climate Change), 15 November 2006, Nairobi.

These assets in the livelihood sense are natural, physical, social, human and financial capital (Nyamwanza, 2012). The IPCC defines adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2007).

The above definition points out that climate change has possible benefits but in analyzing and discussing climate change we often dwell on the negative consequences/impacts, it is therefore important to recognize that climate change has two sides which are useful when analyzing climate change vulnerability. Smit et al. (2001), also reviewed a number of definitions of adaptation with similarities running through them, thus adjustment in a system in response to climatic stimuli, however they indicated difference in them in terms of scope, application and interpretation based on the questions of "adaptation to what"?, "who or what adapts"?, and "how does adaptation occur"?. Addressing these questions is crucial in facilitating adaptation as well as differentiating adaptive responses. The goal of adaptation is to provide security to people, reduce their vulnerability to climate-induced change and to sustain and enhance their livelihoods, especially for the poor (Burton et al. 2003).

Climate change adaptation has been classified into a number of types or categories based on their timing, degree of spontaneity and intentionality. These are reactive and anticipatory, autonomous and planned (Fankhauser et al. 1999; Smit et al. 2001; TERI, 2007; Mimura, 2010; IPCC, 2007, 2014), substitutes and compliments (Fankhauser et al. 1999) and private and public adaptations (Smit et al. 2001; TERI, 2007, IPCC 2007, 2014). A common theme that runs through the different types of adaptation by the authors is outlined as follows: Reactive adaptation takes place after the initial impacts of a climate change have occurred or as a direct response to the occurred impacts of the actual event, while anticipatory adaptation are deliberate decisions to prepare for climate change. It is undertaken before impacts are apparent. Reactive adaptation is undertaken privately while anticipatory adaptation is directly influenced by governments as a conscious policy response strategy to concerns of climate change. It requires advance planning. Autonomous adaptation is a reactive response with no proactive intervention to climatic stimuli. It takes place irrespective of any policy, plan or decision. It involves changes that a system will undergo as natural and spontaneous adjustments in the face of climate change, it is initiated by private actors. Planned adaptation on the other hand requires constant intervention. It is a consequence of deliberate policy decision or an intentional action aimed at predicting effects of climate change and mitigating

their adverse consequences. They are often termed 'interventionist strategies 'based on the awareness that conditions have or about to change which requires some actions to minimize losses. Fankhauser et al. (1999) noted that planned adaptation can be used to influence autonomous adaptation but the distinction between them may be blurred in practice. Substitutes and compliments as a category of adaptation according to Fankhauser et al. (1999) are used to describe the relationship between anticipatory and reactive adaptation or planned and autonomous adaptation. For instance if anticipatory adaptation can enable reactive action and then they are complimentary and are substitutes if anticipatory strategies may reduce the need for reactive action. Private and public adaptation correspond with autonomous and planned adaptation respectively and the difference lies on whether the adaptation is carried out by private (individuals household and companies) or public interest (government).Table 2.1 illustrates the types of adaptation.

Table 2.1: Classification of adaptation options

		Anticipatory	Reactive
Natural systems			Changes in length of growing Changes in ecosystem composition Wetland migration
Human systems	*Private*	Purchase of insurance Construction of house on stilts Redesign of oil-rigs	Changes in farm practices Changes in farm insurance premiums Purchase of air-conditioning
	Public	Early-warning system New buildings codes, design standards Incentives for relocation	Compensatory payments, subsidies Enforcement of building codes Beach nourishment

Source: (IPCC 2001; TERI, 2007).

According to Smit et al (2001) adaptation occurs at various levels ranging from the international, national and community levels to family and individual level strategies for coping with climate variability and change. Autonomous adaptation[8] is often linked to the local level whiles planned adaptation is connected to the national level. The adaptive capacity required by each level is determined by a number of interrelated factors, these include financial resources, human resources, scientific knowledge, accessibility to information,

[8] Autonomous adaptation is relevant to this because the study district and community are at the local level of the governance system in Ghana and the communities take the initiative to adapt by themselves and therefore evolve adaptation strategies as and when the need arises.

institutional systems and infrastructure (Smit et al. 2001; Mimura 2010). The absence of these can constrain adaptation since these factors which Mimura (2010) classified as resource availability, scientific knowledge and its acceptability and levels of institutional arrangements are necessary to facilitate adaptation. Adaptation is important because the costs of adaptation are often less than those of repairing damage caused by the impacts, adaptation is therefore more cost-effective than reactive responses (Mimura 2010:137). To ensure effective adaptation, it is important to mainstream adaptation into major policies such as disaster prevention plans, agricultural and food security policies, water resource and environmental management instead of emphasizing adaptation in isolation (ibid). Similarly, Conde and Lonsdale (2004) also asserted that involving the local level in planning for adaptation is essential for successful adaptation especially those communities most likely to be affected by climate change.

The IPCC (2007) noted that most local communities have developed indigenous-based adaptation strategies which could be harnessed to improve the resilience of the communities and reduce their vulnerability to climate change. Strengthening the resilience of local communities by enhancing the traditional knowledge, technology and social institutions are important in the development of adaptation options (Barnett, 2001; Mimura, 2010). Much in the same vein Adger et al. (2003) were of the view that building on existing coping strategies of local people is one way of building their adaptive capacity and enhancing resilience since it ensures the incorporation of the knowledge and skills they already possess. Ignoring the local adaptation strategies by communities, which are often gained through local knowledge, has led to the failure of most adaptation strategies in developing countries. Nunn (2010) pointed this out when he noted that adaptation strategies sometimes fail in developing countries because many adaptive solutions are superimposed uncritically by persons or agencies with the belief that because those solutions have succeeded somewhere, they will invariably succeed in other communities and this often fail. The failure lies in the fact that the solutions are presented in ways that are culturally inept and therefore interpreted by local people as something that is alien, foreign and unneeded, in such a situation they end up reverting to their traditional practices which could be successful or not. For adaptation to be effective it must take place at the local level. Some authors have therefore suggested that the adaptation strategies that local people have used to cope with environmental stress in the past should be incorporated in the planning of future adaptation strategies. Instead of imposing nationally decided adaptation strategies, current practices should incorporate local adaptation

strategies, since locals are experts of their own situation (Resurreccion et al. 2008; Eriksen and Lind, 2009). Oliver-Smith (2009b:13). The assertion of adaptive strategies sums up the crucial role indigenous knowledge of local communities play in adaptation when he noted that "*adaptive processes are changes introduced over long periods of time by repeated use of particular strategies that have become part of the fund of general knowledge and practice in a culture".* This implies adaptation strategies by local communities are generational in nature and it is embedded in their knowledge systems.

The role of governments and other agencies in adaptation planning should centre on providing an enabling legal, social, economic and regulatory environment for local adaptation. Building the adaptive capacity of individuals and communities by improving their economic and social welfare and enhancing the robustness of various local sectors especially in developing countries to enhance adaptation should be the responsibility of governments (Adger et al. 2003; Boko et al. 2007; Leary et al. 2008). Nunn (2010) suggested that local existing system such as traditional rulers, religious leaders, district leaders, heads of associations and people depending on their influence in the society should be included in adaptation planning. Adaptation policies should be such that they reduce livelihood vulnerability, promote alternatives, improve the quality and quantity of natural resources and decrease resource competition so as to reduce significantly the threat posed by climate change (UNEP, 2011).

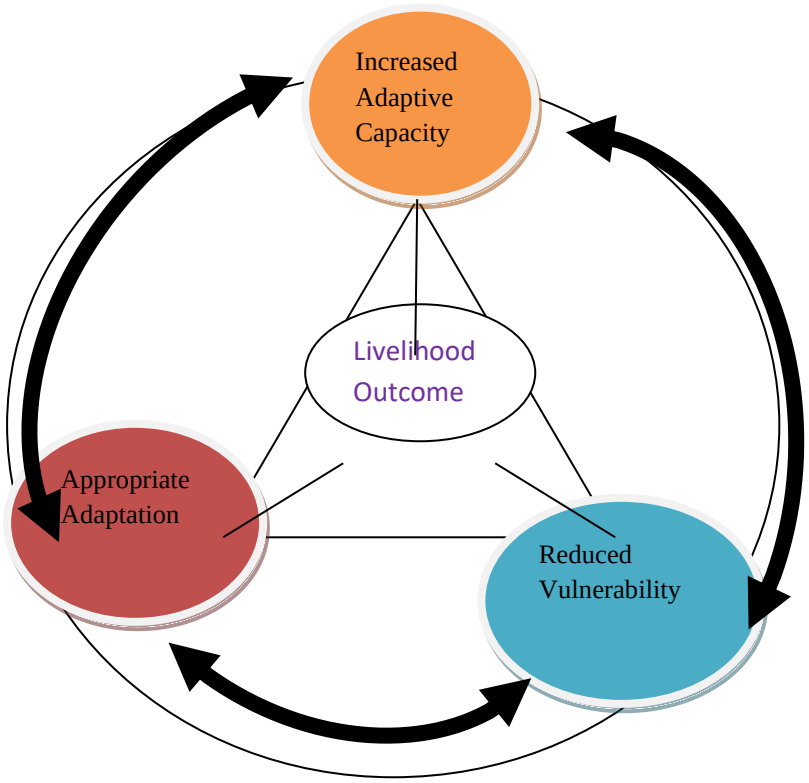
Adaptation and coping strategies[9] that have been undertaken by local communities in Africa and most developing countries include shifts in planting periods, expanding of farmlands, planting drought resistant crop varieties, use of dug-out wells on farms, strengthening existing systems in infrastructure including settlements, labour migration, diversifying food production, credit and borrowing, moderating consumption behaviour and diversifying

[9] Davies (2009:99) differentiates between adaptation and coping strategies. According to her adaptation strategies refer to a long-term or permanent change in the mixes of ways in which (resources) are acquired and involve a change in the prevailing rule system to meet livelihood needs whiles coping strategies are short-term response to an immediate and unusual decline in access to resources that happens within the prevailing rule system. According to her secured livelihood systems tend to adopt coping strategies whereas vulnerable livelihood systems employ adaptation strategies. Overtime coping strategies may develop into adaptation strategies. Oliver-Smith (2009b:13) also noted that adaptive strategies involve coping behaviour, immediate problem solving and decision-making. It is often difficult to distinguish coping strategies from adaptation strategies; they often go hand in hand, this study will consider both as adaptive responses.

livelihood sources (Smit et al. 2001; Adger et al. 2003; IPCC, 2007; Maddison, 2007; Resurreccion et al. 2008).

Vulnerability, adaptive capacity and adaptation in relation to climate change are interrelated (Smit and Wandel, 2006). The capacity of a system to adapt to climate change can be due to vulnerabilities faced by the system. Assessing the vulnerabilities of a system to climatic conditions is a pre-requisite for enhancing the adaptive capacity of that system (Smit and Pilifosova, 2003). The link between vulnerability, adaptive capacity and adaptation are circular rather than linear in nature (Mertz et al. 2009b). Peoples' ability to control the factors that bring about vulnerability may be translated into their ability to adapt (Smit and Wandel, 2006; Mertz et al. 2009b), see also Kelly and Adger 2000 and Luers 2005. Mertz et al. (2009b) highlights vulnerability, adaptive capacity and adaptation interrelationship with the analogy that "if people for example, have a secure income and a diversified food supply, they are less likely to be poor and to experience hunger. This, in turn, will often enable them to respond to stresses by allocating resources differently or abandon/relocate farming areas in other words, they have a better capacity to adapt to stress and the degree of vulnerability determines this capacity. However, adapting to stress might also in itself exacerbate vulnerability; if, for example, the needed adaptive actions to drought will lead to dependence of credit schemes to purchase drought-resistant crops and crop varieties, then a complete crop loss will not only cause hunger but also leave people with debts they are unable to repay". True vulnerability of people can only be assessed after adaptation has taken place (Kelly and Adger, 2000). In some instances strategies to solve one problem can at the same time create another problem, which will call for another measure to solve that problem ('adapting to the adaptation') (Barnett and Mahul, 2007; Mertz et al. 2009b). A good circle to show the relationship between vulnerability, adaptive capacity and adaptation is thus- Reduced vulnerability-increased adaptive capacity-appropriate adaptation. This is illustrated in the figure 2.1 below.

Figure 2.1: Relationships between Adaptive Capacity, Vulnerability and Adaptation



Source: Authors own construct.

Assets are also important in adaptation. According to some authors (Prowse and Scott 2008; Mertz et al. 2009b) assets are important because they are necessary in building the adaptive capacity of societies. These include physical and institutional assets, financial, social and human assets. They are also necessary to generate additional wealth as well as providing capability for maintaining current actions. They directly or indirectly address vulnerabilities of societies, reduce risks and build resilience at any level and provide long-term prospects for climate change adaptation presently and in the future (ibid). Similarly the IUCN (2003) indicated that assets form the basis on how people understand and respond to climate-induced vulnerabilities and should form the basis of any adaptation strategy.

In relation to building adaptive capacity the Local Adaptive Capacity framework (LAC), developed by the Africa Climate Change Alliance Project (ACCRA), is one framework which has been developed to assessing capacity at the local and community levels where majority of adaptation takes place (Jones, 2011). The components of the LAC will complement other concepts so as to develop a conceptual framework to explain climate change adaptation in the study area. The LAC though acknowledging the importance of assets in adaptive capacity, which is central to this study, argues there is the need to move

away from using the traditional asset-based frameworks alone for conceptualizing adaptive capacity. The ACCRA recognizes the difficulty of directly measuring adaptive capacity. The framework therefore brings together five distinct yet interrelated characteristics of adaptation capacity at the local level, each of which is considered important for enhancing local capacity. These characteristics are the asset base, institutions and entitlements, knowledge and information, innovation, and flexible forward-looking decision-making. These characteristics influence and determine the degree of resilience and responsiveness of communities to changes in the external environment (Jones et al. 2010, Jones, 2011). Table 2.2 below illustrates the key characteristics of the LAC and how it enhances adaptive capacity.

Table 2.2: The Local Adaptive Capacity Framework

CHARACTERISTICS	FEATURE THAT INDICATE A HIGH ADAPTIVE CAPACITY
Asset base	Availability of key assets that allow the system to respond to evolving circumstances.
Institutions and entitlements	Existence of an appropriate and evolving institutional environment that allows fair access and entitlement to key assets and capitals.
Knowledge and information	The system has the ability to collect, analyse and disseminate knowledge and information in support of adaptation activities.
Innovation	The community is able to create an enabling environment to foster innovation, experimentation and the ability to explore niche solutions in order to take advantage of new opportunities.
Flexible forward-looking decision-making and governance	The community is able to anticipate, incorporate and respond to changes with regard to its governance structures and future planning and ensures prudent governance of natural resources under its formal and informal authority.

Source: (Adapted from Jones et al. 2010).

The characteristics of the LAC each play important and distinct roles in helping to promote the ability of communities to adapt to shocks and stresses. The LAC goes beyond what a

system has to enable climate change adaptation to include what it does and how it does it (Jones et al. 2010; Piccolella, 2013).

The UNDP acknowledges the relationship between climate change and development since in their view climate change can undermine the achievement of the MDGs. To ensure development the UNDP stresses that adaptation is inevitable and was a key requirement for achieving the 2015 MDGs targets as well as creating conditions for sustained progress. Adaptation according to the UNDP is the insurance policy for the world poor (UNDP 2008; 2014).

In the views of Fankhauser et al. (2009) and Nelson et al. (2010), it is important in climate change adaptation to avoid measures that are reactionary, costly and which in the long-run does not address the impacts of climate change. To them it is necessary to ensure that adaptation by one group does not increase the vulnerability of another; adaptation must be beneficial to all instead of a few which is more often than not the case. This can be done in the view of Levine et al. (2011) by focusing on co-benefits of risks and adaptation measures and increasing the adaptive capacity of households and communities by using their autonomous innovation and strategies as an entry point and helping them to assess current adaptation strategies to ensure one which will be environmentally sustainable and socially acceptable. This should be based on the notion that adaptation measures are area specific hence locally appropriate interventions should be selected (Maharjan and Joshi, 2013). Policies on adaptation should therefore take into account the complex reality of vulnerable societies[10] so that their needs can be addressed in any adaptation policy initiative since the goal of adaptation is to address poverty and inequality and enhance development (Mertz et al. 2009b).

2.7. INDIGENOUS KNOWLEDGE

In this section, the issues I consider are the definition and explanation of knowledge in general and specifically indigenous knowledge and its characteristics as espoused by various

[10]Drawing on van Der Geest (2004), vulnerable societies are equated to his description of vulnerable groups in society taken from Watts and Bohle (1993). Vulnerable groups in society are: (1) the resource poor and those vulnerable to market disturbances; (2) the powerless and (3) the exploited. Vulnerable regions are (1) the marginal regions (2) the peripheral/dependent regions and (3) the crisis-prone regions (Watts and Bohle, 1993: 52-57, van Der Geest, 2004).

authors. I also discuss the views expressed by various authorities on the relevance of indigenous knowledge to development which is a central theme in this study. Finally, I discuss the viewpoints of various theorists to the fact that indigenous knowledge like all knowledge systems should be seen in the social setting in terms of its production and construction and the need to understand the power-relations that exist within and between different knowledge systems since it is crucial to enhance development at the local level.

Knowledge like many concepts does not lend itself to a single definition. Nonaka and Takeuchi define knowledge as "a dynamic human process of justifying personal belief towards the truth" (Nonaka and Takeuchi, 1995). Nonaka et al. (2000) view knowledge as context-specific, relational, dynamic and humanistic (related to human action). Knowledge has also been defined as concerning the way people understand the world, interpret and apply meaning to their experiences (Arce and Long 1992; Blaikie et al. 1997:218). Knowledge therefore should be understood as people justifying their beliefs as the truth, how they understand and interpret the world and attaching meaning to their life experience. Two types of knowledge can be identified; these are tacit and explicit knowledge. The former is subjective and experiential knowledge while the latter is said to be objective and rational knowledge ((Nonaka and Takeuchi, 1995; Nonaka, 2006). The two types of knowledge are not mutually exclusive especially in the era of information technology; tacit knowledge is often converted into explicit knowledge (ibid). Also there is often a distinction between indigenous knowledge and scientific knowledge. The term indigenous knowledge connotes a myriad of terminologies, definitions and cognate concepts based on geographical locations and disciplinary refractions. The myriad of terminologies used interchangeably to refer to indigenous knowledge (IK) are; 'indigenous technical knowledge' (ITK), ethnocology, 'local knowledge', 'folk knowledge', 'traditional knowledge', 'traditional environmental (or ecological) knowledge' (TEK), 'peoples science' or 'rural peoples knowledge' (RPK). Ellen and Harris (2000) and Antweiler (1998:429) said local knowledge can be called indigenous knowledge. In this study the different terminologies will be used to refer to the same semantic space instead of trying to differentiate them. Some authors have distinguished these two categories of knowledge as 'western' or 'indigenous', 'formal' or 'informal', 'insider' or 'outsider' (Okali et al. 1994 in Blaikie et al. 1997:218). Blaikie et al. (1994:219), made a distinction between local knowledge and scientific knowledge. They acknowledge that the differences depend on the development paradigm and the set of assumptions being used. They used the following features to distinguish between the two knowledge systems; Local

knowledge is holistic and contextualized while scientific knowledge is abstract; it is conservative and adaptive while scientific knowledge puts in action radical and swift technological change; it is transmitted informally while scientific knowledge is transmitted formally. Depending on the development paradigm, development practitioners have made a distinction between the two knowledge systems in a manner that gives one premium over the other (ibid).

Indigenous knowledge is generally seen as local or traditional knowledge that indigenous people have brought down with them from earlier times through oral tradition. It is the grounds for local decision-making in agriculture, health, education, natural resource management and other activities and it is embedded in community practices, institutions, relationships and rituals and basically a tacit knowledge that is not easily codifiable (Sen, 2005:375-376). Ellen and Harris (2000) outline the characteristics of indigenous knowledge as being experiential rather than theoretical, rooted in place (local), reinforced by trial and error, transmitted orally, functional, dynamic, shared in a fragmentary manner between individuals within a population and mostly distributed unevenly between them (i.e. no one person, authority or social group knows it all, it is part of a power-relation structure and can be managed in a manner that excludes some members in the community from acquiring it), empirical, and it is embedded in the socio-cultural setting and not easily codifiable.

Indigenous knowledge is not wholly or exclusively local to people residing in their unique environment or community, it is a hybrid of both 'local', 'traditional indigenous knowledge' and 'western scientific knowledge' (Dove, 2000). This is a second school of thought which is different from the characteristics of indigenous knowledge outlined above as bounded local knowledge unique to a particular group in a specific geographical area. Dove (2000) argues that if the origins of knowledge are revealed, the validity of the term 'indigenous knowledge' being a unique knowledge peculiar to a particular group of people in a bounded local environment becomes questionable. For instance Dove (2000) in a study of rubber cultivation in Southeast Asia, concluded that the cultivation and exploitation of the Para rubber is historically a hybrid product of developments carried out by both smallholders and supported plantations in both the old and new worlds, actually from the Amazon (ibid). Similarly Scott (1998:331 in Dove, 2000) posited that the spread of new world maize to Africa in the nineteenth century indicates that the "term 'traditional' as in 'traditional knowledge'….is a misnomer, sending all the wrong signals". Therefore indigenous knowledge cannot be wholly

local. The school of thought of indigenous knowledge being a fusion of 'indigenous' and 'western' or scientific knowledge is captured vividly by Agrawal (1995:422):

"Certainly, what is today known and classified as indigenous knowledge has been in intimate interaction with western knowledge since at least the fifteenth century. In the face of evidence that suggest contact, variation, transformation, exchange, communication, and learning over the last several centuries, it is difficult to adhere to a view of indigenous and western forms of knowledge being untouched by each other".

The concept of indigenous knowledge goes beyond its tenets premised on localization, continuity and homogeneity. The production of indigenous knowledge involves the interaction between local communities who have their own practices and beliefs and external agents or stakeholders who have their own practices and beliefs culminating in the production of new knowledge through experimentation and changes in production technologies (Dove, 2000). In this regard, Stiglitz (2000) acknowledges that the variety and complexity of human society requires the localization of knowledge. That is the process of allowing, adapting and using knowledge created by others (external) to the local environment. Indigenous knowledge from this school of thought is therefore a 'hybrid' knowledge i.e. combination of indigenous and scientific knowledge through co-learning and coproduction (Kristjanson et al, 2009). The origin of knowledge, whether coming from 'within' or 'outside' the community, is inferred in distinguishing between the two schools of thought on local/indigenous knowledge (Derbile, 2010).

Indigenous knowledge is one of the most important assets for local people to create value and hence, adapt to their environment to ensure sustainable development and livelihoods. It is a crucial resource in development (World Bank, 1999). According to Drucker (1993) knowledge is considered as the 'only meaningful resource' today. Similarly, the World Bank (1999) also asserted that knowledge is central in all developments efforts since it is the brain behind innovation. Knowledge gives people greater control over their lives (ibid). Despite the importance of knowledge, in development 'wide knowledge gaps' exist between the developed and developing countries. There is a far greater gap in measures of knowledge creation between the rich (developed) and poor (developing) countries than income (ibid). The World Bank acknowledges that closing the knowledge gap is important to propel development especially in developing countries since it is the most pressing social and economic issue requiring attention and noted that developing countries can take advantage of

knowledge created in developed countries but should not neglect the knowledge at their backyard i.e. Indigenous/local knowledge. The World Bank widely acknowledged indigenous knowledge in its research during the 1990s and launched the indigenous programme in 1998 documenting cases to illustrate the crucial role of indigenous knowledge in development, yet in policy and practice it was ignored (Mohamedbhai, 2013; Enns, 2015). The World Bank ideological approach to development held knowledge from the developed western countries as superior to knowledge from developing countries (Enns, 2015). This view has been espoused by many practitioners or agents of development whose activities have been criticized as having a preference for western-scientific knowledge to the neglect of indigenous knowledge. Instead of closing the knowledge gap they rather perpetuate it working in isolation seeking to impose their scientific solutions to the neglect of indigenous knowledge (Dove, 2000; Sillitoe, 2007).

Several authors acknowledge the pivotal role of indigenous knowledge in development especially in sustainable resource use (Bronkensha et al. 1980; Warren, 1990; Agrawal, 2005; Antweiler, 1998, Gerke and Ehlert, 2011; Chikaire and Nnadi, 2011; Soh and Omar, 2012; Enns, 2015). Indigenous knowledge is important for development because it is the resource that provides the avenue for local people especially the poor to evolve strategies to solve their problems so as to enhance their living conditions (livelihoods). Its importance particularly comes into focus when we consider the relationship between people and their environment. It plays a very effective role in the holistic management of natural resources with sustainability and conservation as its creed (Antweiler, 1998; Soh and Omar, 2012). Its efficiency also lies in its capacity to adapt to changing environmental circumstances and it is in line with the needs of local communities taking into consideration the available natural resources (Pretty and Sandbrook, 1991; Chikaire and Nnadi, 2012). Briggs (2005) noted that the local embeddedness of indigenous knowledge provides it with relevance, power and applicability as well as with agency and efficacy in addressing bottlenecks of local development, though it does not offer a simple solution to development if its ideas are applied out of context. The importance of indigenous knowledge is captured by the assertion of Escobar (1995:8) that: *"The remaking of development must start by examining local constructions, to the extent that they are the life and history of the people, that is, the conditions for and of change"*. Enns (2015:70) therefore describes indigenous knowledge as the 'right' type of knowledge for development.

Despite, the importance of indigenous knowledge to sustainable development, western science and development practitioners have tended to treat indigenous knowledge as backward, therefore the privilege accorded modern, global, scientific knowledge, thereby hindering its participation in development (Dove, 2000: Sillitoe and Marzano, 2009) and the challenge of successful development is the ignorance of knowledge that lies beyond modern-scientific traditions (Dove, 2000). This problem can be solved by seeing indigenous knowledge as central to sustainable development by studying and integrating indigenous knowledge at the beginning of every development project; this is because indigenous knowledge instead of being a hindrance to development represents multiple opportunities (Kristjanson et al. 2009, Silittoe and Marzano, 2009). Sillitoe and Marzano (2009:17) amply captured this assertion when they posited that:

"Only when all perspectives are taken together can we hope to achieve a more rounded and better understanding of the social and natural environments, and the potential for sustainable development". All knowledge must be treated equally by relying on the strengths of all of these knowledge types and this should be a two-way flow of information (ibid; Jessi, 2014). This is in line with Stiglitz (2000) suggestion that it is prudent to "scan globally for best practices but to test them locally, since adaptation often amounts to reinventing the 'best practice' in the new context". Scoones and Thompson (1994:29-30) argue that there is no clear dichotomy between rural people's knowledge and western agriculture, they suggested that they are both general and specific, theoretical and practical, they are value laden, context specific and influenced by social relations of power. In fact Sillitoe (2007) sees local knowledge as scientific, formalized in cultural heritage even though not recorded systematically like global science. Kloppenburg (1991) calls local knowledge as 'successor science' which farmers and agricultural workers continue to produce and reproduce. For instance, Sillitoe (2007:3) argues that even though "subsistence farmers may not consciously hold a formal hypothesis and conduct randomised trials to test it, they continually experiment as they cultivate crops and learn from the results, passing on the knowledge in accumulated lore". Some authors argue that in some instances local people often get it right while science gets it wrong. Therefore local views can enrich scientific understanding and scientist can learn from local practices (ibid; Sillitoe and Marzano, 2009). In view of the above it is prudent for development experts to adapt to indigenous knowledge if they are to ensure sustainable development. This quote from President Benjamin Mkapa of Tanzania supports the above assertion:

"It is the local component of knowledge that requires adaptation-which in turn requires the active participation of those who know and understand the institutional environment. Local adaptation cannot be by the passive recipients of 'development knowledge'; it must be done by the 'doers of development' in the course of their activities" (Wolfensohn 1999). This implies that in the use and fusion of knowledge interface, development agents such as the state actors, NGOs, CSOs and so on need to make sure that the knowledge is applicable locally and the adaptation should be done by the local doers of development but not as a condition imposed from outside since it is through local selection, assimilation and adaptation of knowledge that local people make it their own (Stiglitz, 2000).

Indigenous knowledge has been used over the centuries to solve specific development and environmental problems over centuries throughout the world. Indigenous knowledge has afforded communities in Africa the capability to deal with past and present vulnerabilities to climate related shocks and other stresses (Nyong et al. 2007). Farmers in Africa who have been described as innovators with a sophisticated body of indigenous knowledge (Moretimore and Adams, 2001; Nyong, 2005; Nyong et al. 2007) have used it to adapt to their changing environments and climatic trends (Watts, 1983; Richard, 1986; Guthiga and Newsham, 2011). For instance in the Sahel, farmers are known to have developed early warning systems to climate variability as an adaptation strategy to reduce their vulnerability to climate extremes (Ajibade and Shokemi, 2003; Chikaire and Nnadi, 2011). Zero tilling practices in cultivation, mulching and a host of other soil management practices have also been used by local farmers in the Sahel as a means to conserve C in soils (Schafer, 1989; Osunade, 1994; Nyong et al. 2007). In northern Nigeria, farmers employ varietal experimentation and multiple cropping to guard against uncertain precipitation and high rates of evaporation (Watts, 1983) while in western Kenya, the Nganyi community uses traditional methods of weather forecasting which include the behaviour of ants, bird songs and timing of tree flowering to decide when to prepare lands and sow seeds (Guthiga and Newsham, 2011) and in northern Ghana farmers are still able to accurately determine the beginning of the wet season and when to prepare their fields for planting despite increasing climatic variability (Ofori-Sarpong, 2001). This could be due to the fact that farmers are able to predict when the rainy season is due by observing the flowering of the Shea nut tree, migratory patterns of birds and position of the constellation Pleiades (Benneh, 1970). Local knowledge is dynamic and flexible and has the ability to integrate, accommodate and adapt other forms of knowledge to produce different patterns of knowledge flows (Gerke and Ehlert, 2011).

Indigenous knowledge is able to ensure the participation of indigenous people and development experts working in concert with each other, giving birth to terms such as 'Ethnodevelopment' and 'Development-with-Identity' in the development arena (Laurie et al, 2005; Jessi, 2014). The participation approach has both political and theoretical underpinnings. It is a means to encourage democracy and participation and challenge prevailing power relations where rural poor are seen as bereft of ideas and considered as objects of somebody else's development (Bebbington, 1996).

Indigenous knowledge like all other forms of knowledge is based on people's social construction and this shapes the way knowledge based on interaction and experience is shared (Long, 1992). It is not a natural product of our sense organs (Ratner, 2005). The positivists consider knowledge as something that should be verifiable from the view point of science and view science as the only 'true' form of knowledge and that there is nothing that could be known outside what may be known scientifically (Smith, 1996) but Koch (2005) argues that science has failed to account for its ideological underpinnings to its claim to represent 'true knowledge' since culture represents a dominant form of knowledge construction. Sejersen (2003) also views the production of scientific knowledge as social and cultural practice. Similarly, Watson-Verran and Turnbull (1995) are of the view that local innovation is the implicit basis of scientific knowledge and that knowledge systems may differ in their epistemologies, methodologies, cognitive structures, logistics or socio-economic context but a characteristic inherent in all of them is some degree of 'localness'. In view of this science should be considered as another type of the knowledge system instead of treating it as the only form of knowledge that is rational and objective. Indigenous knowledge is a social construct and its production resides in the way in which social actors interact, negotiate and accommodate each other's life-worlds. The encounter and discontinuities that emerge from these interactions reinforce or transform existing knowledge or the emergence of new forms and an understanding of how the different knowledge systems intersect and interact is important for rural development (Arce and Long, 1992). Knowledge production and the dichotomy between knowledge systems show the relation between knowledge and power and the divide between societies (Watson-Verran and Turnbull, 1995). It is important to analyse the workings of knowledge systems by understanding the power relations both within knowledge systems and between them in the local context. For instance, for indigenous people and local communities, the land is a sacred space that the creator has entrusted to them to take care of, hence the power to do that resides with them (Smith, 2007).

This assertion vividly captures this: "*Earth is our mother, our special relationship with Earth as stewards, as holders of indigenous knowledge cannot be set aside. Our special relation with her has allowed us to develop for millennia a particular knowledge of the environment that is the foundation of our lifestyles, spirituality and world view. Therefore, in our philosophies, the Earth is not a commodity, but a sacred space that the Creator has entrusted us to care for her, this home where all beings live"* (The Hague declaration of the Second International Forum of Indigenous People and Local Communities on Climate Change, 2000:1 in Smith, 2007:206).

The World Bank (1999) makes a strong case that knowledge and not financial capital is important to sustainable and economic development, as well as a form of capital that can be leveraged to overcome poverty in developing countries. In this regard building on indigenous knowledge which is the primary aspect of any society's knowledge system should be the first and important strategy to mobilize such capital. In shaping development and to overcome development challenges everywhere including Ghana therefore requires the integration of indigenous knowledge in the development process. As suggested by Jessi (2014) there needs to be cooperation between agents of development and local communities and indigenous knowledge should be refined in a manner that does not end up distorting it and reinforcing old structures and this can be achieved through respect, cooperation and partnership between development agents and local communities. In this study therefore indigenous knowledge is considered as knowledge peculiar to a group of people in a particular geographical area as well as knowledge that they have developed over the years through the fusion of their unique knowledge and other forms of knowledge since indigenous knowledge cannot be seen as a system in isolation and as noted by Agrawal (1995) knowledge everywhere portrays contact, diversity, exchange, communication, learning and transformation among different knowledge systems and beliefs.

2.8. CONCEPTUAL FRAMEWORK: LIVELIHOOD ADAPTATION UNDER CLIMATE CHANGE

Having discussed various theories and concepts underpinning this study as well as having reviewed relevant literature, I develop a conceptual framework that draws on the various theories and concepts discussed to link climate change and livelihood adaptation. The concepts in the framework are interlinked to illustrate climate change adaptation. Each

concept plays a unique role in the framework and there is a reciprocal relationship between these concepts as they reinforce one another in trying to explain climate adaptation.

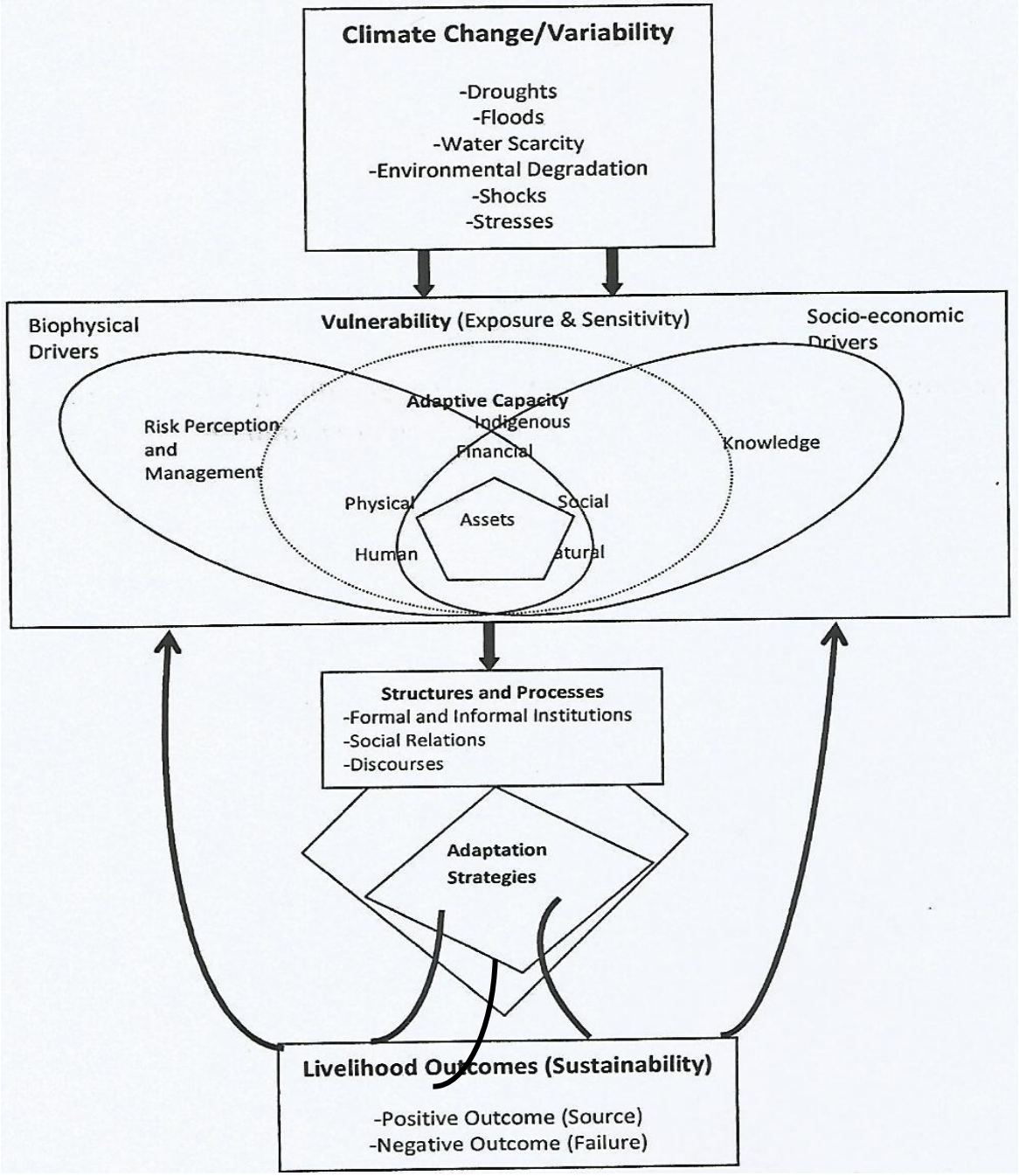
The need to develop a conceptual framework is important because it affords the researcher the opportunity to rely on common concepts to show how adaptation to climate change is analyzed and conceptualized in this study. The conceptual framework therefore serves as a basic unit of analysis. Developing the conceptual framework is necessary because as pointed out Eisenack and Stecker (2011; 2012) adaptation to climate change research although assuming wide coverage especially in the scientific literature is still plagued with the problem of pinning a specific theory to it. According to them, the interdisciplinary nature is still characterized by an emerging and evolving epistemological base thereby making it difficult to propound a common or comprehensive set of theories and language to conceptualize to conceptualized the wide diversity of adaptations. In view of this Eisenack and Stecker (2012) noted that the application of generalized theories about adaptation to climate change should be based on common concepts to map out different adaptation situations. Based on this Eisenack and Stecker developed an action theory of adaptation which recombined various concepts in different ways to analyze real-world adaptations. The theory is based on the principle that "action requires actors and intention" and the "intention is directed towards an impact of climate change" (Eisenack and Stecker, 2011:6).

Eisenack and Stecker (2011) are of the opinion that much of the theoretical work on adaptation to climate change conceptualizes adaptation in relation to vulnerability and resilience. In their view various authors have always attempted to conceptualize vulnerability, adaptive capacity and adaptation from different perspectives and an effort to disentangle these different conceptualizations of vulnerability in relation to adaptive capacity and adaptation becomes difficult. This difficulty in conceptualization in part arises from complications involved in pinning down a distinction between potential and actual action (adaptation). They therefore proposed that adaptation should be seen as "singular actions that are undertaken by actors" which in this study are the small scale irrigation farmers. In their view an action-oriented view should be adopted to analyse the adaptation to climate change which is a departure from the system oriented view which has dominated the theoretical literature on adaptation to climate change. To them the focus should be on "purposeful activities ("adaptations") that moderate harm from climate change" (Eisenack and Stecker, 2011:5). In relation to discourse analysis, discourse is seen as a form of social action that

plays a role in producing the social world including knowledge and social relations and it is based on this that people ascribe meaning to a natural phenomenon such as drought or flood and as such take action to mitigate its effects or adapt (Jørgensen and Philips, 2002). Hence issues of climate change causes and adaptation becomes a matter which is not outside discourse because it is through discourse that they pin to what causes climate change and take action by 'doing' (adaptation). These actions in this study are the strategies adopted by farmers to adapt to climate change. From the forgoing discussion, no single theory is adequate to address the complexities that underpin livelihood adaptation to climate change.

Based on the above discussions, I adopt a conceptual framework that combines or integrates models and components of climate change, vulnerability, indigenous knowledge, sustainable livelihood approach and adaptive capacity to illustrate and analyse how these concepts are intertwined and interrelated to shape how adaptation strategies are evolved to ensure livelihood outcomes of small scale irrigation farmers in the Upper East Region. The study is strongly anchored on the argument that the adaptive capacity of the communities is determined by the knowledge base (Indigenous knowledge), assets, institutions and processes that the communities possess to deal with climate induced changes. This follows the assertion by Yohe (2001) and Olowa and Olowa (2011) that adaptation to climate change takes place within the context or framework of adaptive capacity. Figure 2.2 illustrates the conceptual framework within which the study and discussions are situated.

Figure 2.2: Conceptualizing climate change within the context of vulnerability, indigenous knowledge and adaptive capacity



Source: Adopted from Connolly-Boutin and Smit (2016) and modified by author

From the figure above climate change is taken as the starting point of the analysis and is considered a phenomenon which drives vulnerability in the study area due to its adverse impact on the livelihood of people and households in the community. Vulnerability in this framework is conceptualized as an exposure to climate change effects and the adaptive capacity to deal with the shocks and stresses based on the changing climate. Vulnerability

under the framework takes into consideration the bio-physical and socio-economic, institutional and cultural drivers that operate in the communities to shape adaptive capacity. The bio-physical drivers in this study refer to climate change and physical and biological factors such as soil quality, water availability and diseases and the socioeconomic drivers are the various institutional structures and processes (water user associations and traditional authority), cultural norms and values, economics and other social forces. The concept of vulnerability has already been discussed in detail, and the space of vulnerability by Watts and Bohle (1993) has also been explained, but key to this framework is that vulnerability has two sides, thus an external and internal. The external side deals with risks, shocks, and stresses to which an individual, households or communities are subject and an internal side which relates to lack of means to cope with or capacity to adapt without damaging loss (Chambers, 1989; 2006).

The external side therefore includes issues such as inadequate rainfall, high temperature and droughts and has an impact on adaptive capacity. The external side of vulnerability affects the capacity of the communities to adapt to climate change because it reduces their adaptive capacity. The external factors affect adversely the livelihood of households in the communities through either droughts or floods. They also affect adversely the assets or capitals of households and institutions which the communities depend on for their living; this invariably affects livelihoods as well. The adverse impacts of climate change will trigger a response and in this case an action ('adaptation') to deal with the impacts of climate change. The internal side which includes inadequate knowledge about a phenomenon and lack of assets also affects the adaptive capacity of the farmers, because inadequate knowledge about climate change might limit the farmers' skills and abilities to deal with issues that affect their livelihoods.

Indigenous knowledge is taken as the first line of response in this framework to deal with the impacts of climate change and to enable livelihood adaptation. The indigenous farmers are considered to have an intimate relationship with their environment and as such have useful knowledge to adapt to changing climatic conditions by evolving their own coping strategies. Indigenous knowledge is the main source of information which enables the local farmers in the communities to perceive and to prepare for climate change. Indigenous knowledge and adaptation to climate induced changes is viewed from two standpoints. Firstly, indigenous knowledge enables farmers to understand potential areas of risk and enable climate change

preparedness and risk management. Secondly, it is important for improving adaptive capacity. As noted by MoSTE (2015) indigenous knowledge is used by local people to initiate indigenous practices to plan for adaptation and disaster risk reduction activities at the local level. In the first instance, indigenous knowledge serves as the avenue on how the people perceive climate change and the risk associated with climate change. With regard to climate risks O'Connor et al. (1999:462) conceptualizes risk perception as "the perceived likelihood of negative consequences to oneself and society from one specific environmental phenomenon: global warming". Perception of climate change risk influences the preparation the farmers make to respond to the risks. Risk management is therefore driven by risk perception. Indigenous knowledge serves as a fond of knowledge to manage risks associated with climate change since it provides a source of information for early warning signals about climate change through weather prediction. Through this farmers are prepared to face the adverse impacts of climate change. Secondly, indigenous knowledge enhances the adaptive capacity of the people through social learning and experimentation whereby younger farmers learn the craft of doing things from older farmers through successful past adaptation, and it thus enables the farmers to develop adaptation strategies based on past experiences in dealing with environmental changes. Drucker (1993:24) underscored this though he did not mention indigenous knowledge; he noted however that tacit knowledge is important because a skill (*techne* in Greek) *"could not be explained in words, whether spoken or written. It could only be demonstrated"* as such *"the only way to learn a techne was through apprenticeship and experience".* This is in consonance with the features of indigenous knowledge which evolves through handing down of knowledge from generation to generation through socialization by way of apprenticeship, observation and experimentation (Chambers and Conway 1992; Ellen and Harris 2000; Nyong et al. 2007). Risks perception and adaptation are related in that a high perception of risks associated with climate change may serve as the basis of interest in climate change adaptation and the knowledge of the benefits of adaptation is also necessary to effect behaviour change (Olowa and Olowa, 2011). Therefore a perception of high risk of climate change is likely to enable the communities to employ the social forces including indigenous knowledge to encourage and reinforce adaptive behaviours. Indigenous knowledge forms part of intangible assets as espoused by Chambers and Conway (1992) and according to them in the livelihood framework the most complex is the portfolio of tangible and intangible assets which provides the basis on which the people construct and contrive a living using their physical labour, skills, knowledge and creativity. This skill they noted can be acquired from within the household handed down from generation to generation as

indigenous technical knowledge through apprenticeship, or more formerly through education or extension services, or through experimentation and innovation. In a nutshell indigenous knowledge in this framework is envisaged to have the ability to build the adaptive capacity of farmer household to manage immediate climate risks and enhancing their capacity to address new risks. It will also serve as avenue for farmers to come up with livelihood strategies to adapt to extreme weather conditions. Indigenous knowledge therefore enhances adaptation to climate change by managing risks, serving as an avenue to enable preparation to climate change and building the adaptive capacity of individuals and households to respond to climate change.

Another important component of the conceptual framework which serves as a line of response is the assets the farmers possess. Assets or capitals conceptualized in various literature as endowments and entitlements (Dulal et al. 2010) in line with Sen's entitlement approach in which he describes entitlement as a "set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces" (Sen 1984: 497) , means (Eisenack and Stecker 2011; 2012) and strengths (Moser et al. 2001) are very important for adaptation and a major determinant of how livelihoods work. Assets are used by the farmers to respond to risks imposed by climate induced changes. Kebede and Adane (2011) pointed this out when they noted that the capacity to adapt to a large extent depends on the livelihood assets (natural, social, physical, human and financial capital) that one possess or can have access to, and how well one utilizes the assets. The framework asserts that even though the small scale farmers have limited income, they have other assets and capabilities that they rely on to reduce their vulnerability to climate change.

Assets are combined to ensure households earn a living. This is outlined by Scoones (1998), Carney et al. (1999) and Connolly-Boutin and Smit (2016) based on the sustainable livelihood approach indicating that livelihoods consists of a combination of assets or capitals that allow people to follow a combination of strategies to arrive at livelihood outcomes. Assets according to this framework are important in shaping and enhancing adaptive capacity of farmer households. Assets therefore facilitate adaptation. The assets serve as resources that people combine to build their livelihood strategies (Scoones 1998). Adaptive capacity in this framework follows the conceptualization of Connolly-Boutin and Smit (2016) who see adaptive capacity as "the ability of a person or community to use their assets or capitals in order to deal with or adapt to changing conditions" (in this case climatic conditions). As

noted by chambers (1995) a livelihood is a means of making a living. Assets therefore in this regard enable people to make a living by responding to uncertainties, risks and opportunities in the irrigation sites through various adaptation strategies.

The assets in the communities which help to enhance adaptive capacity, development of livelihood strategies and adaptation by the people include their knowledge (scientific, indigenous and technical) and skills as part of human capital, natural capital such as soil and water, physical capital such as land and the irrigation infrastructure, social capital including the water user associations and the traditional authorities and financial capital which is the presence of some financial institutions in the districts which can be relied upon by the communities. Financial capital is important for developing livelihood strategies and adaptation since it enables the pulling together of the other capitals. Access to assets improves the adaptive capacity of the farmers. The assets available to the farmers are also used as a means to manage the risks arising from climate change and take advantage of opportunities that is afforded by the local institutions in the community. Among the assets available to local farmers, I consider social capital to be of utmost importance to the farmers but that is not to say it takes precedence over the others. According to Bourdieu (1986:88) "social capital is the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition".

Social capital is important because it enhances the ability of human capital to reinforce the production of knowledge (Huang and Wu, 2010) and understand knowledge creation and transfer (McFadyen and Canella, 2004). The importance of social capital also lies in the fact that it facilitates collective ideas and actions among the farmers and therefore serves as an avenue to strengthen the adaptive capacity of the farmers. Bourdieu (1986) indicates the significance of social capital when he asserted that social capital affords members of a group with the credentials which entitles them credit in the various senses of the word and this is guaranteed by the backing of the collectively owned capital. Adger (2003) reiterated this point by pointing out that adaptation as a social process necessitates collective action and that opportunity is provided by social capital. Similarly MoSTE (2015:14) also noted that social capital facilitates collective ideas and action, strengthens the ability of farmers to build their adaptive capacity and enhance resilience. The role of social capital in relation to its interaction with other assets to enhance adaptation to climate change is summed up by Dulal et al. (2010:14) in citing Bebbington (1999) and Adger (2003) when he said that social capital

"enables the society to effectively interact with other capital assets and appropriate institutions, like the state, civil societies and financial institutions that can help formulate livelihood strategies that would enhance their ability to cope with extreme weather conditions". It is therefore critical in any strategy to adapt to climate risks since it enables co-learning through exchange of ideas and information especially on past and present adaptation strategies by local farmers and this helps to build their adaptive capacity.

Access to assets is mediated through the institutions and processes in the community. These institutions include the traditional authorities and the water user associations. Local community members also gain access to livelihood assets through social networks such as kinship and family ties. These ties are also important for adaptive processes. The local institutions for instance play a vital role in ensuring access to common property resources (CPRs) such as land and access to water which are integral in determining adaptive capacity. The institutions lay down the laws, rules and regulations that govern the use of resources since they are the custodians of these resources. They provide the avenue for collective decisions to be taken by the farmers who are the users of the resources, in this way they help determine the livelihood options and adaptation strategies of the local farmers. Proper transformation and functioning of the institutions will help reduce the shocks associated with climate extremes on the resource users. The institutions therefore play a critical role in livelihood outcomes. The importance of local institutions in climate adaptation is echoed by Agrawal (2008) when he said local institutions play important roles in production and integration of knowledge in adaptation to climate change since they are the custodians of indigenous knowledge.

The outcome of all the above discussed issues based on reduced risks and increased adaptive capacity by drawing on indigenous knowledge and assets is the adoption of adaptation strategies which Connolly-Boutin and Smit (2016) described as the "actions that people individually or collectively undertake to adjust to changing conditions in order to maintain or improve their well-being". The end result of adaptation strategies are reflected in livelihood outcomes. The livelihood outcome could either be positive (successful) or negative (unsuccessful). A positive livelihood outcome results in improved food security, increased household income, sustainable resource use, improved adaptive capacity and enhancing resilience to shocks. Positive livelihood outcomes will also lead to an entrenchment and reinforcement of the traditional practices gained through indigenous knowledge and this can

be complemented with appropriate scientific knowledge to further reinforce and build the adaptive capacity of farmers and improve upon the asset base. The resultant effect of this will be the reduction of the vulnerability faced by the communities by enhancing the adaptive capacity of farmer households through feedback mechanisms as illustrated by the arrows in figure2.1. A negative livelihood outcome (livelihood failure) can also happen if the response (adaptation) to climate change has not been positive. This could erode the natural resource base and diminish the physical assets possessed by the local farmers and their households. This could exacerbate the impact of climate change on the farmer households. A failure will encourage the farmers to re-exam their adaptation strategy and either strive to improve their knowledge in the next production cycle. In terms of livelihood outcomes Chambers and Conway (1992) advocated for achieving livelihood outcomes which will not generate risky trade-offs and noted that livelihood activities should ensure that the outcome is both socially and environmentally sustainable. A socially sustainable livelihood is one which can withstand external pressure by way of an enhanced ability to cope with stress and shocks and environmental sustainability deals with the external impact of livelihoods on other livelihoods.

In a nutshell, the framework portrays the use of indigenous knowledge and assets/capitals by farmers and their households as a means to prepare and manage exposure to risks, enhance adaptive capacity and to adapt to climate induced change so as to sustain their livelihoods from the use of community managed irrigation schemes in the Upper East Region as illustrated by the arrows in the figure above.

In summary the key issues which will be looked at with regards to the conceptual framework are the perception of farmers about climate change which is mediated by the risks they perceive about climate change. The vulnerabilities farmers face as a result of climate change and how they perceive its impact on their livelihood, the strategies they employ as a result of the knowledge they possess as well as the assets they have and the institutional structures and processes that enable farmers have access to assets and natural resources in the community.

2.9. SUMMARY

This chapter examined the concepts of climate and climate change, perceptions of climate change, livelihood and the sustainable livelihood approach, vulnerability, adaptation and

adaptive capacity and indigenous knowledge. I also put forward a conceptual framework to explain climate change adaptation.

The first issues I examined were the concepts of climate and climate change as well as perceptions of climate change. With regards to climate change the idea that the climate is changing is no more in contention but it is the rate, magnitude and timing which is still an area of debate. The various definitions of climate change were also highlighted but significant among them is the definition of the IPCC and the UNFCC which differs in the sense that the UNFCC distinguishes between climate change attributable to human activities and climate variability attributable to natural causes whereas the IPCC attributes climate change to be caused by both natural variability and human activities. In the discussion the main cause of climate change is the emission of GHGs in the atmosphere as a result of human activities especially during the advent of the industrial revolution during the mid-18th century. The literature also suggests that we are in the anthropocene epoch. The changing climatic conditions are manifest in all regions of the world but its seriousness is more pronounced in Africa. On the perception of climate change, it is important to note that farmers in Africa have adequate knowledge about the climate and have also indicated that the climate is changing using factors such as rainfall, temperature and winds to justify their claims. It also emerged that the age, educational level of farmers; gender and marital status of famers play significant roles on how farmers perceive climate change.

Secondly, I discussed the issue of livelihoods. A livelihood can be seen as a means of making a living by households through the judicious use of resources at their disposal whiles exploring other opportunities as well as dealing with challenges that might emerge in their quest to earn a living. In the discussion I pointed out that the issue of livelihood should be seen as holistic which should go beyond income. It presupposes that people may not have income but have other assets which they can rely on to build their capacities so as to sustain their livelihoods. These assets include knowledge, skills, natural resources and other human relations such as family relations and friends. A key feature of the sustainable livelihood approach which is important in livelihood sustainable especially under climate change is that it’s a departure from the traditional development interventions which introduced ready-made interventionist strategies. The SLA rather looked for more effective and efficient methods to support people in ways that are meaningful to their daily needs by putting individuals and their capabilities at the core of any development intervention. In the discussion I also shed

light on the fact that securing a livelihood comprises a system of interrelated parts of which the most complex is the portfolio of tangible and intangible assets. It is the portfolio of tangible and intangible assets that provide the groundwork for individuals to construct and contrive a living using their capabilities, knowledge, skills and capabilities. Assets are important in building the capacity of individuals which is crucial in reducing their vulnerability. It is also important in sustaining household livelihoods under climate change. An inherent shortcoming of the livelihood approach is that it lacks a robust approach to solve long-term change in environmental conditions as a result of the likely impacts of climate change especially in poor parts of the world; this is because the impact of climate change has been ignored by the originally conceived livelihood approaches. Despite some short-comings the SLA is still attractive because it combines the different strands of thinking about sustainability which are environment, development and livelihood thinking.

The next issue I discussed in this chapter was vulnerability. It is rational that research and analysis of climate adaptation begin with vulnerability analysis. I have pointed out that the concept of vulnerability lacks a precise definition. In this study I conceptualize vulnerability as an exposure to climate change effects and the adaptive capacity to deal with the shocks and stresses as a result of the changing climate. In the discussion I pointed out that people who are socially, economically, politically, culturally, institutionally, or otherwise marginalized in society are more vulnerable to climate change. In this study I adopted the double structure of vulnerability as a theoretical basis. The double structure of vulnerability indicates that vulnerability has two sides, thus an external and internal side of exposure to risk, stress and shocks as a result of climate change that households are subject to and a lack of adaptive capacity to deal with the exposure to risk, stress and shocks. The external side comprises exposure to risks, stress and shocks that individuals and households face as a result of climate change. In the conceptual framework I pointed out that the external side reduces the adaptive capacity of individuals to adapt to climate change. The internal side arises as a result of defencelessness which relates to lack of means to cope with shocks or capacity to adapt without damaging loss. The internal side can also lead to livelihood failure since it also reduces the capacity of individuals to deal with stresses that might arise. Reducing the challenges that arise as a result of the external and internal sides of vulnerability is crucial for sustaining livelihoods of rural people in the wake of climate change. This can be done by strengthening the capacity and capabilities of individuals to deal with risks and shocks which occur. In the frame I pointed out that if the adaptive capacity of households are strengthened

through indigenous knowledge it helps to deal with the exposure that arise as a result of climate change and this invariably increases the ability of households to deal with shocks as a result of climate change. This study therefore aligns with the thinking that the double structure of vulnerability forms the core components of vulnerability frameworks.

Fourth, I looked at adaptive capacity and adaptation as it relates to climate change. The threat to livelihood as a result of climate change has led to adaptation taking centre stage in dealing with its impacts. The ability of people to deal with the impacts of climate change depends largely on their level of vulnerability and asset base and this has an impact on their adaptive capacity. Adaptation takes place when people have to respond to more permanent changes in their environment. Adaptive capacity on the other hand involves the enhancing the viability of economic and the quality of human life. In climate change discourse it refers to the capacity of system to adjust to climate change including climate variability and to moderate potential damages so as to take advantage of opportunities or to cope with consequences. In the discussion it emerged that strengthening adaptive capacity or otherwise to a large extent depends on the resources that a system has or can access. In my discussion and as pointed out by many authors, there are various types of adaptation but one which is of utmost importance to this study is autonomous adaptation which is a reactive response to climate stimuli and takes place irrespective of an policy, plan or decision. There is no proactive intervention and the actions are initiated by private actors, therefore building on autonomous adaptation is important in enhancing adaptation at the local level. As pointed out in the discussion several scholars have noted that involving the local in planning is crucial for successful adaptation especially those who may be affected by climate change since local people possess the indigenous, technology and social institutions that are important in shaping adaptation options. In the discussion I pointed out that vulnerability, adaptive capacity and adaptation are interrelated as buttressed by many scholars. For instance the capacity of a system to adapt to climate change could be due to vulnerabilities faced by the system. It is therefore important to assess the vulnerabilities of a system to climate change since this can help enhance the adaptive capacity of that system. Thus a good link between vulnerability, adaptive capacity and adaptation is that reduced vulnerability, increases adaptive capacity and this leads to appropriate adaptation.

The next issue I discussed was indigenous knowledge. In this study I adopted the view that indigenous knowledge is not wholly or exclusively local to people residing in their unique

environment or community but it is a hybrid of both local, traditional indigenous knowledge and western scientific knowledge. Indigenous knowledge can be seen as local or traditional knowledge that indigenous people have brought down with them from earlier times through oral tradition. It is the grounds for local decision-making in agriculture, education, health, natural resource management and other activities and it is embedded in community practices (experiential), institutions, relationships and rituals and basically a tacit knowledge that is not easily codifiable. From the discussion many scholars have intimated that indigenous knowledge goes beyond its doctrine premised on localization, continuity and homogeneity. It emerged that the production of indigenous knowledge involves the interaction between local communities who have their own practices and beliefs and external agents or stakeholders who have their own practices and beliefs culminating in the production of new knowledge through experimentation and changes in production technologies as a result of innovations. Indigenous knowledge therefore is a product of localization of knowledge. In the discussion and as supported by several scholars indigenous knowledge is important for development especially in the area of resource sustainability. Indigenous knowledge is important for development especially in North-Eastern Ghana because it is the most important resource that provides the avenue for the local people to come up with strategies to solve their problems so as to enhance their wellbeing in the face of climate change. Indigenous knowledge is also crucial to development in North-Eastern Ghana where the climate is changing because it is an important asset that can help people deal with their livelihood vulnerability to climate change since access to it to a large extent help build the capacity of the individual, access to indigenous knowledge is important because it is not evenly spread among the population therefore those with access wield some power, there is therefore the need to encourage knowledge sharing at the local level through co-learning and co-production. It is therefore important to integrate indigenous knowledge at the beginning of every development initiative since it presents opportunities instead of being a hindrance to development. It is therefore necessary to treat indigenous knowledge like all other forms of knowledge by drawing on its strength and incorporating it into policies geared towards climate adaptation at the local level so as to enhance rural development.

Finally, I developed a conceptual framework that integrates models and components of climate change, vulnerability, indigenous knowledge and adaptive capacity to conceptualize climate change adaptation in North-Eastern Ghana. The conceptual framework demonstrated how these concepts are intertwined and interrelated to show how adaptation strategies are

evolved under changing climatic conditions to ensure that livelihood outcomes are sustainable. In the conceptual framework I argue strongly that adaptive capacity which is a panacea to deal with vulnerability and hence ensure appropriate adaptation is anchored on indigenous knowledge, the asset base of community based irrigation scheme users in the communities and the institutions and processes that the communities possess to deal with climate change. In the framework I pointed out that indigenous knowledge and assets are crucial in building the adaptive capacity of scheme users. Indigenous knowledge enables them to perceive risks arising from climate change since they have an intimate relationship with their environment. Risk perception therefore enables risk preparedness and management to deal with the impacts of climate change by crafting strategies to adapt to the impacts. With regards to assets I pointed out that in this study social capital to be important because it enhances the ability of human capital to reinforce the production of knowledge. Social capital also enables the society to effectively act together with the other capital assets and appropriate institutions and this can enhances the capacity of individuals to formulate livelihood strategies to adapt to climate induced changes. I also pointed out the importance of institutions and processes in the communities since they mediate access to resources especially common property resources (CPRs) which are crucial in livelihood sustainability. The outcome of the above is that farmers are able to deal with the shocks and stresses that individual farmer's face as a result of climate change, hence the external and internal aspects of vulnerability are reduced or dealt with. The end result of all these should culminate in a livelihood outcome which could be positive or negative.

CHAPTER 3: RESEARCH METHODOLOGY

This section deals with the research approach and design that was used in the study. It discusses the sampling techniques that were used to reach the respondent as well as the data collection that was applied to elicit empirical data from respondents or research participants in the field. It also outlines the techniques and procedures that were employed in the presentation and analysis of data. A research methodology can be said to be an outline of the plan of the research. According to Rajasekar et al. (2013:5) research methodology is principally the "procedures by which researchers go about their work of describing, explaining and predicting phenomenon" and also as the "study of methods by which knowledge is gained". It is also described as a systematic way to solve the research problem and aims to outline the work plan of the research, including the steps adopted by the researcher in studying the research problem along with the logics behind them (Kothari, 2004; Rajasekar et al. 2013).

3.1. RESEARCH APPROACH

In order to undertake a study certain approaches and designs underpin the research. Groenewald (2004) after years of studying research methodology indicates that in order to select the most appropriate design, or combination of designs, most suitable for a particular study, one needs a grasp of a vast range of research methodologies and further needs to make an intensive study of the methodology(ies) selected, to undertake good research. The study is eclectic and was designed and implemented, based on a methodological approach that relied on qualitative and quantitative methods. In this study therefore I adopt both qualitative and quantitative approaches. The idea of using both qualitative and quantitative approaches emerged in the 1970s from the fields of applied social and behavioural sciences such as education, nursing and evaluation (Teddlie and Tashakkori 2011). Combining qualitative and quantitative approaches enables the researcher to collect and analyze both qualitative and quantitative data in many phases in the research process. In using both qualitative and quantitative methodology research, the researcher not only combines qualitative and quantitative methods and methodologies, but also combines a philosophy and a method orientation involving the collection and analysis of both qualitative and quantitative data (Creswell, 2011; Creswell and Plano Clark, 2011). The primary aim of using methodological pluralism is to establish meaning using multiple methods and then employ the use of threading to follow a theme or themes across the data sets, "to create a constellation of

findings which can be used to generate a multi-faceted picture of the phenomenon" (Moran-Ellis et al. 2006:16). A significant advantage of using both quantitative and qualitative approaches is that it provides a better understanding of the problem than either approach alone (Creswell and Plano Clark, 2007).

Combing qualitative and quantitative approaches meets the tenets of methodological eclecticism which draws on the strengths of each approach to offset the weakness of the other. Hammersley (1996:167) buttressed this point in the following words:

"What is being implied here is a form of methodological eclecticism; indeed, the combination of quantitative and qualitative methods is often proposed, on the ground that this promises to cancel out the respective weaknesses of each other".

Similarly, Reichardt and Cook, (1979) and McDowell and Maclean, (1998) also noted that blending qualitative and quantitative methods allows the researcher to take advantage of the strengths of one approach to compensate for the weakness and bias of the other.

Johnson, Onwuegbuzie and Turner (2007) also underscored the rationale for using both qualitative and quantitative approaches when they indicated that combining the elements of both approaches in terms of data collection, analysis and inference ensures a broad depth of understanding and corroboration in the research.

Denzin and Lincoln (2005:3) define qualitative research as a

> *"situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that makes the world visible. These practices transform the world. They turn the world into a series of representations including field notes, interviews, conversations, photographs, recordings and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them".*

Qualitative research from the above definition places the researcher in a position to make meaning from peoples perspectives about their natural environment. Qualitative research therefore is a naturalistic, interpretive approach focused on understanding the meanings that are attached to phenomena (actions, beliefs, decisions, values etc.) by people within the social world (Snape and Spencer, 2003). Qualitative research often "place emphasis and value on

the human, interpretative aspects of knowing about the social world and the significance of the investigator's own interpretations and understanding of the phenomenon being studied" (Snape and Spencer, 2003:7). Based on a constructivist epistemology it investigates what it assumes to be a socially constructed reality based on a frame work which is value-laden, descriptive, holistic, context specific and flexible. It involves an in-depth description of the phenomenon under study and the researcher and subject are inextricably linked (Yilmaz, 2013). The aim of qualitative research is therefore to understand and describe the phenomenon being studied by elucidating and explaining the experiences of the participants in their own words. It therefore requires the researcher to undertake an in-depth study of people's lives through observation and interviews with open-ended questions instead of standardized, pre-determined categories of analysis (Yilmaz, 2013).

According to Denzin and Lincoln (2002: x) "qualitative research has become an umbrella term encompassing a wide range of epistemological viewpoints, research strategies and specific techniques for understanding people within their natural context". Qualitative methods are also based on the premise that social reality is the shared creativity of individuals. It therefore enables the researcher to illicit the perspectives of participants engaged in the social interaction (Filstead, 1981). Much in the same vein Bryman (2012:) asserts that qualitative research stresses the "understanding of the social world through an examination of the interpretation of that world by its participants", meaning that social properties are outcomes of interactions between individuals, rather than phenomena 'out there' and separate from those involved in its construction". Also qualitative research ascribes to the tenets that there are multiple realities and truths based on individual and social constructions (Bryman, 2012; Fistead, 1981; Sale et al. 2002). Reality and knowledge are therefore socially constructed (Yilmaz, 2013). This is in line with the thesis since the study is to understand how people perceive climate change and assign causes to climate based on their interaction with the social environment and the meaning and realities they pin to issues of climate change. The study also takes into account what they see as indigenous knowledge and how that knowledge base enables them to adapt to climate change within their own social context and environment.

Qualitative research is also important for this study because it enables the complex and multi-dimensional nature of climate change perception and how people relate climate change to their livelihoods as well as how they use their indigenous knowledge to adapt to climate

change to be explored in an elaborate manner. This is because as noted by Mason (2002:1) qualitative research enables the use of methodologies that celebrate "richness, depth, nuance, context, multidimensionality and complexity rather than being embarrassed or inconvenienced by them" and also has the capacity to enable convincing arguments about "how things work in a particular context". In this vein qualitative research enables a deeper understanding of how people perceive and understand climate change from their own perspective and interaction with their natural environment, how they relate it to their livelihoods and the indigenous strategies they employ to adapt to climate induced change in the upper east region based on the knowledge that they have evolved over the years and transmitted from one generation to another based on their own interpretation and narratives as a result of their lived experiences within their historical and social context.

By contrast, Yilmaz (2013:311) defines quantitative research as "research that explains phenomena according to numerical data which are analysed by means of mathematically based methods, especially statistics". Quantitative research is based on the notion that psychological and social phenomena have an objective reality which is independent of the subject being studied. It stresses the fact that "reality should be studied objectively by the researchers who should put a distance between themselves and what is being studied" (Yilmaz 2013: 312). Quantitative research is based on the premise that the researcher and the subject are seen as relatively separate and independent and follows an objectivist epistemology and aims to develop explanatory universal laws to explain social behaviour based on the assumption that there is static reality out there to be measured (Yilmaz, 2013). Quantitative research enjoins the researcher to follow a pre-constructed standardized instrument in which it is expected that the varying perspectives and experiences of participants is expected to fit in. it is based on the premise that with closed-ended questionnaires the researcher is able to recognize a general pattern of responses from participants which can be measured therefore allowing for generalization through comparison and statistical aggregation of data (Yilmaz, 2013). Quantitative research therefore enables the researcher to analyse numerical data statistically which have the ability to provide measurable evidence to probably help establish cause and effect relationship which enables generalization to a population (Creswell et al. 2011). In quantitative research therefore respondents are denied the opportunity to express their personal or individual experiences, therefore the meaning that participants will attach to a phenomenon being studied is mostly overlooked (Patton, 2002; Yilmaz, 2013).

Quantitative research is therefore necessary for this research study because it enables the generation of numerical data on the factors which account for people's perception about climate change and how they relate these factors to their livelihood outcomes. It also makes it possible to identify factors which have significant influence on the respondents' ideas about climate change as well as identify the factors which impact most on their livelihoods based on certain parameters such as on income levels of respondents, access to social services as well as other social and financial constraints.

In summary, researchers in recognising that all methods have limitations, maintain that using methodological pluralism ensures that biases inherent in any single method can be neutralized or cancelled by the use of other methods through triangulating data sources as a means for seeking convergence across qualitative and quantitative methods (Creswell, 2009). Alternatively, the qualitative and quantitative data can be merged into one large database or used side by side to reinforce each other (Creswell, 2009).

3.2. RESEARCH DESIGN

Research design can be said to be a logical plan as to how to answer the initial set of questions (Yin 2014). This study adopted a case study research design which is also referred to as qualitative study (Rudestam and Newton, 2001). Case studies are a strategy of investigation in which the researcher explores in depth a programme, activity, event, process, or one or more individuals. Cases are bound by time and activity, and researchers collect in depth information using a range of data collection procedures over a sustained period of time (Stake, 1995). Yin (2003, 2014) advocated for this strategy when 'how' or 'why' question is being asked about contemporary set of events, over which the investigator has little or no control.

Yin (2014:16) defined a case study as an "empirical inquiry that investigates a contemporary phenomenon (the 'case') in depth and within its real-world context especially when the boundaries between phenomenon and context may not be clearly evident". Case studies investigate social life within the confines of openness, naturalism, communicativity and interpretivity (Sarantakos, 2005). In this study the research questions seek to address how and why questions concerning climate change perceptions, effects and the use of indigenous knowledge to adapt to climate change. In all these the researcher has no control over them since these are contemporary events in the North-Eastern part of Ghana. In view of this the case study approach enabled the researcher to collect varied information to explain certain

occurrences and relationships that exist within the peoples socio-cultural settings within a certain context. The study therefore collected views of individuals across generational lines which comprised the aged, middle aged and the youth. Issues of gender were considered in collecting data so as to represent the varied views of climate change and livelihood adaptation along the milieu of indigenous knowledge.

Cases represent the central interest of the topic empirically. Cases may be individual, organizational document, artifact or amalgamation of all these (Yin 1994, 2014).

One of the major strengths of the case study design is that it enables the use of multiple sources of information; it can therefore be based on the combination of qualitative and quantitative evidence in a triangulation fashion to enhance validity (Denscombe 2010; Yin 1994; 2014). This enables the researcher to compare the perceptions of various individuals and communities by inferring from different data sources.

3.3. PHILOSOPHICAL FOUNDATIONS

The philosophical foundations adopted for this study are social constructionist and post positivist worldviews in line with Greene and Caracelli (1997) who advance an argument for researchers using both qualitative and quantitative methods to adopt multiple worldviews and this need to be made explicit and honoured. They advocated for the integration of both post-positivist and constructionist paradigms so as to synergistically benefit from both paradigms. These philosophical choices or assumptions can be called world views, knowledge claims, epistemologies or paradigms and these philosophical assumptions constitutes a part of inquiry as to what constitute knowledge (Swanson and Holton, 2005).

3.3.1. SOCIAL CONSTRUCTIONISM

According to Bryman (2012:33) “constructionism is an ontological position (often also referred to as constructivism) that asserts that social phenomenon and their meanings are continually being accomplished by social actors”. Social constructionism roots can be traced to rationalist and empiricist school of thoughts and the ancient debates that ensued between them (Gergen 1985). Alvesson and Skoldberg (2009) also trace the roots of social constructionism to phenomenology and in recent times have associated it to postmodernism. Social constructionism is a broad and multifaceted perspective which has been compared to, contrasted and in most instances seen as an alternative to positivism and critical realism and

often associated with the study of how reality is social constructed (Alvesson and Skoldberg, 2009). Social constructionism may be defined as a perspective that propagates that human life exists to a large extent due to social interpersonal relationships, influences and experiences (Alvesson and Skoldberg, 2009; Owen, 1995; Gergen, 1985). Social constructionists believe that reality and truth are socially constructed based on the interaction between individuals. Therefore realities are local and specifically constructed (Guba and Lincoln 1994). In their words to buttress the above assertion they said that to the constructivist or constructionist "realities are apprehendable to the form of multiple, intangible mental constructions, socially and experientially based, local and specific in nature (although elements are often shared among many individuals and even across cultures), and dependent for their form and content on the individual persons or groups holding the constructions" (Guba and Lincoln 1994: 110-111). Bryman (2012:34) buttressed this point when he said "constructionism essentially invites the researcher to consider the ways in which social reality is an ongoing accomplishment of social actors rather than something external to them and that totally constrains them". It therefore implies that the researchers own accounts of the social world are constructions. Much in the same vein Gergen (1985) previously asserted that the parameters to understand the world can be found in social artifacts and the products of historically situated interchange among individuals and groups. In his view, the position of the constructionist in understanding the world is not automatically propelled by the forces of nature, but is the outcome of an active, cooperative enterprise of people in relationship. Bryman (2012) in supporting this view intimated that the categories that persons use in aiding them to understand the natural and social world are in essence social products. Gergen (1985) therefore argued that inquiring about a social phenomenon should be based on the historical and cultural bases of a variety of world constructions. To the social constructionist "knowledge is not something people possess somewhere in their heads, but rather something people do together (Gergen, 1985: 270), and language plays an important role in this process since "languages are essentially shared activities" (Gergen, 1985: 270). Bryman (2012) supported this view and further related language to discourse analysis when he pointed out that meaning is built up during interaction and this is depicted in language to present categories in certain ways that portray this interaction and this tendency is seen principally in discourse analysis. Similar to the above assertions Alvesson and Skoldberg (2009) said that human beings form habits and routines through a certain way of acting and these can be repeated in similar situations. This sort of actions has been described by Berger and Luckmann (1991) as subjective reality of society. Alvesson and Skoldberg (2009) are also of

the view that new habits are also formed within our social relations with others all the time by observing the actions of others and these new habits, routines and categories are formed and shared among actors. Through this process whole bodies of knowledge develop and this knowledge is then transferred between individuals in a society at a particular time and over generations and through these new traditions arises and this is central to constructionism. The assertions of Alvesson and Skoldberg (2009) support the view of Schwandt (2003) that "we are all constructivist if we believe that the mind is active in the construction of knowledge".

Social constructionism largely rejects the notion that we can divorce knowledge from social experience and access objective and external reality (Jones, 2002). Jones further noted that this view is gaining grounds in the analysis of environmental problems. This notion is heightened by Macnaghten and Urry (1998, cited in Jones, 2002:48) when they acknowledged that there are 'multiple natures' as a result of the cultural implication of "even the most apparent physical environmental issues".

In this thesis the main issues are to address the perception of irrigation scheme farmers about climate change, the impact of climate change on their livelihood, the use of indigenous knowledge by farmers to sustain their livelihood and how other stakeholders how deal with farming and the environment have incorporated indigenous knowledge in their planning and the assistance they offer to small scale irrigation scheme farmers to adapt to climate change and also sustain the irrigation schemes. This therefore means that a number of stakeholders are engaged in shaping perception of climate change and its impact on their livelihood and how to use indigenous knowledge to overcome the vulnerabilities associated with the effects of climate change. This is paramount because it enabled the researcher to get standpoints from different stakeholders. in view of this and coming from a social constructionist point it is necessary to identify the multiple realities and the power relations that exist within and between these stakeholders in line with the assertion by Guba and Lincoln (1994: 110-111) that" realities are apprehendable to the form of multiple, intangible mental constructions, socially and experientially based, local and specific in nature (although elements are often shared among many individuals and even across cultures), and dependent for their form and content on the individual persons or groups holding the constructions". This therefore means that how we perceive a phenomenon is a result of our interactions with each other and the environment through a process of discourse which assigns meanings and this is embedded in

the social and cultural set up in which people find themselves. This thesis therefore adopted the notion outlined above.

Social constructionism with regards to environmental issues has been critiqued for not being able to contribute to the understanding of environmental issues (Milton 1996; Jones 2002) but other authors have posited that a social constructionist paradigm on environmental issues has several advantages (Capek 1993; Hannigan 1995; Burningham 1998). In the view of some scholars environmental problems are constructs of individuals or organizations that perceive these issues as environmental problems (Hannigan 1995; Dryzek 2005). It therefore means that environmental problems do not just emerge by themselves and this is where the utilization of constructionist approach becomes paramount as it is through different constructions of environmental problems that useful solutions can be proffered to resolve environmental issues including climate change.

Social constructionism has been categorized into different versions by different authors. This is due to the fact that social constructionism believes that realities are conceptual in nature and there is no single external reality and is of the belief that we have 'meanings' rather than 'truths' (Milton, 1996; Jones, 2002) and that "knowledge" can exist side by side if they are equally competent (Guba and Lincoln 1994). Gergen and Gergen (2003 cited in Hopkins, 2013) further noted that social constructionism as a paradigm has a list of assumptions, logics and values to which a social constructionist must hold on. This view has also been espoused by Jones (2002:248) who stated that "different types of social constructionist thought may be uncovered that rest on different epistemological and ontological foundations". In identifying and distinguishing the various variants of social constructionism Schwandt (2003) differentiates between weak and strong social constructionism, Sismondo (1993) identifies strict, radical or extreme social constructionism compared to a mild or contextual form of it. The former denies physical reality and that social processes are at play in (nearly) every step in the construction of knowledge (Sismondo, 1993) while the latter assumes that there is no nature outside what is socially constructed (Vogel 1996). Hannigan (1995) talks about strict constructionism referred to by Milton (1996) as extreme social constructionism which is based on the notion that there is no right knowledge claims and that one set of 'facts' or 'truth' is more or less as good as the other (Symanski, 1994; Jones, 2002). Hannigan (1996) also indicated that the alternative to strict constructionism is known as contextual constructionism which Milton (1996) also terms moderate constructionism which

differentiates diverse world views as being different interpretations of a common reality rather than diverse truths and that culture are composed of different meanings. Burr (2003) also distinguished between micro and macro social constructionism. According to Burr (2003) micro social constructionism is one which takes place in everyday discourse between people in interaction. Micro constructionism is of the view that multiple versions of the world are possible through discursive, constructive work and there is no need to hold one version as true or more real than the other. To this end we can lay claims about the existence of a real world outside our descriptions of it. On the other hand macro social constructionism accepts the constructive power of language but looks at it as derived from, or at least related to, material or social structures, social relations and institutionalized. This study therefore adopted the view of Burr (2003:22) and the study does not consider one of the views thus micro and macro social constructionism as being more justifiable and thus responses which emerge from farmers and officials of NGOs and government were not considered as mutually exclusive in line with Burr's (2003:22) assertions that "there is no reason in principle why they should not be brought together in a synthesis of micro and macro approaches".

3.3.2. POST-POSITIVISM

Post-positivism emerged as reaction to some of the philosophical assumptions of positivism and its early thinkers are Karl Popper and Thomas Kuhn. Post-positivism has been influenced by 19th century writers such as Comte, Mill, Durkheim, Locke and Newton (Smith, 1983; Creswell, 2009) and later by writers such as Phillips and Barbules (2000 cited in Creswell, 2009). Post-positivism assumptions have influenced quantitative research more than qualitative research. Postpositivist world views come under different names such as scientific method or doing science research, empirical science and post positivism that is the thinking after positivism (Creswell, 2009). Post-positivists reject the positivist notion of the absolute truth of knowledge and the idea that the researcher and the respondent are independent of each other (Philips and Barbules, 2000; Creswell, 2009). Researchers should not see the people s/he is researching as subjects from whom information is to be obtained; the researcher therefore assumes a learning role instead of a testing role (Ryan 2006). They acknowledge that when studying human behaviour and actions we cannot be certain about our claims of knowledge. To them the researcher can never be certain and in the social sciences they focus on confidence which has to do with how much the researcher can rely on his or her findings and how well they predict certain outcomes (Creswell, 2009; Sukamolson,

2007). The post-positivist approach believes in the researcher investigating his or her own epistemologies and understanding how they affect the researcher. In doing so the researcher gains an understanding of how people construct, make meaning and maintain perceptions of the world (Ryan, 2006). The researcher therefore makes an effort to engage his participants in the social construction of a narrative, a departure from an interviewee giving prepared responses to standardized questions designed to be unbiased and neutral (Ryan, 2006).

Post-positivists believe that we cannot observe the world we are part of as being totally objective and we cannot also be disinterested outsiders and accept that the natural sciences cannot provide the model for all social research (Sukamolson, 2007). Post-positivists therefore believe in objective reality. They urge approximation of reality as best as we can while realizing people's subjectivity in shaping reality. Instead of finding the truth they normally try to represent as best as they can. They therefore are of the view that researchers will never be able to totally uncover reality through our research (Sukamolson, 2007). Post-positivists therefore place premium on meaning, seeing the person, experience and knowledge as "multiple, relational and not bounded by reason" (Henriques et al., 1998; xviii cited in Ryan, 2006: 16).

According to Creswell (2009) post-positivists posit that causes likely determine effects or outcomes. This means that the phenomenon studied by them calls for the need to identify and assess the causes that influence outcomes. The knowledge that is developed by post positivists is based on a "careful observation and measurement of the objective reality that exists 'out there' in the world" (Creswell, 2009: 7). In this respect though post positivists concentrate on numerical measures this study largely depends more on qualitative data and as such numerical data was used as a backup to buttress the qualitative analysis.

The post-positivist approach believes and makes use of tools such as the concept of discourse; post-positivists are also concerned with the issue of power, and they respect the value of narrative as well as always striving to be reflexive. Discourse may in brief be defined as the relationship between language and meaning. Discourse enables us to construct the ways people think, talk about and respond to phenomena. Post-positivists are concerned with the construction of new meaning and knowledge and discourse shows that meaning is never neutral but favours certain interests due to the interplay of power within that society. Post positivists also try to take the reader into a story as pointed out by respondents and also shows how people take up positions in certain discourses (Ryan, 2006).

In this thesis I explored how people perceive climate change and its causes, the relationship between climate change and their livelihood and how they are able to adapt to climate change through indigenous knowledge. In this regard numerical data was generated to understand their experiences and why they see some issues to be more critical to them than others. Post positivism therefore allowed the researcher to use some statistical data to validate findings obtained from qualitative interviews

3.4. SAMPLING AND DATA COLLECTION

The sampling methods used for this study was both purposive sampling and simple random sampling techniques. Purposive sampling was used to sample respondents who are mainly stakeholders who have either been working on rural development and irrigation development and management in the study area or who have relevant knowledge on the subject matter. People in this category included the Directors of the District Agricultural Development Unit. Also traditional authorities, NGOs and CBOs working on water resource issues were also contacted. Purposive sampling is appropriate for this study because in the view of Neuman (2007), purposive sampling is used in situations in which an expert uses judgement in selecting cases with a specific purpose in mind. Simple random sampling was used to select respondents to take part in the survey. Individual water users were selected using simple random sampling; this method was used because the WUAs have a list of all registered farmers and this served as the sample frame from which farmers were randomly selected. The lottery method was employed to select the respondents. In using this method I obtained the sample frame which was the registered farmers in possession of the WUA. The registered farmers were assigned numbers on a piece of paper, each number corresponding to a name of a farmer. The numbers were then put in a bowl and numbers were picked randomly and subsequently aligned with the name of the farmer. The chairmen were asked about the availability of the farmers, and it emerged that some had travelled out of the community and others had given up farming due to certain challenges they faced, and these categories of framers were therefore dropped. At the end of the exercise a total of 185 farmers had been sampled. These farmers were in the community and were still engaged in dry season irrigation farming. The numbers sampled comprised 84 and 101 farmers in Tanga and Bongo respectively. In the case of the key informants they were selected purposively due to their knowledge of the irrigation schemes and experience in farming. The officials of organizations were identified through the survey questionnaire administration, in-depth interviews and

FGDs when they were mentioned as organizations offering some form of assistance to the irrigation scheme farmers.

In this study both primary and secondary data sets were used. The primary data was obtained directly from field work through interviews of various personalities who have direct connection with irrigation use and management in the Region or study districts. Questionnaires were administered to selected individuals. Site visits and field observations were also used. This technique enabled the researcher to directly observe the irrigation schemes especially the infrastructure and types of crops grown at the scheme. The secondary sources of data included various publications; articles, journals and books on the core concepts under study; these include climate change, climate change adaptation strategies, community managed irrigation schemes, sustainable livelihood, rural development, water management and livelihoods of small scale irrigation scheme users. Other relevant published and unpublished literature, legislative instruments, journals, reports and conference papers was also taken into account. Some of these were obtained from the officials of the Bawku West and Bongo Assemblies and any other relevant government and private institution such as the District Agricultural Development Units. Weather data was also obtained from the Ghana Meteorological Service to ascertain the climatic condition of the region. The weather data also provided a basis for the researcher to compare the perception of farmers about climate change based on certain climatic factors such as temperature and rainfall. .

The sample size of the study as stated above was conveniently arrived at using the lottery method and 185 farmers were administered with the survey questionnaire. They were 84 and 101 farmers in Tanga and Bongo respectively. Also as mentioned above the key informants and officials of organizations were purposively sampled for the study and in-depth information was gathered from them. A total of 25 respondents were contacted and the breakdown is in table 3.1 gives a breakdown of these key informants.

Table 3.1 Type and Number of key informant respondents for the study

Type of Respondent	Number of Respondents
WUAs Chairmen	03
WUAs Secretaries	02
ACTIONAID Programme Officer (Bawku West)	01
Red Cross Society Manager (Bawku West)	01
District Director Agriculture (Bongo)	01
Selected Farmers (Tanga)	10
Selected Farmers (Bongo)	07
Total	25

Source: (Field Survey, 2017)

3.5. QUALITATIVE DATA COLLECTION

In collecting qualitative data the following data collection techniques and tools were used. These are in-depth/key interviews, Focus Group Discussions, narratives/storytelling and photography and observation. These methods and how they were used are outlined below.

3.5.1. IN-DEPTH /KEY INFORMANT INTERVIEWS

In-depth interviews formed a key component of qualitative data collection methods in this research study. The in-depth interviews entailed a face-to-face interaction with key informants who were purposively selected for this study. Semi-structured interview guides were used to gather information from the respondents. During the interview sessions the information given by respondents was audio recorded, notes were taken especially with respect to relevant statements which needed to be quoted. The interview was later transcribed, coded and used for the analysis. In-depth interview as a data collection tool is flexible and is mostly conversational and informal; it uses open-ended but structured questions and topics but allows for further probing and questioning which enables participants to explain their views and ideas in a more elaborate and detailed manner under a carefully controlled way (Cresswell, 2014; Grenier, 1998).

In this study, a semi-structured interview guide (See Appendix 2) with mainly open-ended questions was used to elicit information from the respondents. These included farmers and officials of institutions which assist the farmers. An interview schedule was prepared and used to solicit in-depth information from farmers and the executives of the WUA. The method helped in the identification of farmers' experiences. The first part of the interview gave the respondents the opportunity to give a narrative of their experiences, challenges as farmers in general and also to give an account of what they know about their irrigation schemes. The method further helped in providing information on the perception of small-scale irrigation scheme farmers about climate change and its causes and how they relate climate change impacts on the irrigation schemes and its impact on their livelihoods. It further helped in the identification of various indigenous practices used by farmers based on their local/indigenous and local knowledge to deal with the adverse impact of climate change especially with regards to water management, soil fertility management, pest and disease management and harvest and storage of produce in their schemes. Organizations which were identified as assisting farmers in the irrigation scheme were also contacted and information about the nature of assistance they offer farmers was also achieved through the in-depth interviews. A separate interview guide was administered to this category of respondents (See Appendix 4). Respondents in this category were purposively selected and included authorities of the District Agricultural Development Unit (DADU) and officials of NGOs who provided support to irrigation scheme farmers. The use of this method enabled information which could not have been captured by the other methods such as the survey questionnaire; for instance local methods of dealing with climate change impacts came to light using this method due to the flexibility it afforded the researcher to probe and clarify responses. In all, a total of 25 key informants were contacted and the average interview time was between 40-45 minutes. In the case of sampling these respondents the executives of the WUAs were known and contacted by the researcher and subsequently interviewed. The farmers who were involved in the in-depth interview were selected by the researcher in collaboration with WUA executives. During the survey questionnaire administration, the research identified some farmers who were deemed to have experience in irrigation scheme farming over the years and with the assistance of the WUA executives the farmers were informed and those who agreed were chosen and interviewed. With regards to officials of agencies the names of their organizations came up during the administration of the survey questionnaire as organizations which were assisting them or have assisted them before. The researcher subsequently contacted them and they were interviewed in that regard.

3.5.2. FOCUS GROUP DISCUSSIONS (FGDS)

This method is a form of in-depth qualitative data collection method involving the interaction of a group of participants. FGDs can therefore be said to be a research technique that collects data through group interaction on a topic in order to explore a specific set of issues through discussions with the aim of providing various options and solutions and establishing a mechanism for the formation of opinion through brainstorming (Kitzenger 1994; Morgan 1996; Sarantakos, 2005). Purposive sampling was used to select the participants for the FGDs. In selecting the respondents I took into consideration the knowledge and experience of the participants because this method required participants who have knowledge on the topic to be discussed. The participants included the opinion leaders/key informants (WUAs Executives) and farmers who were perceived to have a good knowledge about the development of the irrigation schemes, farming practices and environmental changes over the years and have been engaged in farming in the irrigation schemes for over a decade. In order to get information that reflected climatic trends in the community and the changing conditions around the scheme. I decided to choose participants who were above 40 years with the assumption that they will have good observational and local expert knowledge as compared to younger farmers. All the participants were farmers.

The respondents for the FGDs were selected with the assistance of the key informants. The key informants recruited the respondents they perceived to fit the criteria I outlined above. During the survey questionnaire administration I identified farmers (Respondents) who were deemed to be experienced and invited to be part of the discussions. The participants were verbally informed and a date acceptable to all was agreed. The FGDs were conducted along the lines of gender thus separately for males and females in line with Neuman (2007) suggestion that FGDs should have a homogenous membership. Also the males and females were met separately because in Northern Ghana the culture as indicated by Eguavoen (2008) assigns to women the role of home keepers and are therefore not key decision makers at the household and community levels. In view of this seemingly unbalanced power relation, I separated the women because they may not be free and comfortable to express their views, perceptions and experiences about the topics of the research study. In addition, engaging the groups separately helps in generating diverse information which reflects their experiences.

In the research study, a total of four (4) FGDs were held, two in Bongo and two in Tanga. Each group consisted of twelve participants. The choice of four groups was informed by the

notion that many groups increase the complexity of the analysis (Bryman, 2012). The FGDs were held in the mornings and each session lasted approximately 40 minutes even though there were informal discussions with participants afterwards. The mornings were appropriate because the respondents could easily be mobilized at that time after they had finished watering their crops. The discussions were held with the help of a research assistant each in the two study communities who clarified words for which I could not give the equivalent in the local dialect. All the discussions were held in the local language and audio recorded. The various topics discussed focused on the objectives of the study.

This method is useful because of its snowballing nature and ability to produce complex and diverse responses as a result of its interactive synergy, spontaneity and security of participants within the group (Sherraden et al., 1995). Sherraden and her colleagues further contend that the responses gain high face validity because of the context and discussion detail. Similarly, Bryman (2012) is of the view that FGDs affords the researcher the opportunity to study how people perceive phenomena and collectively construct meaning in relation to the phenomenon. Much in the same vein, Neuman (2007) is of the view that FGDs enables people to express their ideas, opinions and views freely because of the natural setting the technique provides, enabling participants to explain their answers, thereby enriching the information being gathered. FGDs therefore provide the opportunity for the researcher to study how participants co-construct meaning about a phenomenon under study. This therefore helped the researcher to explore into detail the knowledge, perceptions, experiences and diverse opinions and views of the participants on climate change and indigenous adaptation strategies being used and the need to integrate knowledge as expressed by some of the participants.

The advantages notwithstanding, this method has its shortcomings. A notable disadvantage is that it is time consuming and has the ability to produce fewer ideas than other methods such as in-depth individual interviews (Neuman, 2007). FGDs are also difficult to coordinate especially in instances where the researcher has to manage the participants and collect data simultaneously (Krueger and Casey, 2009). This led me to recruit a research assistant to help during the FGDs sessions. The findings too may not be representative since respondents are not randomly sampled as in the case of surveys (Sarantakos, 2005). Also, power relations among members of the FGD may also influence the interaction, the more powerful dominating the less powerful. This is why homogeneity in FDGs is important so that social class relations do not silence the voices of the less powerful. In spite, of the challenges the

FGD method helped me to understand how people make meaning out of their experiences and perceive certain phenomenon based on their lived environment.

3.5.3. LIFE STORIES/ HISTORIES

Life stories uses oral history interviewing techniques based on unstructured in-depth interviews (Bryman, 2012). Life stories are an increasingly popular form of narrative-based inquiry in diverse fields such as anthropology, sociology, history to women's studies. Narratives or life stories have been given different names such as autobiography, auto ethnography and life history just to mention a few. Irrespective of the different labelling it simply deals with an inquiry into the lived experience by representing it in a narrative form (Gough, 2008). According to Smith and Watson (2010) life narrative can be said to be a general term for acts of self-presentation of various kinds and varied media that takes the producer's life as their subject. In their own words they said that narratives are "stories that include the temporal ordering of events and an effort to make something out of those events; to render, or signify, the experiences of persons-in-flux in a personally and culturally coherent, plausible manner" (ibid:162). Narratives are therefore essentially made up of stories comprised of actions, settings, characters, happenings, discourse or plot usually centered around individuals, but also of groups, societies, and cultures (Churchil and Churchil 1982; Sandelowski 1991; Gough 2008).

Polkinghorne (1988) categorized narrative research into descriptive and explanatory. In this research study the former was employed. This type of narrative research seeks to describe individual and group narratives of lived experience or life episodes where responds are asked to recollect and reflect on their past event.

Life narratives have an advantage in that it enables the researcher to notice different and in some cases contradictory strands of meaning in order to bring them into useful dialogue with each other so as to understand more about individuals and social change (Tamboukou et al. 2013).

In relation to this study in-depth interviews were used to collect oral historical accounts from the respondents. The information collected was based on the use of open-ended questions which allowed the participants to freely express themselves and give accounts of what the researcher wanted from them. The first section of the in-depth interview guide was used to obtain the oral historical data. This method was used to obtain information on the experiences

of farmers, their challenges as farmers and how their farming activities have evolved over the years. The method also provided a detailed account of past and current climatic conditions of the study area, local weather predictions and forecasting, state of the natural environment now and before, incidence of droughts and floods as well as food production in the past and now. Through this method detailed information on the detailed processes which took place before the irrigation schemes were constructed were also obtained.

The data collected using this method took a reference year of the past 30 years. This is because it is generally recommended that climate change issues focuses on changing conditions in the past 30 years and beyond. Participants who were selected and information obtained from them were the elderly and experienced farmers who were part of the key informant (in-depth interviews). They were chosen because the first part of the in-depth interview schedule was used for the oral stories. This method was important because it provided vital information about events in the past which are not available in written documents. This provided a broader perspective on how farming activities have changed over time as well as how the climate has changed over time and the hazards it poses on the workings of the irrigation schemes in the study areas.

3.5.4. DIRECT OBSERVATION AND PHOTOGRAPHY

Observation was one of the methods employed in this study to gather information. The observation was semi-structured as it did not fellow strictly a pre-determined set of issues to observe in the field. The method was necessary because it helped in getting extra information to cross-check issues which were not well articulated during the use of other methods such as in-depth interviews, questionnaire surveys and focus group discussions. It was not strictly formal but I developed a checklist which was used to observe physical features that are important in the analysis of data. This method was used to capture the state of the physical environment of the communities especially with regards to issues of human activities which were said to have had an impact on the changing climate. The observed issues included the vegetation especially with respect to tree felling and the land cover of the communities in respect of bush burning and how marshy areas which were hitherto said to have been covered with grassland have become dried and scorched bare lands. Observation was also used to capture the physical impacts of climate change and variability. Observations were also made at the irrigation sites to get first-hand information on the current state of the irrigation schemes and the activities that took place at the schemes. The issues observed included the

state of canals, banks and the water levels to ascertain how it was dwindling. In addition the type of crops and farming practices as well as the adaptation strategies adopted by farmers based on their knowledge were also observed on the farms.

At the household level observations were made to get information on storage of crops. This method helped in providing information on the vulnerabilities of irrigation scheme farmers to changing climatic and environmental conditions in the study area. The observed information was recorded in a field note book. Photographs were also taken to complement the notes and to provide a visual impression of the physical features and prevailing conditions in the study areas. The information gathered from observation was integrated and provide connections to other data in the analysis.

3.6. QUANTITATIVE RESEARCH DESIGN

The quantitative research design considered for this research study was community level questionnaire survey. The survey employed structured interviews which were administered to respondents verbally due to the high level of illiteracy among the targeted respondents.

3.6.1. QUESTIONNAIRE SURVEY

Questionnaire survey was an important method for collecting quantitative data for this study. The questionnaires (See Appendix 1) were administered to small-scale irrigation scheme farmers in the study area to collect their views on the issues under study. The questions on the questionnaire for this study were both closed and open ended in order to find out the perceptions, opinions and views of respondents about climate change, how it impacts on the schemes and their livelihoods and the indigenous strategies they employed to deal with climate change impacts as farmers. It was prudent to adopt both methods in the questionnaire design because it served as a balancing. The open ended questions provided the opportunity for respondents to also freely express themselves. The usefulness of the questionnaire survey technique is that it allows for wider coverage and more easy and quick access to respondents (Sarantakos, 2005). Similarly, the technique enables uniform measure with regards to questions leading to standardisation of questions being asked. Bryman (2012) therefore asserts that the process of standardisation of questions reduces errors that might arise from interviewer variation thereby ensuring greater accuracy and ease of processing answers provided by respondents.

Questions in the questionnaire survey were under various headings based on the objectives of the of the research study. The first heading covered the demographic and socio-economic characteristics of the respondents. The information gathered under this heading/section included their age, sex, education, level, religion, ethnicity, family size, occupation, farm size and types of crops cultivated by farmers. The second heading centered on their knowledge about climate change dwelling on their perception based on certain climatic variables and causes of climate change. The third heading captured the impact of climate change on their irrigation schemes and how it impacts on their livelihoods. The data in this category dealt with how irrigation infrastructure is being impacted by climate change as well as how it affects their living conditions. The fourth section centered on how traditional/local knowledge on climate change has stimulated and diversified farmers' adaptation strategies to climate related shocks and the challenges they face using such knowledge. The last section of the questionnaire captured information on governmental and other agencies support for small-scale irrigation scheme farmers and whether they assist them in dealing with climate change impacts. Questions in this section were open ended because the researcher did not have first-hand information about organizations which assist farmers. The questions therefore provided the opportunity for the farmers to provide names of the organizations and the nature of assistance they received from them.

In order to show the relationship between variables, questions were mainly based on a pre-determined set of statements which respondents were asked to rank on a continuous point scale depicting the importance of each statement. These statements demanded rankings which included strongly agree, agree, not sure, strongly disagree, disagree with corresponding points assigned to them such 5,4,3,2 and 1 respectively. After gathering data using this method the information was used to run a Poisson regression analysis, Likert scale analysis, Kendall ranking and chi-square analysis on cross-tabulated data. Using this method came with some challenges which included the misinterpretation of questions by some respondents and the challenge of not having the equivalent of some words in English in the local languages, and much time was therefore spent to explain these words or concepts to the respondents. Also some questions were not properly answered and I had to sort out those questions and follow up on the interviews carried out.

3.7. PRE-DATA COLLECTION

Data collection was preceded by the preparation of data collection instruments. After this the instruments were pre-tested to ensure validity and consistency. Pre-testing according to Sarantakos (2005:255) are “small tests of single elements of a research instrument that are predominantly used to check its ‘mechanical’ structure”. Pre-test are employed to ensure that the study instruments are correct, suitable, reliable and valid (Sarantakos, 2005). It is therefore used to correct weaknesses and inadequacies in data before actual data collection starts. The actual field work was preceded by the organization of two weeks training session for four research assistants who were students who had completed their undergraduate programmes and were residing in the study communities. The study was important because it served as an avenue to explain the purpose of the research study to the research assistants. The questions were explained to them and in collaboration with them we were able to come out with common meanings to words and statements used in the questionnaire. After this exercise the questionnaires were pre-tested in the communities with a small number of respondents. The pre-testing was important because it provided valuable information which afforded the researcher the opportunity to edit, revise and make appropriate adjustments to the questionnaire and interview guides. The revisions that were made after the pre-testing helped to minimize errors and made the questions more understandable to the respondents thereby minimizing response bias. The exercise ensured smooth data collection with reduced length of time spent on administering questionnaires and conducting interviews.

3.8. ACTUAL FIELD WORK

In order to collect data without any problem in the actual data collection I visited the study communities and informed the executives of the WUAs about my intention to undertake a study in their communities, specifically with irrigation scheme farmers who were their members. I was granted permission by them after they informed their members, they subsequently also led me to the chiefs and elders where I also sought permission.

The actual field work and collection of data started in February, 2017 and ended in August, 2017. The first phase of the data collection focused on the irrigation scheme users, thus the farmers including the WUAs executives. The quantitative aspect was first carried out and this involved the use of the survey questionnaire with mostly closed-ended and a few open-ended questions which were administered to the farmers. The in-depth interviews and FGDs

followed after the survey respectively. The in-depth interviews were carried out with semi-structured interview guides with open-ended questions to collect qualitative data (see Appendix 2). The second and final phase of data collection was with the identified officials of organizations which were assisting the irrigation scheme farmers in the study districts. Data collected included their own views about climate change and the kind of assistance they give to farmers to enable them adapt to climate change and also enhance their livelihoods (see Appendix 4). Historical rainfall and temperature data on two local meteorological stations were also collected from the Regional Meteorological service to complement qualitative data from the field.

The meetings for the survey questionnaire administration, in-depth interviews and FGDs were conducted in the mornings. The mornings were ideal because it was the time of the day that farmers can easily be accessible when they come to work in their fields. Interviews did not take place on market days thus Zebilla and Bongo market days because most of the farmers take that day off to shop and also sell their farm produce. In Bawku West District I stay in the capital and commuted with as pillion rider on a motor cycle to the community. Bongo I resided in Bolgatanga and moved in everyday in taxi to conduct the interviews. Interaction with farmers during the interviews was not possible because I stayed a distance from the study communities and access to means of transport was also difficult.

3.9. DATA VALIDITY AND RELIABILITY

Research cannot be free from validity and reliability threats (Cohen et. al, 2007:133). It is therefore necessary as a researcher to take into account issues that can affect the validity and reliability of the research. Validity and reliability cannot be totally achieved in any research (Cohen et. al, 2007), hence they should be regarded as a matter of degree instead of an absolute state (Gronlund, 1981; Cohen et al, 2007). They therefore suggested that researchers must at best strive to minimize invalidity and maximize validity. Kothari (2004:73) coming from a quantitative view defined validity as “the extent to which a test measures what we actually wish to measure” while reliability “has to do with the accuracy and precision of a measuring instrument”. Sarantakos (2005) see validity as measuring the precision, accuracy and relevance of a research instrument and reflects the quality of the research instruments. Reliability, on the other hand, refers to consistency of a research. It deals with the ability of a research instrument to produce the same results in repeated use (Sarantakos, 2005; Bryman, 2012). In qualitative research design many authors have used terms such as rigor, quality and

trustworthiness to refer to validity and dependability, consistency, transferability, credibility and confirmability to refer to reliability (Lincoln and Guba, 1985; Clont, 1992, Seale, 1999, Stenbacka, 2001; Davies and Dodd, 2002; Sarantakos, 2005; Bryman, 2012).

Reliability and validity are therefore important in establishing consistency and trustworthiness of research findings. From the above analysis the concepts of validity and reliability in this study refer to the precision, credibility, accuracy, consistency, trustworthiness and meaningfulness of research findings or results (Flick, 1998, Sarantakos, 2005, Leedy and Ormrod, 2010, Bryman, 2012; Creswell, 2014).

In order to ensure the validity and reliability of the research findings in this study, a number of measures were put in place. The first measure put in place was the training session for research assistants and the pilot study carried out before actual data collection. The training session was important in this regard because it clarified the concepts and terms used in the questionnaire and the interview guides for the in-depth interviews and FGDs. The process enabled the research team to arrive at a precise, uniform and consistent understanding and meaning to the terms and concepts used in the research instruments. The pilot study or pre-test also enabled the revision and dropping of some questions which exhibited some inconsistencies leading to inappropriate answers. Other problem areas were identified in the questionnaires through the pre-test and addressed to enhance validity of the instruments. For instance the appropriate translation of some concepts such as "climate and soil fertility" were problems identified, these were addressed and adjusted by way of getting translators to give the equivalent meanings. The pre-test helped in minimizing bias and wrong responses that could have emerged during the data collection. The pre-test ensured that the instruments were used to collect the appropriate information that the research study intended to collect and this ensured content validity (Creswell, 2014).

Another measure that was used to ensure credibility of interpretation was through triangulation, thus the use of multiple methods and data sources in pursuit of a research objective (Cohen et. al, 2007) as recommended by (Denzin, 1970; Cohen et. al, 2007). In this study I incorporated a number of data sources namely farmer survey, in-depth interviews, FGDs and Observation to collect similar information to enhance the credibility of the research findings. This was achieved through the convergence of the information from different responses from the different sources. Also more than one source of data also consulted during the study to enhance the credibility of the research. This is in line with

Cohen et al (2007:141) contention that if many data sources yield the same results through triangulation, it ensures greater 'research confidence'. The credibility of this research was also enhanced through the reviews and feedback from my supervisors.

In order to ensure dependability in the research process, all interviews were audio-recorded and field notes were also taken. The recordings were transcribed from the local languages, namely Gurune and Kusaal into English. The audio-recording and field notes enabled the researcher to make verbatim quotations throughout the analysis and findings chapters. This ensured interpretation and meanings are not interfered with.

Finally, to ensure that errors in responses are not encountered which can affect the credibility, accuracy and authenticity of findings, I made sure I checked all questionnaires that were returned to me on a daily basis in order to identify inconsistencies and incomplete questionnaires. Questionnaires that were found to contain inconsistencies and incomplete were given back to the field assistant for verification and if they were not able to verify, I requested that they go back to the field to correct the inconsistencies or complete the questionnaire. In some instances I went with them to the field to carry out the exercise. Also the FGDs were conducted with the aid of a research assistant who speaks the local dialect, so that he can assist in questions which need further explanation. I moderated the discussions and the field assistant took notes. Occasionally I also took notes. The discussions were also recorded and later transcribed for the purpose of analysis. In order to recapture the main issues discussed I allowed the respondents at the end of the discussion to give their overall views and impression.

3.10. DATA ANALYSIS

Data analysis entails a process of bringing order, structure and meaning to the mass of data collected to allow for ideas and patterns to be generated and linked with other research findings (Marshall and Rossman, 1999:150; Bernard and Ryan, 2010:109). Data analysis is important because it enables the researcher to reduce into manageable form the data collected so as to make sense out of it (Bryman, 2012:13). Data analysis is therefore the management, analysis and interpretation of data (Bryman, 2012:14) .Data collected from the field was both qualitative and quantitative in nature. In order to manage the data and make meaning out of it data processing and analysis was performed on both the qualitative and quantitative data gathered from the field.

The qualitative data analysis began with the listening of the audio-recordings from the field interviews, FGDs, and life stories. The recordings were then transcribed on the basis of the initial categorisation of themes in the interviews and FGDs. The information was then coded and patterns identified. The patterns and codes were categorised into themes. The coding was done systematically through the examination of the text to identify common themes. The coding took the form of examining the sentences, phrases and words used in the text. The identified sentences and phrases represented the views and opinions expressed by the respondents in the field capturing different conditions in line with the objectives of the study. The texts were also examined to identify various discourses which emerged during the interviews and discussions. The interpretation of data was done through narratives by relating the information with the key themes. The narratives ensured that how people perceive and make meaning out of their environment was taken into account and this provided the basis for in-depth qualitative analysis of the data. Reliability of qualitative data analysis was done by using the triangulation method where I pulled together information from all the other techniques to check veracity of the same information. The qualitative analysis was therefore in line with Cohen et al., (2007) assertion that qualitative analysis should be an art whereby the researcher organises, accounts, explains and makes sense of data taking into consideration the respondents' definition of the situation.

The survey questionnaire was the technique used to collect quantitative data. It contained data on the demographic and socio-economic data of the respondents, it also contained data on farmer's perception on climate change and its causes, as well as data on indigenous knowledge practices that farmers use to adapt to climate change and other issues on their farming challenges, the support they receive and the assistance they need. The quantitative data was processed and analysed through the use of the Statistical Package for Social Scientist (SPSS) software. The data were provided with codes and entered into the spread sheet. The software generated data which were used to generate various categories under various themes. The data generated enabled relationships to be made between variables. The software enabled the generation of graphs, charts and frequency tables which were used as simple descriptive statistics for presentation and analysis. Cross-tabulations were generated using the SPSS software and chi-square analysis was run on them to see the interdependence of variables. The likert scale or scoring method was also used to determine the order of importance of statements made by respondents based on a five point score. In a nutshell the

qualitative and quantitative data analysis complemented each other in the data analysis as it was used to cross check information that was provided by respondents.

3.11. DISCOURSE ANALYSIS

Discourse according to Fairclough and Wodak (1997) is a way of ascribing meaning to a particular domain of social practice from a particular perspective. Discourse can therefore be understood as a complex bundle of simultaneously and sequentially interrelated linguistic acts which manifest themselves within and across the social field of actions as thematically interrelated semiotic, oral or written tokens, very often as texts that belong to specific semiotic types or genres (Wodak and Meyer, 2001). Discourses are socially and culturally formed but historically changing (Gee, 2000), therefore the way discourse acts to produce meaning through the use of language should be embedded in the cultural and historical location of those meanings (Gee, 2000).

Discourse therefore denotes how language is used in social interaction. Discourse describes our reality, at once depicting and delimiting our understanding of the world and our place in it, and discourse can also be described as the script unpicked to reveal the contingency of what it includes and excludes. The discourse of adaptation to climate change is one such description. Discourses include representations and imaginations of how things are and have been, that is the representations of how things might or could or should be. The 'knowledge' of the knowledge-based economy includes imaginaries in this sense – projections of possible states of affairs, 'possible worlds'. This is critical in studying issues of climate change and sustainable livelihood adaptation where knowledge and perception are very crucial.

Gee (1999) also explains discourse as different ways in which we humans integrate language with non-language 'stuff' such the different ways in which we think, act, interact, value and use symbols, tools, and objects in the right places and at the right times so as to give meaning to the material world through our experience. Gee's assertion suggests that a core theme in all discourses is producing and maintaining certain identities and power relations. Discourse and technology are thus intertwined; a change in one entails a change in the other. Gee (2011; 2014; 2015) in order to label different discourses they may be defined as capital or big D and a small or little d discourses. The big D discourse according to Gee (2015) is mainly to capture the ways in which people enact or construct and identify socially and historically important identities or "kinds of people" through "well-integrated combinations of language,

actions, interactions, objects, tools, technologies, beliefs, and values". According to Gee (2015) "discourse" is always a "conversation" among different historically important kinds of people or social groups. The big D involves more than one or two discourses which show patterns of association among recognizable social groups or actors. On the other hand the small or little d discourse according to Gee (2015) is the analysis of the flow of language-in-use and how the patterns and conventions across them make sense and guide our interpretation. Munger et al. (2016:210) based on Gee's (2011) work see the little d as "stretches of oral or written language- in-use". According to Munger et al. (2016:210) Gee's definition of Discourse "is a theory that explains how language works in society". The capital 'D' Discourse therefore sets a larger context for the analysis of discourse with a small 'd' (Gee, 2015) in what can be described as a web of discourse. This notion therefore served as a guide to the interpretation and categorization of the various discourses that emerged during the study.

A myriad of approaches exist to undertake discourse analysis. Amongst these is Critical Discourse Analysis' (CDA) which is one of the many approaches towards the social analysis of discourse (Fairclough and Wodak 1997, Wodak and Meyer 2001). These approaches differ somewhat in theory, methodology, and the type of research issues to which they tend to give prominence. CDA may be defined as fundamentally concerned with analyzing opaque as well as transparent structural relationships of dominance, discrimination, power and control as manifested in language. CDA primarily deals with the inter-relationship between language and power. Discourses according to Foucault (1972) are hierarchically arranged and as such have different degrees of power and influence. According to Chouliaraki and Fairclough (1999) CDA is both a theory and a method. CDA offers both a description and interpretation of discourses in the social context as well as an explanation of why and how discourses work (Rogers, 2004).

The study was inspired by CDA to look at the content of language used on the issue of climate change and the indigenous adaptation strategies discussed in Tanga in the Bawku West District. The themes that emerged and the issues discussed during interviews and FGDs on the issues of climate change and adaptation were of particular interest in this study. The thesis does not contain a typical linguistic analysis, but it is based on Fairclough's version of CDA which assesses and interprets societal phenomenon on the basis of text derived during interviews and discussions with a starting point of constructionism which looks at how

interactions between people create social reality. This is in line with Fairclough's notion that CDA is one of an interdisciplinary approach that combines textual and social analysis in a relational, interdisciplinary and a dialectical manner (Jørgensen and Phillips, 2002; Fairclough, 2003, 2013).

In addition to being inspired by Fairclough's version of CDA for the analysis and labelling of discourses, the study also adopted Gee's discourse analysis approach which labels discourses into capital D and small d for discourse categorization with a visualization of belief systems underlying the various discourses through a web of discourses.

Discourse analysis is important in climate change research because it helps us to better understand how people interpret social issues and how we may shape social responses to these issues. Using CDA enables the researcher to investigate prevailing discourses and the way meanings are constructed, and it is an important approach to understanding environmental issues and provides practical understanding and management of environmental issues. Discourse and social constructionism are therefore interrelated because they both seek to construct meanings from our experience and interactions with one another within the social context. Discourses therefore emanate from social interactions within particular social settings.

3.12 ETHICAL CONSIDERATIONS

Social research involves human participants and as such raises serious ethical considerations. In contemporary times ethical issues has gained considerable attention (Cresswell, 2014). Neuman (2007:48) noted that ethics deals with "the concerns, dilemmas, and conflicts that arise over the proper way to conduct research" and helps to "define, what is or is not legitimate to do". Several scholars therefore see ethics in social inquiry as code of conducts that protect the rights of participants, prevent physical harm and psychological abuse, prevent deception, misconduct and ensure privacy, anonymity and confidentiality (Sarantakos, 2005; Neuman; 2007; Bryman, 2012). Creswell (2014) similarly said that it is important for the researcher to protect their research participants, ensure there is trust between them, promote the integrity of research and above all guard against misconduct and impropriety. Researchers should therefore take ethical issues seriously when conducting research in order to ensure trustworthiness and credibility of research findings. Ethical issues were considered in several ways in the course of the research in line with the above ethical principles.

During the field work I adhered to the ethical principle of informed consent devoid of deception. I did not coerce the respondents to be part of the research but explained to the participants the purpose of the study and made it known to them that it was purely for academic purposes and that the study wanted to seek information on their perceptions on climate change and how it affects their irrigation farming. This process was also a means to gain the trust and confidence of the respondents. The participants were made aware that their participation was voluntary and they are at liberty to withdraw if they wished. I also explained my professional background and motivation to the participants to calm any tensions that could have arisen during data collection. The officials of organizations contacted were given introductory letter which I obtained from the Faculty of Integrated Development Studies of the University for Development Studies introducing me and the purpose of the study. The aim of this was to get the officials consent to take part in the interview.

During the analysis of data the privacy, anonymity and confidentiality of participants were adhered to. The participant's identities were shielded during the analysis. Their names were not mentioned in the analysis or attached to any information in the research findings. The participants were given numbers and codes (Participant T1, B1 etc.) during the interviews and FGDs. I also made it known to participants that the study may not directly or instantly benefit them but that it could benefit them in the future since the findings may contribute to knowledge about the area and policy makers may gain access to it and base on that offer some assistance or policy redress. Finally, all secondary literature used was duly referenced to prevent academic misconduct.

3.13. SUMMARY

This chapter presented the methodological approach adopted in carrying out this thesis. The chapter outlined the tenets of both qualitative and quantitative approaches which were used in this study and described the advantages of using both methods in the study by way of their complimentary effect on each other to enrich analysis. This chapter also discussed the research design employed. The case study design was used and it was acknowledged that the case study design allowed for in-depth exploration of an even by asking 'how' and 'why' questions to ascertain people's perceptions which the researcher has no control over. Thirdly, the chapter examined the philosophical foundations underpinning this study. The social constructionist and post-positivist paradigms formed the philosophical foundations of the

study. These were used to describe the nature of information and analysis based on the qualitative and quantitative methods respectively.

Furthermore, the chapter discussed the sampling techniques and procedure used and the data collection methods employed. The chapter explained in detail purposive and simple random sampling. The survey questionnaire administration, in-depth interviews, FGDs and observation as methods of data collection were thoroughly explained and the nature of data collected and each one explained.

This chapter also highlighted the importance of credibility and trustworthiness of research findings by highlighting the measures put in place to ensure validity and reliability of research findings. The analysis and interpretation process was also outlined in this chapter. It gave an account of the processes, such as coding, categorization of data and putting them into themes for analysis. It also highlighted the statistical inferences made from the survey data through the use of the SPSS. Discourse analysis and how it was employed to aid data analysis was also captured in this chapter.

Finally, the chapter considered in detail the ethical issues that were upheld in this research and ensured that participants are protected from any harm that the research might cause. The ethical issues that were taken into account included informed consent, avoiding deception and ensuring the privacy, anonymity and confidentiality of participants.

CHAPTER 4: PROFILE OF THE UPPER EAST REGION

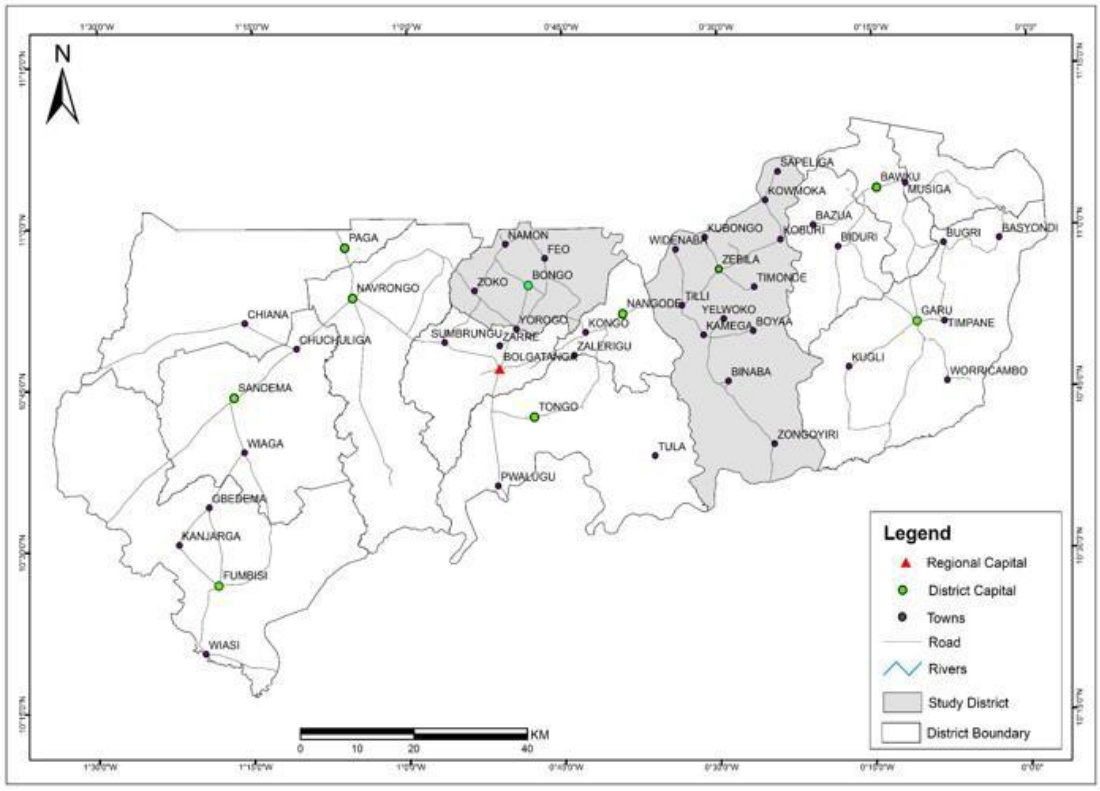
4.1. INTRODUCTION

Small scale irrigation scheme farmers undertake their livelihood activities within a certain milieu encompassing the physical, socio-economic and demographic environment. The environment within which they live has consequences on their livelihood activities especially within the context of climate change. The precarious environmental situation and pressure on resources in the UER has made it a focus of development intervention in natural resource management (Tappan et. al. 2016). This chapter therefore offers a brief profile of the Upper East Region which is located at the North-Eastern part of Ghana hence the depiction of the study topic as North-Eastern Ghana which is synonymous with Upper East Region. The chapter highlights the geophysical characteristics of the study area that makes it prone to changes and variability in climatic conditions. The section also highlights the socio-economic conditions of the study area that creates a condition of vulnerability among the people and specifically small irrigation farmers. The chapter therefore highlighted on the location and size of the region, the vegetation, demographics characteristics, social and economic structure of the region which has a bearing on climate change and the livelihood and adaptation strategies of farmers in the region.

4.2. LOCATION AND SIZE

The UER was curved out from the former Northern Territories on July, 1st 1960 and later divided into present day Upper East and Upper West Regions in 1983. The UER is located at the extreme north-eastern part of Ghana, between longitude 00 and 10 West and latitudes 100 30”N and 110N and is boarded by Burkina Faso to the north, Togo to the east, the west and south by Sissala East District in the Upper West Region and West Mamprusi District in the Northern Region respectively. The region is made up of thirteen (13) districts and fifteen (15) political parliamentary constituencies with Bolgatanga as its capital.The region occupies a total land area of land area of 8,842 sq. km, translating into 2.7 percent of the total land area of Ghana thereby making it the ninth region in terms of land size (Blench, 2006; GSS, 2013). The region is marked by the line of the Gambaga Escarpment from West-East along its southern edge (Blench, 2006). Figure 4.1 shows the map of UER.

Figure 4.1 Map of the Upper East Region.



Source: (Department of Environment and Resource Studies (UDS), 2017)

4.3. VEGETATION, SOIL AND DRAINAGE

Ghana's natural vegetation is divided into six Agro-Ecological Zones (AEZs) based on the climate namely, the Forest Savannah Transition zone, Guinea, Sudan and Coastal Savannah zones, the Semi-Deciduous Forest and High Rain Forest Zones (EPA, 2002:52). But laube (2007) classified the bio-graphical features in West Africa into five by putting together the savannah zones and his estimation was that the savannah occupies about 60% of the surface of tropical Africa. Similarly Buah (1998) summarised these six AEZs in Ghana into two thus the Savannah of the north where the vegetation is prone to degradation and the rich forest lands of the south. The EPA (2002:52) describes the Sudan savannah as consisting of "*Short drought and fire resistant deciduous trees interspersed with open savannah grassland. Grass cover is very sparse and in most areas the land is bare and severely eroded"*. The UER therefore has been described by Blench (1999; 2006) as being semi-arid savannah, divided into Guinea savannah along its southern limits, grading into Sudan savannah above the escarpment. The natural vegetation is therefore described as the savannah woodlot dominated by drought-resistant trees and grasses that is susceptible to bushfire or scorched by the sun

during the dry season (GSS, 2013). The common tree species in the UER are Shea (*Vitellariaparadoxa*), Locust ('dawadawa') (*Parkiabiglobosa*) and Kapok (*Ceibapentandra*) with a ground cover of perennial grasses such as *Andropogongayanus.* Further north, the dominant species are Baobab (*Adansoniadigitata*) and Whitethorn (*Faidherbiaalbida*) (Blench, 1999; 2006; GSS, 2013).

Blench (2006) described much of the land area of the UER as an 'extreme anthropogenic landscape'. The natural fauna of the region has been severely depleted and almost every tree species except *Parkia* and *Vitellaria* systematically has been eliminated from the farming areas (Hunter 1967; in Blench, 2006:2). Bush fires which are common in the area have also greatly contributed to eroding the natural vegetation of the region by reducing all large tress such that even in remote areas young tress dominate the natural vegetation (Blench, 2006). According to him, a tiny proportion of the original biodiversity in the region has been conserved in settlements where the practice of conserving sacred forest is prevalent. Human interface with ecology is therefore a significant factor contributing to the near semi-arid conditions in the UER (GSS, 2013).

Blench (2006) in his studies in the UER noted that an up-to-date vegetation figures for the region were not available. He therefore used estimates put together by FAO/IFAD identification mission in the UER in 1989 as a basis for analysing vegetation and land use in the region (Table 4.1).

Table 4.1 Vegetation and Land use in Upper East Region

Category of use	1978 Satellite Imagery (‘000ha)	1989 Preparatory Mission Estimate (´000 ha)	Derived Mean (´000 ha)	(%)
Tree Savannah	134	134	134 to 153	15.2 to 17.3
Shrub Savannah	222	222	222	25.1
Grass Savannah	26	26	26	2.9
Fallow	206	128	167	18.9
Cultivation	223	300	261.1	29.6
Plantations	5	5	5	0.6
Wet Bottomland	51	51	51	5.8
Other	18	18	18	2.0
Total	884	884	884	100.1

Source: (IFAD, 1989; in Blench, 2006:3)

Though the original IFAD/FAO commissioned the study about two decades ago, these figures are still relevant in analysing land use and vegetation change in the region. From the table above it can be observed that area for cultivation from the satellite imagery in 1978 increased from 223 (‘000ha) to 300 (‘000ha) in 1989 based on the preparatory estimates of the mission and a corresponding reduction of fallow land from 206,000 to 128,000 between 1978 and 1989. This scenario clearly indicates that human activities and population increase has exerted a considerable pressure on land needed for cultivation. This trend is therefore a factor accounting for land cover change in the region as woodlands and grasslands are converted to croplands to meet food production requirements. To combat the fast depleting natural vegetation of the region some efforts have been made by the Forestry Commission through local plantations of neem, teak and cassia and in recent time cashew has seen a massive promotion by the Forestry Commission due to its soil improvement qualities (Blench 2006). Table 4.1 shows forest reserves in the UER.

Table 4.2 Forest reserves in the Upper East Region

Forest District	Administrative	No. of reserves	Km^2
Navrongo	KasenaNankana and Builsa	17	72.5
Bawku	Bawku East and West	8	29.2
Bolgatanga and Bongo	Bolgatanga and Bongo	3	45.5

Source: (Sakaa, 1998:7, in Blench, 2006:3)

In spite of the Forestry Commission's efforts to create forest reserves there is still pressure from the local population in the region for the forest reserves to be opened for them to harvest trees for firewood (Blench, 2006). Also the recent harvesting of rosewood in commercial quantities in the region has further contributed significantly to depleting the natural vegetation. The combined effect of these activities is that it is going to exacerbate and seriously threaten the livelihoods of the people in the region who are already suffering from the harsh impact of climate change (citifm, 2017).

Ghana's geology is predominately of the pre-cambrian rocks comprising the Dahomeyan and Birrimian systems (Bates, 1962 in EPA, 2002).The Birrimian system is the source of most of the minerals of Ghana, and it underlies nearly all the forest zone and the entire landscape of the Northern, Upper East and West Regions. The Birrimian system is made up of granites consisting of geosynclinal sediments and partly granitized volcanic rocks (EPA, 2002). The vegetation and climate of Ghana primarily determines her soil formation. The soil of the region is made up of the upland soil developed from granite rocks (RCC, 2003). The region lies within the Guinea and Sudan Savannah belt and the common soil types are Lixisols, Acrisols, Luvisols, Gleysols and Lithosols (EPA, 2002; RCC, 2003). The soils are generally shallow and low in inherent soil fertility and weak with low organic matter content. The soils are mostly coarse textured. The Valley soil range from sandy candy loams to salty clays. They have higher natural fertility, but more difficult to work and prone to seasonal water logging and floods (RCC, 2003; GSS, 2013). The inherent low fertility of the soils is captured aptly by EPA (2002:58) in the following quotation.

> *Most of the soils are developed on thoroughly weathered parent materials. They are old and have been leached over a long period of time. As a result, their organic matter content is generally low. Their buffering capacity as well as caution exchange*

capacity is also low since their predominant clay mineral is kaolinite. The soils are consequently of low inherent fertility. The two most deficient nutrients are nitrogen and phosphorus particularly because of the very low organic matter content. The build-up of any amount of organic matter is further constrained by the regular burning of crop residues and/or competitive use of these residues for fuel, animal feed or building purposes. The low vegetative cover during the long dry season also renders most of the soils susceptible to erosion during the rainy season. This, in turn, exacerbates the low fertility problem.

High temperatures as a result of the changing climate have also been noted as a contributory factor to the low soil fertility in the region (Derbile, 2010). The region is drained mainly by the White and Red Volta and Sissili Rivers (RCC, 2003).

4.4. CLIMATE

The climate of Ghana is largely the monsoon type characterised by two air masses. The climate of the UER is characterized by conditions in the synoptic station in Navrongo. The climate of the region is characterized by semi-arid conditions (EPA, 2002; Blench, 2006, Derbile, 2010). The influence of two air masses oscillating thus the North-East trade and South-West monsoon winds over the region accounts for the two main seasons, the wet and dry seasons. The North-East trade winds emanating from the Sahara desert blows throughout the whole West African sub-region. The winds normally occur between November and late March, reaching its peak in December-January. The season is known as the 'Harmattan' and it is characterized by a dry spell with dry, cold and dusty winds (DGRD, 1992; Yaro, 2004; Derbile, 2010; Nana, n.d). After the North-East trade winds, the South-West monsoon winds originating from the Atlantic Ocean push northwards across the country and then drifts southwards carrying with it warm air masses. The warm air mass carried by the winds brings with it wet, humid and moist conditions resulting in torrential rainfall and in some instances thunderstorms. The South-West monsoon winds occur between April and September reaching its peak in July-August (DGRD, 1992; Yaro, 2004; Derbile, 2010; Nana, n.d, Krishnamurti et al. 2012).

In terms of rainfall the northern part of Ghana, unlike southern Ghana which experiences a bimodal rainfall pattern has a unimodal rainfall regime lasting 5-6 months from April-September and 6-7 months from October-April is the drought period in the year. This means

that the region has a single rainy season. The region also relies mainly on rain-fed agriculture and with limited irrigation development and maintenance the livelihood of many people is threatened. The rainfall is often erratic and patchily distributed. The impact of this is that farmers often plant seeds a number of times before the rains set in reliably, and with a region which is already faced with high poverty and unemployment rates, the scenario poses a major problem for the development of the region especially among smallholder farmers. In addition to this, farming being the main occupation of the people and agricultural production relying on rain, a limited irrigation infrastructure creates a situation of underemployment among the population. This situation creates a situation of livelihood vulnerability, which has adverse implications for the overall development of the region (Derbile, 2010). The annual rainfall for the region is estimated at around 700-1200mm with an annual average of 921mm (Blench, 2006) and falling mainly between May and October (RCC, 2003).

The observations by Blench (2006) and other rainfall patterns in the study areas are in consonance with meteorological data collected from the Vea and Manga stations in the Upper East Region (Figures 4.2 and 4.3). Rainfall data was collected between the years 1990 and 2016 for Vea station; the data set for 2012 was missing and therefore eliminated in the analysis, and for Manga the data was collected between the years 1980 and 2016[11]. The data gathered from the two meteorological stations indicated a decline in annual rainfall variability and a decline in annual rainfall trend in both stations (Districts). The rainfall variability however showed fluctuations between years even though the trend showed a decline in annual rainfall in proceeding years as depicted in the figures below.

[11] In finding out why the Vea station records were as recent as 1990, the meteorological officer in charge of the region at the time told me that getting permanent staff for the station was difficult from 1990 to 2016; the data was much consistent, which is why the data he gave me started from that period. He added that rainfall variability in the Vea station in the Bongo district was not markedly different from the other stations in the region.

Figure 4.2 Total annual rainfall for Vea station in Bongo District

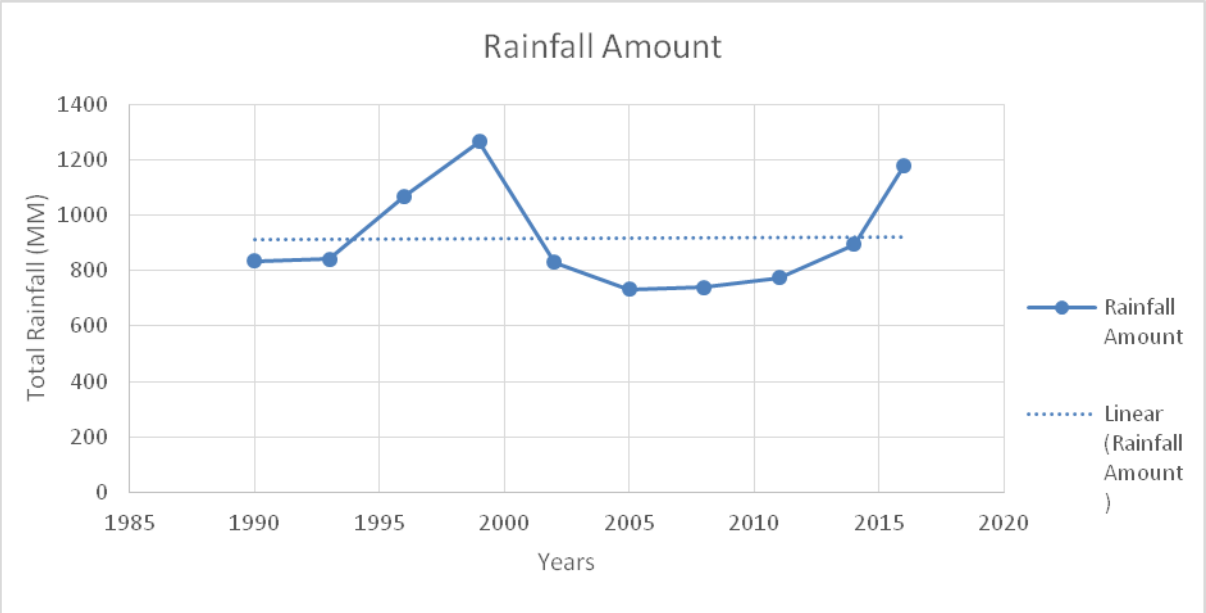
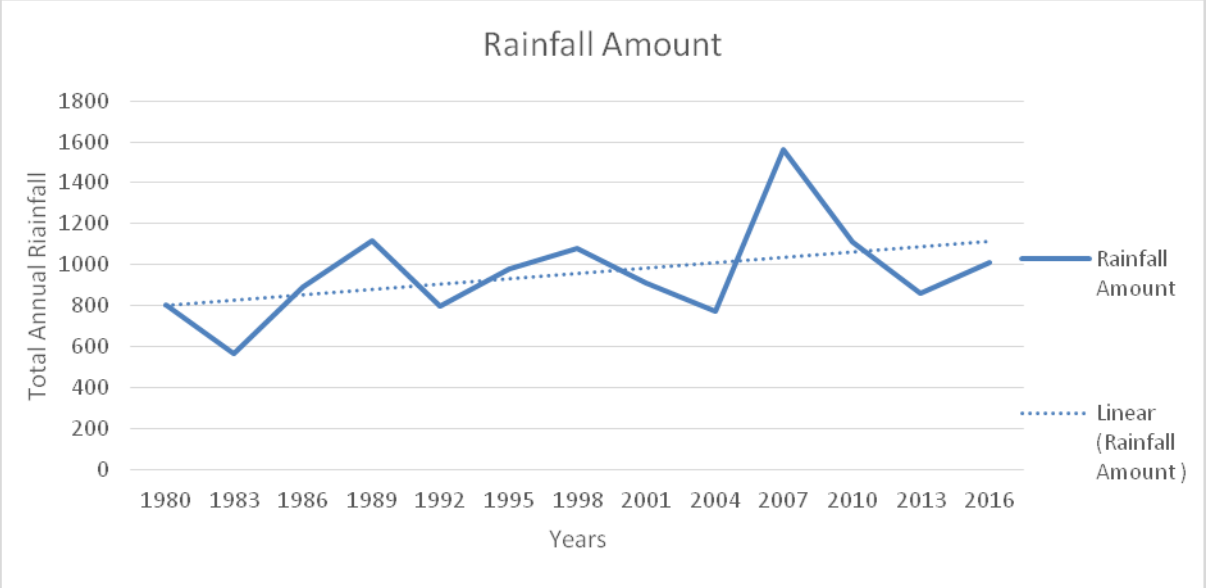


Figure 4.3 Total annual rainfall for Manga station



With regards to temperature the annual average temperature recorded in the dry season from the Navrongo synoptic station is 28°C from December to February at minimum limits and the highest at 45°C between March and May.

Data from two meteorological stations in the region, that is Vea Meteorological Station in Bongo District and Manga Meteorological Station serving Bawku West District, buttresses the scenario in the Navrongo synoptic station. The temperature figures indicate that both the mean annual minimum and maximum temperatures have being increasing steadily in the

region since 1981 to 2014 in the Bongo District and 1981 to 2015 in the Bawku West District. The changes however come with fluctuations between the years, and years for which full data could not be captured have also been eliminated (Figures 4.4, 4.5, 4.6 and 4.7). The mean annual temperature for Bawku West Districts was 27.9 °C. The lowest and highest annual temperatures within the period (1981-2014) in Bongo District were 20.9°C and 36.0°C and occurred in 1994 and 2011 respectively while for Bawku West District within the period (1981-2015) the lowest and highest annual temperatures were 19.1°C and 36.7°C and occurred in 2008 and 2010 respectively. The highest temperature for Bongo District and Bawku West District within the above stated periods were recorded in March and April with mean values of 41.1°C and 40.2°C respectively for Bongo Districts and 41.9 °C and 41.5 °C respectively for Bawku West District and the lowest temperatures within the same stated periods for the two study districts occurred in January and December. In Bongo District the mean values were 16.9°C and 17.8°C respectively and for Bawku West District the mean values were 13.1°C and 14.0°C respectively. The associated high temperatures in the region comes with its own effects in that it leads to high evaporation of water during the day time which reduces the water levels in the reservoir of the dams meant for small-scale irrigation scheme farming and this affects crop production and outputs in the irrigation schemes thereby hampering the livelihoods of many small-scale irrigation scheme farmers.

The humidity of the region is low. The relative humidity ranges between 30% and 80% in the dry and wet seasons respectively (RCC, 2003; Blench, 2006). The very high temperatures occurs just before the onset of the single rainy season in March and the low temperatures experienced in December is as a result of the drying up of the vegetation by the desiccating winds from the Sahara. The dry spell during this period creates a conducive atmosphere for bush fires and the burning of the vegetation, which has become an annual ritual. This situation also has repercussions for the environment, climate and agricultural activities thereby impacting negatively on livelihoods (RCC, 2003).

Figure 4.4 Annual mean minimum temperature for Vea in Bongo District (1981-2014)

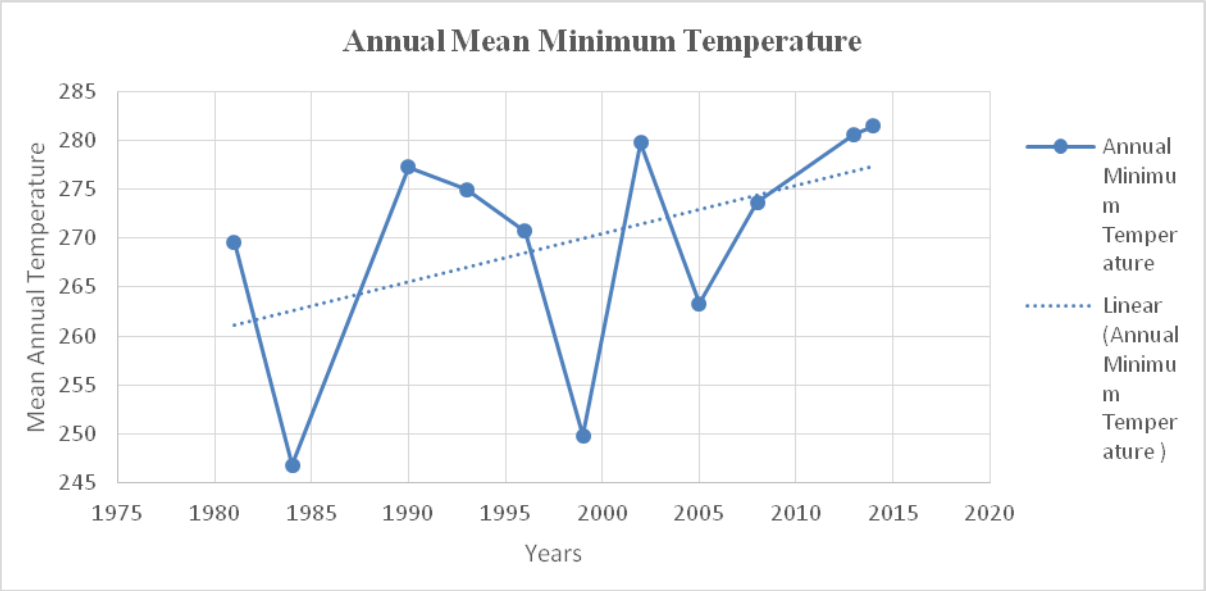


Figure 4.5 Annual mean maximum temperature for Vea in Bongo District (1981-2014)

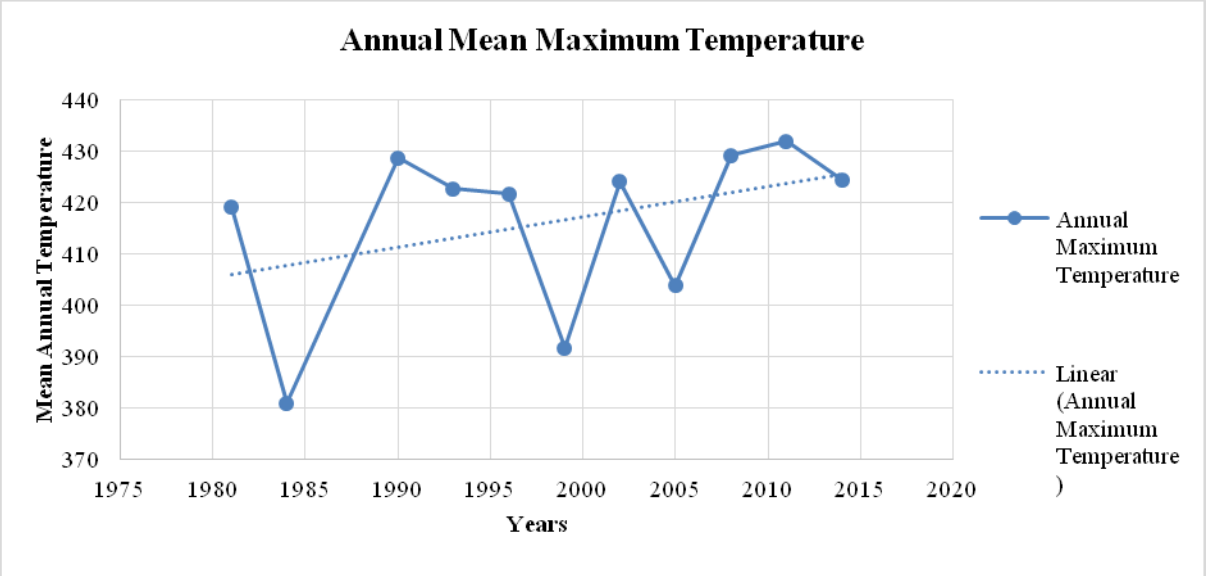


Figure 4.6 Annual mean maximum temperature for Manga representing Bawku West District (1981-2015)

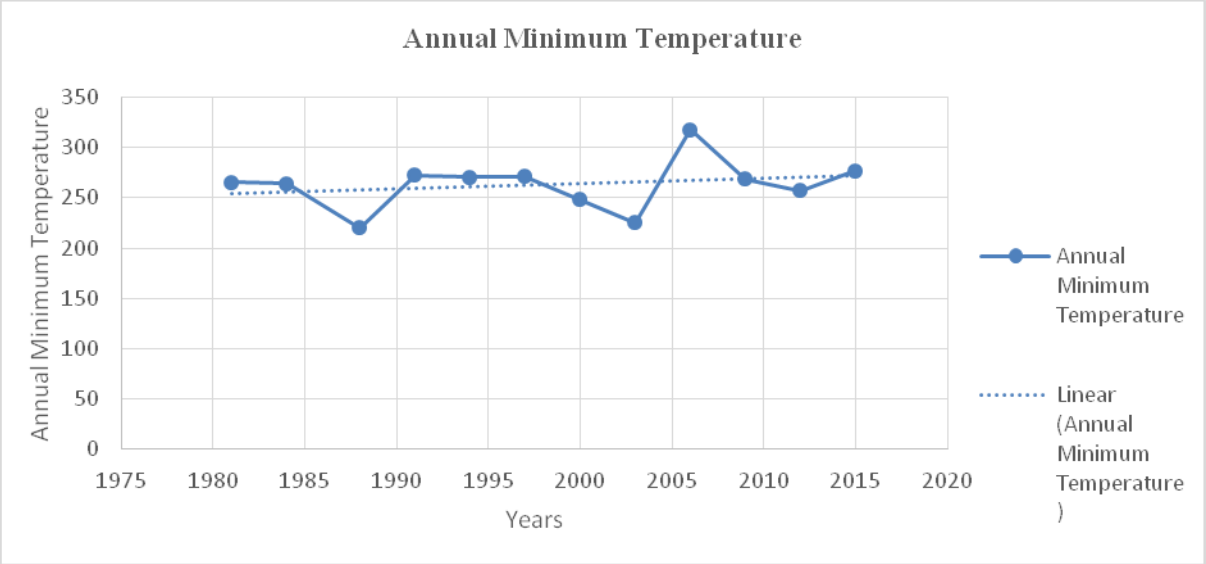
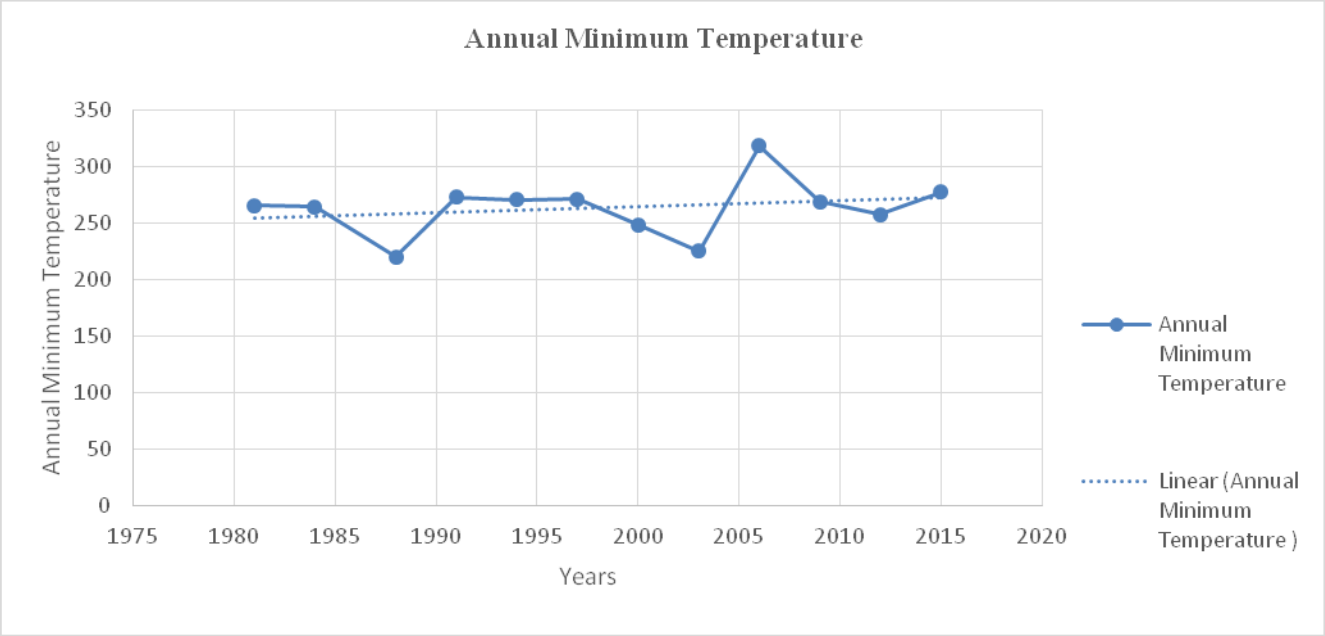


Figure 4.7 Annual mean minimum temperature for Manga representing Bawku West District (1981-2015)



4.5. DEMOGRAPHIC CHARACTERISTICS

In pursuit of development in any given geographical area, demographic issues especially population dynamics is very important. The population of UER in 2010 was 1,046,545 which was an increase of 13.7% from the 2000 population which was 920,089. The Region's population of 1,046,545 is not evenly distributed among the nine Districts which hitherto existed prior to 2012. The Districts currently stands at 13 districts. Table 4.0 shows that five

Districts which have populations of 100,000 or more (ranging from 109,944 for the Kassena-Nankana Municipal District to 217,791 for the Bawku Municipal District) (GSS, 2013). Kasena-Nankana West District has the smallest share of the Region's population (6.8%) followed by Bongo District (8.1%) and Bawku West District (9.0%) (GSS, 2013).

In terms of population vis-à-vis the national population the region is ninth. The region has a population growth rate of 1.2% as compared to the national population growth rate of 2.5% which is the lowest regional growth rate recorded (GSS, 2013). The population density of the region stands at 118.4 Persons per square kilometre higher than the national density of 103.4 persons per square kilometre making the region the fifth most densely populated region in Ghana. The population density therefore puts a lot of pressure on the scarce arable land and water resources needed for rain fed agriculture and dry season farming. This situation largely accounts for the spiral nature of poverty in the region since livelihoods are affected by large population density in addition to poor and unfavourable climatic conditions. The population by district is shown in table 4.3 below.

Table 4.3 Population by District of the Upper East Region

District	Population	Proportion Share of Regional Population
Builsa	92,991	8.9
Kassena- Nankana West	70,667	6.8
Kassena- Nankana Municipal	109,944	10.5
Bolgatanga Municipality*[12]	131,550	12.6
Talensi Nabdam*	115,020	11.0
Bongo	84,545	8.1
Bawku West	94,034	9.0
Garu- Tempane*	130,003	12.4
Bawku Municipality*	217,791	20.8
Upper East Region	**1,046,545**	**100.0**

Source: (Ghana Statistical Service, 2010 Population and Housing Census).

[12] *These are newly carved districts and it should be noted that other districts have been added but the official census has not yet been carried out.

4.6. SOCIAL STRUCTURE AND RELATIONS IN UPPER EAST

This section looks at social structure of the Upper East Region and the significant and diverse factors, which shape the social organization and patterns of relations contributing especially to resource allocation and knowledge flows. The section begins by looking at the social structure of Ghana and the region and the social networks and relations and analysis of the social structure that contributes to maintaining the social life of the people, which invariably has a bearing on their economic well-being as well as the maintenance of social cohesion. Issues to consider in the section include the kinship and family system of the people, the religious institution, ethnicity and the institution of chieftaincy. The central issue in the section is to discuss how these institutions have evolved and continue to be relevant over time in contemporary Ghana where the traditional social structure has had to live side by side with contemporary development during and after colonialism and the current democratic dispensation the country is enjoying after independence. The section also highlights how the traditional social structure is crucial in socialization and local knowledge flows, as well as how they negotiate to provide resources for individuals to engage in livelihood activities that are important in dealing with the vulnerability posed by climate variability and change.

To begin with, Ghana has a long history of maintaining her traditional socio-cultural institutions and shared values. Though these social-cultural institutions and values have come under threat due to modernization, they continue to hold on their own in most activities in Ghana (National Research Council, 1993). At the height of the Ghanaian society is the family institution maintained through a series of kinship networks and marriage. The family is seen as an important social institution in Ghana. It is important in the communal structure of the Ghanaian society and considered the bedrock of all social life (Van de Walle and Meekers, 1994; Gyekye, 1996). The lineage ties often determine a wide range of behaviour ranging from marriage to transfer of property. The basic social structure of the people in the UER is kinship ties, which emphasise the importance of the family. The importance of the family in Africa, and for that matter Ghana, is seen in a quote by Siegel (1996:1) on his interaction with a senior Zambian bureaucrat who advised him in these words "*don't be fooled, here in Africa, the family is first. This will never change*". The family in Ghana is based on the lineage system through a network of kinship ties. When someone speaks of the family, the person is referring not to the nuclear family (comprising of father, mother and children) but the extended family which is made up of a large number of blood relatives who trace their

descent from a common ancestor and are therefore bonded by a sense of obligation to one another (Gyekye, 2006). The extended family system in Ghana, which is based on kinship and lineage ties, is identified with two main family systems through social relations among family members (Lockwood, 1995; Nukunya, 2016). The two main systems on the basis of lineage ties are the matrilineal system where the lineage of family members is traced through the female line of descent and the patrilineal system where family members trace their lineage through the male descent (Lockwood, 1995; Nukunya, 2016). The patrilineal system is practised widely in the UER.

The kinship structure and economic relation shaped by both culture and religion play an important role in livelihood activities in Ghana (National Research Council, 1993). The family in the UER, and in Ghana as a whole, functions as a socializing agent in the sense that the family transmits traditional values and knowledge to its younger ones (Gyekye, 1996). The transmission and accessibility of local knowledge and internalization for sustainable livelihood in UER is done at the household level, which is the basic unit of the family, providing first hand environment for learning. It is seen as a major source and means of sustaining indigenous knowledge and production systems at the household level (Derbile, 2010). The family is also the basic unit of production and distribution and serves as the main agent of social control in Ghana (Van de Walle and Meekers, 1994).

The family structure, kinship ties and social relations play an important role by providing a network of mutual support for its members in Ghana (National Research Council, 1993). The family therefore becomes a mutual aid society in which members have both the obligation to help others in the family and the right to receive help from them in times of need. Family members are therefore mandated to support each other in times of difficulties such as funerals, ill-health and during festive times such as marriage ceremonies and naming of infants which is often overseen by the family elders. The family elders also serve us arbiters during disputes and domestic quarrels to maintain harmony in the family (US library of Congress, n.d). The family is not only the basis of social organization but is also the means of social security in old age both financially and emotionally (Van de Walle and Meekers, 1994). It means that younger ones who were socialized and taught skills and knowledge in entrepreneurial and other livelihood activities are obliged to take care of their aged family members. The family institution is the therefore the place where communal values such as solidarity, mutual helpfulness, concern for the well-being of members and interdependence are well expressed. An important resource, which is at the heart of this study, is land, and the

access to this resource is through the family and kinship relations. Land in Ghana is ordinarily the property of the lineage and as a fundamental property in Ghanaian societies, it is communally owned (Gyekye, 1996). In Ghana gender and kinship relations play pivotal roles in the determination of land rights and production relations (Runger, 2006). Land belongs to the ancestors and is held in trust for them and administered by family elders to members of the kinship group to work on. It is inherited by members of that unit (US library of Congress, n.d). Also in Ghana approximately 80% of land is held under customary land tenure systems, though they vary significantly from ethnic group to ethnic group and from community to community (Minkah-Premo and Dowuona-Hammond, 2005; Oba, 2011; Higgins and Fenrich, 2011); but one common thing is that rules of customary land use are based on kinship and other social relations with a complex scheme, but nonetheless are clearly defined rights that are transmitted from generation to generation (Ubink, 2009; Higgins and Fenrich, 2011). The above analysis shows the importance of family and kinship ties in mediating livelihood activities and the socialisation of younger generation in livelihood activities through the transmission of knowledge and skills because access to land in the UER where people depend on the exploitation of land is based on your membership to the kinship group or lineage.

Another issue of the social structure of Ghana, including the UER, which is important for livelihood and development is ethnicity. The UER is made up of diverse ethnic groups who generally live peacefully with one another. The main ethnic groups that are indigenous to the region are the mole-Dagbon, Grusi, Mande-Busanga and Gurma. Among the Mole-Dagbom, the Nabdam, Kusasi, Tallensi, Nankani/Gurense and Builsa are significant. The significant other sub groups are the Kasena among the Grusi, the Busanga among the mande-Busanga and the Bimoba among the Gurma (GSS, 2013). The ethnic diversity and their peaceful co-existence is a catalyst for the development of the region and the various communities because it enables diffusion of knowledge through knowledge sharing and this goes a long way to enhance economic activities including farming. The peaceful co-existence and tolerance among these ethnic groups also allow people to go about their day-to-day activities. Ethnicity in the region is also important because power and authority is derived by belonging to a certain ethnic group and family. The power to govern in the communities and make decisions emanates from belonging to a particular ethnic group and family. This therefore brings me to another institution that is crucial for advancing livelihood activities and development. This institution is the chieftaincy institution.

In Ghana chiefs emerged as natural leaders and were the founders and by extension the father of his traditional area and was respected because he was seen as the mouth piece and leader of his people (Abotchie, 2006). In Ghana several definitions have been made as to who is a chief, and various legislative instruments have also sought to define and give legitimacy to the chieftaincy institution in Ghana. The current laws that define and give legitimacy to the chieftaincy institution are Article 277[13] of the 1992 Constitution of the Republic of Ghana and the Chieftaincy Act 2008, Act 759[14]. In simple terms, Brobbey (2008: 168) said that the title "chief" is generally used to refer to the head, leader or person in charge of a group or organization. He further said that a chief refers to a clan or tribe head within the chieftaincy institutions (Ibid). The two definitions, which are invariably the same, show that the family, which is the basic unit of socialization, is also the means through which one qualifies to hold the high position of a chief in any part of Ghana. The UER has seventeen Paramount Chiefs representing the various traditional councils. The Paramount Chiefs are supported by Divisional Chiefs and several Sub-Division Chiefs and Queenmothers (GSS, 2013). The chieftaincy institution in Ghana generally has had its fair share of controversy. In pre-colonial Ghana the chieftaincy institution was the nucleus for performing executive, legislative, judicial, military and religious functions (Abotchie, 2006). The advent of colonialism in Ghana saw the institution being linked to the politics of the country. The era saw the diminishing influence and functions of chiefs as a good part of their functions were taken away from them and their powers curtailed, this was further exacerbated after Ghana gained independence in 1957 through the establishment of various institutions of state, which hitherto were performed by chiefs (Abotchie, 2006). This notwithstanding, the institution has endured and chiefs still perform important roles in the development of their communities. Brobbey (2008) in stressing the importance of the institution acknowledged that studies have shown that about seventy percent of Ghanaians still adore and cherish the chieftaincy institution and as such have been given due recognition under the 1992 Constitution of Ghana. According to various authors (Gyekye, 2006; Abotchie, 2006; Brobbey, 2008, Nukunya, 2016) chiefs among other things perform severally functions to enhance development. These include maintenance of law and order in his jurisdiction; they perform

[13] The 1992 Constitution says that a "chief" means a person, who, hailing from the appropriate family and lineage, has been validly nominated, elected or selected and enstooled, enskinned or installed as a chief or queenmother in accordance with the relevant customary law and usage.

[14] The Chieftaincy Act 2008, Act 759 says that a chief is a person who, hailing from the appropriate family and lineage, has been validly nominated, elected or selected and enstooled, enskinned or installed as a chief or queenmother in accordance with the relevant customary law and usage.

the judicial role of reconciling people through the settlements of disputes, the prevention of crime and punishing people, who commit offences seen as hateful to the gods such as stealing, adultery, rape and so on. He is also the link between them and the ancestral spirits hence performs a religious function, which is crucial for the functioning of the community and the environment. They make sure that places reserved for the gods are preserved so as to maintain a good environment which is crucial in dealing with issues of environmental degradation and punish those who go against such laws. The chiefs also perform rituals on important festive occasions such as festivals to solicit for the help of the ancestral spirits for the peace, progress and prosperity of individuals and the state. Chiefs also contribute to the economic development of their communities by mobilizing for the initiation and execution of development projects especially during festivals and through other endowment funds. As custodians of the land they are also important in providing resources to enable individuals carry out various livelihood activities. In a nutshell, chiefs embody the moral and ritual purity of the people and a means to help maintain moral and social control in their communities and therefore are able to control both the individual and collective actions of their people. The strong traditional institutions could therefore serve as perfect leadership grounds for drawing support activities to combat climate change and climate change adaptation mechanism.

Another important institution, which plays a role in ordering the behaviour of people in the UER is the religious institution. Religion plays a critical role in how people behave and relate to each other in their communities. Religion is an essential aspect of Ghanaian culture and permeates all aspects of Ghanaian life and to a large extent determines every aspect of life (Gyekye, 1996). The dominant religions in Ghana as well as UER are Christianity, Islam and African Traditional Religion (ATR). The breakdown of these religions in UER is as follows ATR (27.9%), Islam (27.1%) and Christianity (41.7%). The heritage of Africa is intensely religious and all actions are inspired by religious beliefs and all activities from ploughing the land, cultivating, harvesting and acquisition of land is inspired by religion (Gyekye, 2006). Even though Christianity and Islam emerged in Ghana in the seventieth and early eighteenth century, ATR has survived in the scheme of livelihood issues and the practice is still handed down from generation to generation in Ghana and traditional knowledge of various livelihood practices is still handed down to generations through a process of indoctrination and socialization (Gyekye, 2006). As noted by (Olupona 2006; Schuman et al. 2018) ATR speak directly about nature because of that it is expected that ATR beliefs will influence a person's adaptation to climate change. Schuman et al, (2018:3) therefore said that "perceptions of

climate change risk and vulnerability, along with religious conceptualizations of nature and the human-nature relationship, influence the feasibility and acceptability of adaptation planning, policy-making and implementation".

ATR therefore plays a significant role in how knowledge is handed down from generation to generation in the UER and religious norms and values should be critical in planning climate adaptive strategies in the region. This is in line with a conclusion by Nunn et al, (2016; in Schuman et al. 2018:3) on the study of the Pacific Island Countries that a high degree of spiritual engagement with nature (based on religious beliefs) creates possibilities for the communication of adaptive measures which are acceptable to the indigenous communities.

4.7. ECONOMIC STRUCTURE OF THE REGION

In the Upper East Region and the whole of Ghana Agriculture is the mainstay of the economy. A large proportion of the population especially in the rural areas, which covers much of the land of Ghana, rely on agriculture for their livelihoods. It dominates in employment in the UER and the whole of Ghana. About 80% of the economically active population in the UER engage in agriculture and nationally employs more than half of the population. The agricultural sector is the major foreign exchange earner contributing over 55%. In 2018, the sector contributed 19.7% to the Gross Domestic Product (GDP) (GSS, 2019). The two dominant agriculture related activities are crop production and animal production. Fisheries and cash crop production such as cotton and cashew are equally giving attention (GSS, 2013). The sector is a major source of raw materials for manufacturing industries both within Ghana and outside the country.

Over the years, and in spite of its contribution to the economy and livelihoods of people in UER and Ghana, agriculture has not grown as expected as a result of declining investments in the sector by successive governments. For instance the growth of agriculture declined from 6.1% in 2017 to 4.8% in 2018 and its share to GDP also declined from 21.1% in 2017 to 19.7% in 2018 (GSS, 2019). This scenario, coupled with other stressors such as climate change in Ghana and a growth rate of 2.5%, will compromise food security, rural incomes, employment and the development of the entire country, especially in rural areas where livelihood activities are based on agriculture (EPA, 2002, Derbile, 2010). Pressure on arable land will also increase thereby exacerbating poverty. In an effort to improve and develop the sector, the Government of Ghana (GoG) has rolled out various programmes and projects

under various policies in recent years. Among these are Vision, 2020, GPRS I and II and in 2017 Planting for Food and Jobs (PFJ) and Rearing for Food and Jobs (RFJ), all geared towards addressing the declining growth in the Agricultural sector, and the results have been mixed. Many farmers have embraced the RJF which is to address meat deficit in the country through the rearing of animals and PFJ which targets food crops and cash crops to increase yields and also to produce more cash crops for export, but the sector still declined in 2018. The multiple stressors still faced by the sector include climate variability and environmental degradation, which partly accounts for this decline (derbile, 2010).

In the UER the rainfall is unimodal meaning that a majority of subsistence farmers cultivate under a single rainfall which increases poverty, and nearly 90% of the Region is under rain-fed farming (Kasei et al., 2010). The high temperatures, erratic rainfall and eroded soils means that the top soils which contain nutrients and organic matter pose extreme challenging conditions for farmers in the region. This leads to lower crop yields thereby affecting the livelihoods of many people (Blench, 2006).

In order to deal with these challenges, irrigation development was seen as an option. Small-scale water reservoir development in the UER has its roots from the colonial period. Dry season water needs of the people led to their development and the proceeding years have seen donors take interest in the rehabilitation and construction of new schemes (Tappan et al. 2016; Snyder et al. 2013). Blench (2006) corroborated this view when he stated that in the 1950s and 1960s irrigation schemes were vigorously pursued in the UER with major ones being the Vea Project in Bolgatanga covering 850 hectares and the Tono Project in Navrongo covering 2,490 hectares. The UER within that same period benefitted extensively from dugouts and small dams for trapping water for irrigation purposes, human use, and livestock watering as well as for fish farming in the dry season. He further stated that these small dams and dugouts were later rehabilitated and structured to small-scale irrigation schemes with support from International Fund for Agricultural Development (IFAD) projects such as Upper Regional Agricultural Development Programme (URADEP) and Land Conservation and Smallholder Rehabilitation Project (LACOSREP) and projects by the World Bank. The UER is therefore believed to have over 240 dams and dugouts as at 2006 and presently it is estimated at 149 small reservoirs and 129 dugouts serving farming and domestic purposes and as at 2013 a total area of nearly 9 km^2 was irrigated by these schemes (Tappan et al. 2016; Snyder et al. 2013). The number is most likely to increase with a GoG policy through the Ministry of Special Initiatives to carry out extensive construction of dams in the northern

part of Ghana. Despite the construction of these dams to enhance dry season farming, the region vulnerability to climate variability and change makes it susceptible in its quest to enhance sustainable livelihoods of majority of farmers. This is in line with the IPCC (2007) assertion that in Africa by 2020, between 75 and 250 million people are projected to face more severe water shortage as a result of climate variability and change. It is also likely to reduce the supplies of water for irrigation. Climate variability and change is likely to compromise agricultural production and food security with a reduction of crop yields by up to 50% and crop revenues by as much as 90%.

Industrial activity in the Region is not well developed with only the cotton ginnery at Pusu-Namongo (near Bolgatanga) being operational. Most of the older industries established after Ghana's independence mostly in the 1960s such as the Zuarungu Meat Processing and Pwalugu Tomato Canning Factories to take advantage of raw materials in the region are not operational and have been put up for divestiture (GSS, 2013). This means that majority of the populace have to still rely on agriculture which is open to the vagaries of the weather for their livelihood.

Mining and quarrying are the two main extractive industries in the region (GSS, 2013). The quarrying industry is more developed and vibrant with two active commercial quarries operating in the region. These are the Upper Quarry Limited situated at Pwalugu and the Granites and Marbles Company Limited found in Tongo. The quarries produce granite chippings and cut rocks in the shape of bricks respectively for the local construction industry and for export (GSS, 2013).

The gold mining industry in the region on the other hand is beset with challenges and it is not strongly developed. Nangodi was an area in the region where gold mining was undertaken during the colonial era but was discontinued in 1930 (GSS, 2013). In recent times small-scale artisanal gold mining referred to in the local parlance as "galamsey" (gather and sell) or "alakpikiri" takes place in mostly the Nabdam and Talensi Districts. The unregulated nature of the mining activities has led to a lot of environmental destruction. Manganese deposits have also been reported to exist in Duusi and Nangodi in the Nabdam Distict (GSS, 2013). This gives an indication that if the mineral deposits of the region are well developed it can serve as an alternative source of livelihood for people in the region.

The strength of the region lies in her small-scale industries mostly in the areas of arts and crafts. These industries strive well in the region because of the presence of inputs locally and

the fact that the practice involves the use of simple indigenous technology. Areas of specialization in these industries include wood carvings, leather works, pottery, basketry, straw works and smock weaving. A key characteristic of these cottage industries is that it is based on traditional talent and skill and is more labour intensive (GSS, 2013). The industrial related activities in the region suggest that it could provide a medium of sustaining alternative livelihood outcomes through value addition. The craft industry in particular is an important source of livelihood diversification in the region which if developed can be a major source of income both domestically and internationally for the crafts men and women.

The Region is not left out when it comes to sites and scenes of ecotourism. Most of these sites are managed by the communities and the Ghana Tourism Authority. These sites draw in revenue for the local community thereby boosting the local economy. Notable among these ecotourism sites attractions in the Region are the Paga Crocodile Pond, the Gbewaa shrine and the Kulungugu Bomb site, where there was an attempt on the life of Dr. Kwame Nkrumah, Ghana's first President (GSS, 2013).

Other tourism sites worth mentioning in the region are the three point elevation at Pusiga where Burkina Faso, Togo and Ghana converge, the Tengzug Shrine and Tongo hills. The Tengzug Shrine is believed to have the power to grant good luck and prosperity. Many people both indigenes and foreigners journey to Tongo to seek for spiritual favours and requests from the Tengzug shrine and this serves as a source of income to the local people (GSS, 2013). The development of tourism is crucial because it could help in livelihood diversification in the region and this can positively impact on the livelihoods of the people.

4.8. SUMMARY

This chapter looked at the profile of the UER taking into cognizance areas that have an impact on climate variability.

On vegetation, soil and drainage I showed that the region is occupied by the savannah which is prone to environmental degradation and low fertility and has generally been described as being shallow and low in soil nutrients and organic matter thereby making the vegetation susceptible to climatic variability and change. This makes the region an extremely 'anthropogenic landscape'.

Another issue discussed in this chapter is the climate of the region that does not support all year round farming. The region has two seasons, the dry and wet seasons, which supports just

one cropping season of about five months in a year, making the region vulnerable in terms of livelihood options since the region is mainly agrarian.

The population density of the region was also described in this chapter. The population density of the region stands at 118.4 persons per square km and makes the region densely populated since it is above the national average of 103.4 persons per square km. The population growth and density has really put a lot of pressure on the scarce natural resources in the region especially on arable land which majority of the people depend on for their sustenance as well as water for dry season irrigation farming and this largely accounts for the pervasive poverty in the UER. The population growth and density has also been a key factor in man-made (Anthropogenic) cause of deforestation and environmental degradation which contributes significantly to climate change in the region.

In this chapter, I also highlighted the fact that the social organization of the region and patterns of relations contribute to resource allocation and knowledge flows, especially local knowledge. The main driver of these knowledge flows lies in the family and kinship ties of the people. The family, I noted, is the main unit of socialization and is the main unit where resources are negotiated and allocated to family members for their livelihood activities which is critical in dealing with vulnerability posed by climate change.

Another area that took centre stage in this chapter was the economic issues. The region is mainly agrarian and employs over 70% of the active population in the region, especially in the rural areas. One significant issue is that the contribution of agriculture GDP in the region and the nation has being decreasing, putting the livelihood of the majority of the population in danger. The trend is largely due to low investments of successive governments in the agricultural sector. In 2017, the GoG has sought to invest in the agricultural sector and it is expected that the investment will boost the sector in the region especially with regards to dry season irrigation farming through the one village one dam policy of the government in the northern part of Ghana to augment which were built some decades back and later rehabilitated by IFAD, LACOSREP, URADEP and the World Bank.

Finally, the region also boasts small-scale industries, especially in the craft industry, namely pottery, leather works, basketry and smock weaving. These industries have contributed in diversifying the economy of the region and providing livelihood support to a number of people. Tourism I also noted is an economic venture in the region, which contributes to the development of the region and provides a source of livelihood for people in the region

through ecotourism. This is because there a number of tourism sites dotted in communities in the region and when given the needed attention will go a long way to contribute the development of such communities thereby contributing to poverty alleviation in the region and spur up socio-economic development.

CHAPTER 5: SOCIO-DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS OF IRRIGATION FARMERS

5.1. INTRODUCTION

The socio-demographic and economic issues considered in this study include age, ethnicity, marital status, household size, level of education, religion, other occupation apart from irrigation farming, farming experience, farm size and mode of land acquisition. Some of these issues were cross-tabulated to provide a comprehensive understanding of how they influence farmers' access to land, perception of climate change, the causes of climate change and how it impacts on their adaptation strategies using their indigenous knowledge which will be discussed in chapter seven of this thesis.

Analysis of the background information is important because several authors, such as Maddison (2007), Gbetibouo (2009), Deressa et al. (2011), have argued that farming experience, age, gender, marital status and level of education play important roles on how farmers perceive climate change and also have a strong impact on how farmers may adopt (or not) to one or more adaptation strategies.

5.2. SEX, AGE AND FARMING EXPERIENCE OF RESPONDENTS

The study results included an analysis of the sex of the respondents. It was discovered that out of the 84 respondents selected for the survey, 55 representing 65.5% were males while the remaining 29 representing 34.5% were females. The sample size selection was random without any special consideration for males and females. This means that access to irrigation facilities for farming in the study areas and therefore the region has not been influenced by gender considerations.

The study also included an analysis of age distribution of the respondents (see Table 5.1). Age in this study is considered as one of the most important characteristics which influence how farmers perceive climate change, its causes and the indigenous measures they employ to deal with climate change impacts. The study considered farmers who have been involved in farming for at least 10 years and have in-depth knowledge and information on the changing environment and farming activities in the study area and in the irrigation scheme.

Table 5.1: Age and Sex Characteristics of Respondents

Age	Frequency	Percent
30-39	41	48.8
40-49	19	22.6
49-50	16	19.0
50-59	7	8.3
60 +	1	1.2
Total	**84**	**100.0**

Source: Field Survey (2017)

From Table 5.1 out of the 84 farmers surveyed, 48.8.1% of them were between the ages of 30-39, 22.6% had attained ages between 40 to 49 and 19.0% of them were found within the ages of 49-50 years. Besides, 8.3% of the respondents were within the ages of 50-59 and only 1.2% of them were 60 years and above. The above scenario shows that young people participate more in irrigation farming and as they grow older they give up the activity. The results of ages of respondents also suggest that people below the ages of 30 are not found among the irrigation farmers. This means that the youth are not interested in irrigation farming. On the other hand, people who have reached the age of 60 and above still engage in irrigation farming. This has implications for institutional memory since the older farmers can pass on their experience to the younger farmers. This scenario is further corroborated by the fact that when it comes to experience in farming in the irrigation scheme those who have experience up to 10 years dominate.

This brings me to the analysis of farmers' experience in irrigation farming which has a significant bearing on their knowledge on climate change, how it impacts on their livelihood and the indigenous strategies they may employ to deal with the impact of climate change. From the data gathered on the experience of farmers in the irrigation schemes, it emerged that out of the 84 farmers 51.2% of them have less than 10 years of experience in irrigation farming but have been engaged in rain-fed farming for more than 10 years, 41.7% indicated that they have 10-19 years' experience in irrigation, and 7.1% confirmed that they have 20-29 years of experience in irrigation. Judging from the above, it can be seen that more farmers have more than 10 years in farming but have less than 10 years' experience in irrigation farming, the reason for this could be due to the fact that majority of the irrigation scheme farmers were within the ages of 30-39 (48.8%) and might have just started irrigation scheme

farming in recent years while those within the ages of 50-60+ were in the minority (9.5%) which indicates that the younger generation dominate in the scheme. As noted earlier, these farmers will have in-depth knowledge on the changing climatic conditions in the scheme and also would have used several adaptation strategies to deal with climate change. This view is supported by Maddison (2007) who noted that experienced farmers in Africa are more likely to perceive that the climate is changing.

In order to give a clear understanding of those who participate more in irrigation farming, an analysis of age and sex was carried out. The analysis indicates a link between the two variables as suggested by a significance of chi-square statistics at 1% (P-value < 0.001). This means that both male and female farmers who are participating in the irrigation scheme have age differentials. From the results (Table 5.1), relatively young males (within age 30-39) participate more than their female counterparts within the same age brackets. Besides, the number of male participants decreases with increase in age. However, the proportion of female farmers is almost the same throughout the different age cohorts. This also means that females who engage in irrigation farming remains in the occupation throughout while male farmers tend to leave the occupation as they grow very old (above 60 years).

5.3. RESPONDENTS' ORIGIN AND ETHNICITY

The study examined the origin and ethnicity of respondents to determine whether the farmers were either born and bred in their respective communities or have migrated into their current locations. The results reveal that a majority (98.8%) were indigenes who were born and bred in the community while the remaining 1.2% (1 respondent) was a migrant, the low number of migrants in irrigation scheme farming could be due to the fact that lands in the scheme are owned by families in the community and accessibility to land for farming is controlled and mediated by the landowners so in the event of access to land indigenes tend to be favoured than the migrants.. Analyses of the number of years the respondents have stayed in the community were further carried out as shown in Table 5.2.

Table 5.2: Number of Years stayed in the Community by Respondents

Years stayed in the community	Frequency	Percent
30-39	62	73.8
40-49	11	13.1
49-50	5	6.0
50 +	6	7.1
Total	**84**	**100.0**

Source: Field Survey (2017)

From Table 5.2, out of the 84 respondents, 14.2% of them have stayed in the community for 30-39 years, 13.1% have stayed in the community for 40-49 years, 6.0% have stayed for 49-50 and another 7.1% stayed more than 50 years. The scenario indicate that people move out of the community and come back meaning they migrate and this has implications for knowledge diffusion, especially for farming purposes. This is because farmers who migrate and come back might return with new ideas and knowledge which can be employed in their farming activities and adaptation to climate change and also lead to knowledge transfer among the farmers.

Respondents in the study area (thus, Tanga) were found to have come from different ethnic groups which were considered as a demographic variable of the study. Observations and analysis showed that the major ethnic groups in the study area were Kusasi, Mamprusi and Bissa. The majority of small scale irrigation farmers were Kusasis (79.8%), followed by Mamprusis (15.5%) and Bissis (4.7%). This corroborates with data from the 2010 Population and Housing Census (GSS, 2012) that found these ethnic groups to be the dominant ones in the Bawku West District. The significance of this is that people with different ethnic backgrounds will have different cultures especially in their methods of production. This means that they will have different indigenous strategies regarding natural resource management and in their crop production process. This invariably, will lead to the adoption of different strategies through knowledge diffusion in adapting to climate change.

From the above analysis it can be deduced that origin and ethnicity can influence perceptions and adaptation to climate change. From the analysis of the few migrants in the district, it can be seen that the migrants have stayed in the communities long enough to be able to recognize the changes in climate and its impact on their production activities. Also, the period of staying in the communities is long enough for them to be able to integrate themselves with

the cultures of their communities and also share their cultures with the indigenes (cross-cultural discourse) and this can lead to knowledge diffusion especially in the application of indigenous knowledge in adaptation to climate change. From the results, the Bawku West District in particular have three ethnic groups among the farmers, the implication of this is that the District is likely to benefit enormously from the cultural and knowledge base of these ethnic groups especially on management practices at the irrigation scheme, sharing information on climate change and integration of their local knowledge in climate change adaptation.

5.4. RESPONDENTS' MARITAL STATUS AND HOUSEHOLD SIZE

Marital status and household size were also considered for this study. The operational definition of a household, according to the author, refers to people who share a common compound or dwelling and eat from the same 'pot' as a single unit. Household size and, for that matter, having children serves as a guarantee that the knowledge that is held by farmers can be transferred to the younger generation. This therefore serve as a good basis to pass on knowledge from generation to generation including knowledge on climate change, farming methods, management of the schemes and adaptation strategies. Household size also influences farm size in the irrigation scheme and perhaps the adaptation strategies that a farmer may adapt.

From the survey (Table 5.3), it was revealed that 68 (81.0%) of the respondents were married, 9 (10.7%) of them were single, and 7 (8.3%) were widow/widower. In finding out the number of children they had, 66 (78.6%) of the respondents revealed that they have children from 1-5, 9 (10.7%) of them had no children while 7 (8.3%) and 2 (2.4%) of have children numbering 5-10 and 11 and above respectively. Marital status, though is not the only determinant, has a strong bearing on household size in traditional Ghanaian societies where married couple tend to have larger families especially children because they are seen as a blessing.

Table 5.3: Household Size of Respondents

Household size	Frequency	Percent
1-5	58	69.0
6-10	24	28.6
11-15	2	2.4
Total	**84**	**100.0**

Source: Field Survey (2017)

From the above table and analysis it can be interpreted that the majority of farmers have on the average a household size of more than five which means that having a sizable household is still prevalent among them. A large household size serves as a source of labour for farmers; as such farmers with large family sizes tend to acquire large plots of lands at the scheme and are also able to employ indigenous strategies which are labour intensive such as composting which was reported by many farmers during the in-depth qualitative interviews and FGDs. This was evidently captured by a respondent during the in-depth interview in Tanga when he stated that:

"The only issue is inadequate funds and lack of labour to help us use certain adaptation measures especially the collecting of livestock and chicken dropping to enable us spread on the farms" (Interview excerpt 2, quote 1).

From the above it can be said that there is a relationship between household size and the adaptation strategies employed by irrigation farmers and this invariably has an impact on crop production, consumption and livelihoods. The household forms part of the human capital (DFID, 2001; Ellis, 2003) of the farmers, which is the ability to labour and is very crucial in farm production.

5.5. EDUCATIONAL LEVEL OF RESPONDENTS

As part of human capital (Ellis, 2003), education equips individuals with the skills and knowledge to pursue different livelihood options under different environmental conditions. From the conceptual framework used in this study, human capital, which is education, helps to build their adaptive capacity and enable them develop various adaptation strategies to climate change based on their knowledge (scientific, indigenous and technical) and skills.

Education also provides a basis on how farmers perceive climate change, its causes and impacts. Table 5.34presents a descriptive statistics of the educational level of respondents.

Table 5.4: Level of Education of Respondents

Level of education	Frequency	Percent
Basic/Middle	26	30.9
Secondary/Vocational	14	16.7
Tertiary	1	1.2
No formal education	43	51.2
Total	**185**	**100.0**

Source: Field Survey (2017)

Table 5.4 indicates a relatively low educational status among respondents. The evidence is that 51.2% of the respondents out of the sampled farmers have no formal education. The study further disclosed that 30.9% of the survey respondents have only basic/middle education whiles 16.7% of them have acquired secondary/vocational education. However, 1.2% of the respondents from the study community had attained tertiary education. . The low educational status can be said to influence the discourse on climate change perception and its causes as many farmers during the survey ascribed the causes of climate change to spiritual and natural factors, even though majority mentioned activities of human beings as also being causes of climate change after the responses in the questionnaire had been explained to them. Also, during the in-depth interviews and the FGDs, the causes of climate change took more of a spiritual and science-based natural phenomenon discourse and this can be attributed to their low educational status where non-scientific factors are blamed for climate change.

Education also serves as a good conduit for them to share and be able to understand discussions on climate change in the media and officials who visit them to discuss and teach them methods of farming and adaptation to climate change. The low level of education was also evident when most farmers could not remember organizations that have offered them assistance in the irrigation scheme and could not also tell when the irrigation schemes were constructed. In view of this, farmers based climatic events in relation to key memorable and notable national events such as the era of certain Ghanaian heads of states. Education is therefore an important variable on how the small-scale irrigation farmers perceive climate

change and its causes; it is also an important factor which influences farmers' adaptation strategies. This view is consistent with Maddison's (2007) and Deressa et al.'s (2011) findings. According to the authors, though several factors play important roles in how farmers perceive climate change and its causes, those who are more likely to respond by undertaking at least one adaptation strategy are the educated farmers.

5.6. RELIGIOUS AFFILIATION OF RESPONDENTS

Religious affiliation of respondents was an important variable for this study. The relationship between religious beliefs and climate change has been established by several authors (West et al., 2008; Mertz et al., 2009a; Kemausuor et al., 2011; Yaro, 2013). The authors found that small-scale or subsistence farmers in many parts of Africa tend to assign social, religious or moral and superstitious reasons to explain natural events including climate change because it is the only means of information available to them. For instance, West et al. (2008) in their work in Burkina Faso concluded that farmers' perceptions on climate change are based on their local history, regional history and culturally significant events. This indicates that religious affiliations, which informs farmers' views on climate change, goes hand in hand with their indigenous knowledge which is handed down from generations.

Three main categories of religions identified in this study were Christianity, Islam and African Traditional Religion (ATR). The study results (Table 5.5) shows that 61.9% of the respondents believed in Christianity, whilst adherents of ATR and Islam were 27.4% and 10.7% respectively. From the qualitative in-depth interviews, the study further found a similar pattern on religious affiliation, but in this instance the majority of the respondents were believers in ATR, followed by Christianity and Islam.

Table 5.5: Religious background of Respondents

Religion	Frequency	Percent
Christianity	52	61.9
Islam	9	10.7
African Traditional Religion	23	27.4
Total	**84**	**100.0**

Source: Field Survey (2017)

The religious affiliation of respondents was significant because it helped the researcher to understand how religious beliefs form a basis on how irrigation farmers construe climate change and the factors that cause it. From the analysis of my field survey, it was observed that farmers from all the religious groups attribute causes of climate change to spirituality and an act of God. Farmers who were adherents to ATR mostly mention God as the architect of climate change as well as the disrespect for taboos and farming in sacred grooves as causes of climate change. All adherents to the various religions also mentioned human activities such as felling of trees which causes climate. In instances where human induced activities were mentioned as causes of climate change, a common narrative by farmers was the intersection of such causes and religious factors with the adherents of one religion blaming the actions and inactions of other religious beliefs as the causes of climate change. The diverse religious beliefs ultimately pointed to variations in the discourses on especially the causes of climate change in the study community. This will be further discussed in section 6.4 of chapter six

5.7. RESPONDENTS' FARM SIZES

The analysis of farm size in this study took into account several factors which influences farm sizes in the study areas. The analysis of farm size is important because it is driven by household size and ultimately influences the farming method and adaptation strategies that irrigation farmers may adopt. The farm sizes of respondents were analysed in relation to sex and household size, number of years in irrigation farming and level of education. This was important in the study because it gives an indication of farm holdings and factors which influence that. It was also important because land holding is an important resource for survival and wealth creation in rural areas in Ghana. Land is also seen as a source of power.

The more land one has the more he or she wields substantial influence in the community. Families with more land are therefore accorded higher statuses in the community and become influential in the affairs of the community.

Analyses of respondents' farm size indicate that the minimum farm size in the scheme (hectares) of the sampled respondents was 0.002 and the maximum was 0.04. The mean farm size in the scheme (hectares) was observed as 2.98 with a standard deviation of 3.506. The mean and standard deviation indicates that majority of farmers own farm sizes of approximately 0.008 hectares. This scenario might affect crop production in the area, thus affecting the livelihoods of the farmers. In terms of mode of land acquisition, 3.6% of the respondents did not indicate how they acquired it, 1.6% of them indicated that they held family land, 76.2% (which was the majority) confirmed that they acquired it as a gift from land owners but it was not given to them permanently, 10.8% indicated that they hired the land, 14.3% said that they acquired the land through inheritance, and 6.0% of the sample population confirmed that they owned the land. Findings from qualitative interviews also indicate that those who did not own land but wish to engage in irrigation farming were allocated the land by the WUA. This clarifies why some respondents could not tell exactly how they acquired that land and similarly majority of the respondents who indicated they hired the land actually got it from the WUA after registering and paying a fee. The relative small farm sizes of respondents led to small scale irrigation scheme farmers engaging in other occupations aside farming. Results from table 5.5 clearly shows that 38.9% of the sample population were engaged in crop (rain-fed) farming only as their other occupation, respondent who were engaged in crop (rain-fed), livestock and fishing farming were 1.1%, those in livestock farming only were also 1.1% while the remaining 57.8% of the respondents were into crop (rain-fed) and livestock farming.

Results from in-depth interviews were consistent with findings from the survey data. Respondents further added during the interviews that they were engaged in other occupations, such as paddy rice production, Shea butter production, trading and formal employment with a private company as labourers (Table 5.6).

This was captured by a respondent during the in-depth interview in Tanga when she stated that:

"I engage in rain-fed crop production, rearing of poultry and livestock and trading in paddy rice to support my family and farming in the irrigation scheme" (Interview excerpt 8, quote 2).

The other sources of occupation are important because they are sources of funding for the irrigation farmers which they use to support their farming activities in the schemes.

Table 5.6: Occupations other than irrigation farming

Occupation	Frequency	Percent
Crop (rain-fed) farming only	47	38.9
Livestock farming only	2	1.1
Crop (rain-fed) and livestock farming	33	57.8
Crop (rain-fed), livestock and fish farming	2	1.1
Total	**84**	**100.0**

Source: Field Survey (2017)

Findings on farm sizes in the irrigation scheme in relation to size indicate the there was no significant differences between farm sizes held by men and women. The men and women average farm sizes of were approximately 3 plots. This scenario indicates that though the community is patriarchal in nature and men tend to wield more power when it comes to decision making and resource allocation (Eguavoen ,2008) in the case of land allocation for small scale irrigation scheme farming men and women are afforded equal opportunities to land and are given unfettered access to resources in the scheme and this contradicts the norm as espoused by Eguavoen (2008). Also in terms of farm sizes in relation to household size it was observed respondents with larger household sizes held the most land thus farmers with household sizes ranging from 11-15 held approximately 2 plots followed by farmers with household sizes of 6-10 and 1-5 holding approximately mean farm sizes of 1.87 and 1.47 respectively. The analyses indicate that labour is crucial in the farming decisions of farmers and the more labour available to the farmer the more land he or she might acquire to maximise the available labour.

The findings on respondents' farm sizes with respect to number of years in irrigation scheme farming (Table 5.7) shows that farmers who are into the small scale irrigation farming for less than 10 years and 10-19 years had farm sizes ranging from 0.002 to 0.04 hectares with majority of them having farming sizes of approximately 0.006 hactares. Farmers with experience between 20-29 years had plots ranging from 0.002-0.04 hactares with majority having approximately 7plots thus 0.014 hactares. The variation in farm sizes from the point of view of this research is that farmers with fewer years in irrigation farming are mostly the younger farmers who are energetic and have the zeal for farming, the reason why some of them go in for as much as 0.04 hectares whiles those above 29 to 30 years might have gained enough experience which makes them more efficient and because of that would also go for very large farm sizes, the reason why majority of them approximately on the average keep larger farm sizes of 0.016 hectares.

Table 5.7: Farm Size of respondents by number of years in Irrigation Farming (Plots of 20 square meters).

Age	N	Min	Max	Mean	Std. Dev
Less than 10 years	43	1	20	2.88	2.954
10-19 years	35	1	20	2.63	3.144
20-29 years	6	1	20	5.67	7.339
Total	**84**	**1**	**20**	**2.69**	**2.823**

Source: Field Survey (2017)

With respect to educational level of respondents and farm size (Table 5.8), respondents with no formal education had farm sizes ranging from 0.002-0.04 hectares, those with basic/middle school education and secondary/vocational education also had sizes from 0.002-0.04 hectares as well and a respondent who had tertiary education had 0.002 hectare. The differences in farm sizes across the different levels of education could be due to the fact that farmers without formal education and those with basic/middle school education rely mainly on agriculture for their livelihood and would necessarily need more land for their farming activities. Also, they are the majority when it comes to irrigation farmers whiles those with secondary/vocational education and tertiary education might be engaged in irrigation farming as a secondary occupation.

Table 5.8: Farm Size of respondents and Level of Education

Level of education	N	Min	Max	Mean	Std. Dev
Basic/Middle	26	1	20	3.08	3.654
Secondary/Vocational	14	1	20	3.86	4.881
Tertiary	1	1	1	1.00	.
No formal education	43	1	20	2.67	2.917
Total	**84**	**1**	**20**	**2.69**	**2.823**

Source: Field Survey (2017)

5.8. SUMMARY

The chapter presented the socio-demographic aspects of the small-scale irrigation farmers. Data on the socio-demographic characteristics indicated that there was no discrimination in providing opportunities for small-scale irrigation farming between males and females in the study area. It also showed that majority of the farmers had no formal education and were mostly adherents of the ATR. Farmers access to land included ownership to the land, inheritance, gift from land owners, hiring of farmland and allocation of land by the WUA. Access to land in the study area is crucial because land is seen as a source of power, therefore those who own land outright and families with more land are regarded in high esteem and accorded higher statuses and therefore are influential in decision making and affairs of the community. The chapter also showed that irrigation scheme farmers engage in other occupations which included rain-fed crop farming, livestock rearing and fish farming whiles others engaged in Shea butter production, paddy rice production and trading. The findings indicate that the other sources of occupation serve as sources of funds for irrigation scheme farmers which they use to support their irrigation farming activities in the study area. The educational background and the religious beliefs of the respondents, from the study, could have an impact on the way the respondents perceive climate change and its causes as well as the adaptation strategies that they might adopt in their irrigation farming to overcome the impacts of climate change.

CHAPTER 6: SMALL SCALE IRRIGATION FARMERS' PERCEPTIONS ON THE CAUSES OF CLIMATE CHANGE IN BAWKU WEST DISTRICT

6.1. INTRODUCTION

Climate change and variability have gained considerable attention because they impact on the wellbeing of people who depend on the natural environment for their livelihood. Climate change affects agricultural production, employment and water availability, which is at the core of agriculture, especially in sub-Saharan Africa where a majority of the people depend on smallholder agriculture for their livelihood. Its attendant impact is that it will impede the efforts to reduce poverty in the region (UN, 2006; Slater et al., 2007; Assan et al., 2009; IPCC, 2007; Yanda and Mubaya, 2011). The main focus of this chapter is to present the findings and discussions of small scale irrigation farmers' perception on climate change. The chapter begins by presenting the farmers sources of information on climate change since sources of information on climate change provides them with information and knowledge on climate change which enables them to form their own opinions and construct climate change discursively. The chapter then continues with the presentation of findings on the causes of climate change as discussed with small scale irrigation scheme farmers in Bawku West District. The farmers' perceptions of climate change are analysed taking into account local climatic indicators and the various discourses that emerged. The causes of climate change as perceived by farmers are also presented with emphasis on the discourses about factors that causes climate change.

6.2. FARMERS' SOURCES OF INFORMATION ON CLIMATE CHANGE

The respondents in the study area demonstrated that they were aware of climate change and the likely causes of it (which will be discussed in the subsequent section). Results from the survey data indicate that out of the 84 respondents, 81 representing 96.4% have observed changes in the weather conditions in the last 30 years while 3 (3.6%) indicated that they have not observed any significant changes in the weather conditions in the last 30 years. These respondents were mostly young farmers who have not been farming in the irrigation schemes for more than 10 years. Results from the qualitative data correspond to the findings in the survey data. All the respondents indicated that they have witnessed changes in the climate

especially in ‘recent times’ and they mentioned mostly changes in rainfall and temperature as the major climatic factors where they have witnessed changes.

In exploring the sources of information among the farmers who have observed changes in climatic conditions, the results of the survey data indicated that farmers rely on their personal experiences, the media, social groups and extension officers as their main sources of information, which enables them to form an opinion on climate conditions and their environment. Analysis of the survey data, as indicated in Table 6.1, reveal that 92.9% of the small-scale irrigation farmers rely on their personal experiences based on their personal knowledge about climate conditions and their lived experiences with their environment. The personal knowledge about climate change does not stay within these farmers but they share with parents/family members, friends/neighbours and village leaders. Knowledge and information within the communities is shared through interaction of farmers in religious places (Churches, Mosques and Shrines) and social groups (farmer associations, women, men and youth groups) they belong to, and through community meetings. This indicates that farmers’ interactions among themselves and other community members lead to knowledge and experience sharing and bring about co-learning amongst them. Such internal information and knowledge sharing help farmers to adopt new strategies and to strengthen existing ones.

Table 6.1: Sources of information on climate change

Sources of information on climate change	Frequency	Percent
Personal experience	78	96.8
Parents/family members	29	37.8
Village leaders	39	40.0
Friends/Neighbours	48	32.4
Religious places	32	33.5
Social groups	57	44.3
Community meetings	26	25.9
Media, (Radio and television)	72	71.4
NGOs/CBOs	37	25.9
Extension officers	24	42.2

Source: Field Survey (2017)

Apart from internal sources of information on climate change through personal and shared experiences, small-scale irrigation farmers also receive information on climate change from external sources. The survey results revealed that 71.4% of the farmers receive information on climate change from the media. The major outlet is through the local radio stations, followed by mobile phones and television. The high illiteracy rate accounts for farmers not relying on written sources such as newspapers and magazines for information on climate change. The radio stations they rely on are found in Bolgatanga and Zebilla (the regional and district capitals respectively) and they mostly broadcast in Kusaal and Gurune. Also, increasingly, climate change advocacy NGOs/CBOs are very active in the region providing information about climate change to the farmers - 44.0% of the respondents confirmed that their source of information on climate change include activities of NGOs/CBOs and a further 28.6% of them indicated that their source of information was from extension officers. These external sources of information on climate change have an impact on how farmers will perceive climate change and its causes as well as the adaptation practices and farming

methods they adopt. The external sources provide information which is based on scientific knowledge and these help farmers to adopt scientific and modern methods in their farming and adaptation strategies. The coming together of these sources of information reinforces each other in a mutual way and influences the narratives on how the farmers perceive and construct climate change discursively.

The above sources of information on climate change were also supported by in-depth interviews and FGDs when farmers affirmed that they heard about climate change from the radio stations in Bolgatanga and Zebilla. They also indicated that they have heard about climate change from their neighbours, colleague farmers, and agricultural extension officers as well as during community meetings. In buttressing this, a female farmer from Tanga (Interview excerpt 13) stated that:

"...I have heard issues of climate change on the radio, from neighbours and also during our community meetings. From the radio, they normally advise us to start farming when we see the rains and not wait for the period we think it is time to farm because the weather pattern has changed" (quote 3).

Much in the same vein, a female participant during FGD in Tanga said that:

…Colleague farmers also talk about it, especially the male farmers who normally trek to Zebilla and back. Those of us who also trade in Zebilla market hear other traders talking about changes in the rainfall pattern and temperature in their communities" (quote 4).

These narratives indicate that irrigation farmers in the UER of Ghana learn about climate change from their interaction and lived experiences with their environments, from official sources such as extension officers, radio stations and television networks as well as unofficial sources such as from friends and colleagues. This gives them a wider and broader perspective about how they might perceive climate change and its impact as well as inform the adaptation strategies that they might adopt. The preceding argument would also suggest that the sources of information can lead to knowledge integration on climate change where the advantages of indigenous knowledge and scientific knowledge can be synergised for effective adaptation to climate change. This is because farmers tend to get information from meteorologist and agricultural extension officers as well as from neighbours and experienced farmers and these can be used for effective adaptation to climate change.

6.3. IRRIGATION FARMERS' DISCURSIVE PERCEPTIONS ABOUT CLIMATE CHANGE

Previous research indicated that farmers' perceptions about climate change are based on their lived experiences with their locality and these are shown in their local climatic conditions (Kurukulasuriya and Rosenthal, 2003; Boko et al., 2007). Small-scale irrigation farmers' perceptions about climate change in Tanga are based on their personal experiences with their environments and the information gained from community members and external sources. Data from qualitative interviews with farmers on their farming experiences over the years and the overall impression about their farming activities indicated that farmers have seen changes emerging in their communities and are therefore used to such changes. The changes they narrated ranged from economic, environmental, and social to political. In terms of the climate, the changes manifest themselves in local climatic conditions such as unpredictable rainfall pattern, unavailability of water, changing wind conditions, extreme heat, proliferation of pests and diseases, severe harmattan, floods and droughts and changes in the vegetation cover. In my study, results from survey data based on a descriptive statistics computed from a likert scale[15] are shown in Table 6.2 below.

[15] The Likert Scale has scores ranging from 1-5 with the minimum score being 1 and 5 being the maximum score

Table 6.2: Types of change observed by small-scale irrigation Farmers (measured on a likert scale)

Changes noticed and the extent of change	N	Min.	Max.	Mean	Std. Dev.
Increased temperature	84	4	5	4.89	.311
Decreased temperature	84	1	5	1.74	.793
Increase in rainfall amount	84	1	5	1.81	.799
Increase in rainfall intensity	84	1	5	1.81	.814
Increased in length of rain season	84	1	4	1.76	.705
Early onset of rains	84	1	5	2.18	.996
Late onset of rains	84	1	5	4.60	.808
Decreased in rainfall amount	84	1	5	4.30	.875
Decreased in rainfall intensity	84	2	5	4.19	.885
Decreased in length of rain season	84	1	5	4.58	.779
Erratic rainfall	84	2	5	4.42	.764
Long dry spell	84	2	5	4.32	.763
Floods seem to be frequent	84	1	5	3.73	.961
Increase in strong wind events	84	1	5	4.33	1.101

Source: Field Survey (2017)

Note: for extent of change; Strongly agree=5, Agree=4, Not Sure=3, Disagree=2, and Strongly disagree=1.

From the results, a majority of the respondents with a mean score of 4.89, which is approximately a total score of 5, indicated that they had observed an increase in temperature. This is followed by late onset of rains with a score of 4.60, decreased in length of rainy season (4.58), erratic rainfall having a score of 4.42, increased strong wind events with scores of 4.33, long dry spell (4.32), followed by decreased rainfall amount (4.30) and rainfall intensity with a score of 4.19. The majority of the respondents also disagreed that temperature has decreased with a mean score of 1.74, followed by increased length of rainy season (1.76), increase in rainfall amount (1.81), increase in rainfall intensity (1.81) and early onset of rains

(2.18), while the majority of the respondents were not very sure whether floods were frequent with a mean score of 3.73, though getting close to 4.0. The results from the survey data on floods contrasts with results from qualitative data when respondents during in-depth interviews and FGDs indicated that floods have been recorded, especially during 2007 and 2009. This assertion is supported by UNDP (2009) and Adu-Boateng and Oppong (2011) when they reported that the Upper East Region and the two other regions in Northern Ghana witnessed torrential rainfall which led to flooding after a two months of below average rainfall in 2007.

The survey results are also supported by the findings of Brown and Crawford (2008 citing EPA, 2007:7-8) when they projected a rise in temperature and reduction in rainfall in Ghana over the next decades. Using historical data across Ghana from 1960-2000, they showed that there is a progressive and noticeable rise in temperature and a simultaneous decline in rainfall in all agro-ecological zones in Ghana. They therefore estimate an average temperature rise of 0.6°C, 2.0°C, and 3.9°C; a rainfall decrease of 2.8 per cent, 10.9 per cent and18.6 per cent; and a sea-level rise of 5.8 cm, 16.5 cm and 34.5 cm by 2020, 2050 and 2080 respectively. This is also in contrast with Semenza et al. (2008) and Deressa et al. (2011), who held that people with higher incomes are more likely to be aware that the climate is changing than individuals with lower income. In their view higher incomes have a positive influence on peoples' public perception of climate change because people will have access to information through the print and electronic media. This view therefore contradicts the situation in the study areas where 80% of the people are considered poor (GSS, 2010) and rely on agriculture for their livelihood (GSS, 2013) without much income from their farm activities, but still being aware that the climate is changing. Findings of the study corroborates West et al.'s (2008) views that perceptions of farmers in West Africa on climate change are grounded in local history, regional history and culturally significant events because the farmers in the study area perceive climate change through their lived experiences, interactions with colleagues and elders and rely on events in the past to talk about climate change.

Qualitative data results support the above results from the quantitative survey. The major responses from qualitative data during in-depth interviews and FGDs with small scale irrigation farmers were high and unbearable temperatures, low rainfall, erratic and unpredictable rainfall, strong winds, severe harmattan, floods, soil infertility and proliferation of pests and diseases in the farms. The climate change features (Thus, indicators of weather) most often mentioned in the survey as well as in the interviews may be divided into four main

categories that are somehow interrelated. These indicators are temperature, rainfall, wind and other indicators. The main characteristics of the temperature indicators are high temperature, unbearable heat, scorching sun and evaporation of water due to high temperatures. Rainfall was the most often mentioned feature and was referred to as low rainfall, erratic rainfall, unpredictable rainfall pattern, delay onset of rains, reduction in the volume and increase in the intensity of rainfall, floods and shortened rainfall duration. The wind indicator is characterised by strong winds dispelling rains and strong winds accompanying rains. The final indicator, which I refer as other indicators, is made up of both climatic and non-climatic features. These features are severe harmattan, depletion of vegetation cover, soil infertility and proliferation of pests and diseases in the farms.

From the narratives, farmers' perceptions about climate change are based on the indicators they provided. It is discernible that the dominant discourse construes climate change as a natural science phenomenon through a variety of climatic indicators. Also discernible are the lived experience discourse and religious Discourse on small-scale irrigation farmers' perceptions about climate change based on the climatic indicators. The following sub-sections discuss farmers' perceptions about climate change with reference to the perceived indicators.

6.3.1. TEMPERATURE INDICATORS

From the data gathered and analysed, what appears to be predominant discourses in relation to how farmers perceive climate can be classified into four discourse categories based on Gee 2014; 2015) where he categorized discourses into big or capital D and small d discourses. The discourses identified are therefore: (i) a religious/spiritual Discourse which is the Big D Discourse and the sub-group thus the African Traditional Religion (ATR) where farmers perceive climate change and associate it with the actions of God and the gods in the community due to community members disobedience and disrespect for the gods; (ii) a science-based natural phenomenon Discourse where climate change is perceived as occurring irrespective of any human activity, hence the farmers see it as naturally occurring even though they agree that human activities also has an impact on climate change; and (iii) indigenous knowledge Discourse with its sub-group as a lived experience discourse where they relate and perceive climate change based on their personal experiences with their local environments embedded in the local and social realities of the farmers and as such relate it to their own actions and (iv) anthropogenic Discourse (Man-made). Thus nature affected by

human activities. The sub-group categories being: agriculture and horticulture discourse; technological discourse. It must be noted that some of these discourses intertwine leading to some discourses carrying elements or bearing traces of more than one discourse, thereby leading to a hybrid discourse. For instance an African Traditional Religion discourse could be based on knowledge that has been passed down or what people have been socialized to believe and could also be based on the farmers' experience on what he has come to believe is an action of God. Table 6.3 shows an illustration of the discourse categorizations below.

Table: 6.3 Categorizations of Discourses

Religious/Spiritual Discourse	Science-based Natural Phenomenon Discourse	Anthropogenic Discourse	Indigenous Knowledge Discourse
African Traditional Religion discourse (the gods)	Natural disaster discourse (earthquakes, lightening, floods, thunderstorms (nature takes its course).	Agriculture/ horticulture discourse	Lived experience discourse
Christianity discourse (God)		Pest control discourse	Bodily sensation discourse (e.g. exposure to scorching sun and high temperatures)
		Technological discourse	
Lamenting discourse (hardships, complains), Household economy discourse (income), gender discourse (role of women in the economic activities) and Needs discourse (food, clothing, social services and activities)			

Source: Authors own construct (2020)

Temperature was a major indicator of climate change identified and discussed by small-scale irrigation farmers. They mostly discuss temperature in relation to sunshine and heat. The perception of farmers on temperature in the study sites point to an increase in temperature, which is in line with both my quantitative and qualitative data as well as weather data sourced from the Ghana Meteorological Agency (GMA) in the Upper East Region. In an attempt to find out from farmers how they predict the weather from their own experience or indigenous knowledge, they unanimously conceded that with regards to temperature, they do not have the knowledge and expertise to predict the temperature and that they only talk about it based

on how they feel the effects of the sunshine. They maintained that, with respect to temperature, it was only God who determines that, while others say they only know how the temperature will be for the following day through the radio stations and televisions, when they forecast the weather for the day; a few farmers think that predicting the temperature was for the experts whom they refer to as 'those who know', (i.e., people who have studied about the weather).

The answers given primarily draw on a religious belief system and what I shall refer to in this study as African Traditional Religious discourse (ATR discourse). The Discourse on religion is seen in the fact that farmers ascribe the change in temperature to 'God', whom they believe to be 'powerful' and can determine how he wants to schedule the temperature (sunshine) whilst the scientific Discourse is based on the daily weather forecast which farmers observe in the media in order to predict the weather. I call it scientific because the meteorologists base their pronouncement on information obtained using various scientific instruments to predict changes in temperature and it is therefore based on evidence. A male farmer an adherent of ATR during an in-depth interview (Interview excerpt 2) in attributing temperature trends to a religious belief made the following comment: *"no, I cannot predict the temperature, it is the work of God, so I cannot predict" (quote 5).*

With the scientific aspect, and referring to how they predict the weather by way of listening to modern methods of communication, another male participant in Tanga (Interview excerpt 3) indicated that:

"...No, it is only through the radio station in Bolgatanga, the regional capital, and sometimes news from Accra through Television that I hear issues on climate when they are discussing climate change issues or giving news update on the climate by way of weather forecast and prediction and making projections on the climate" (quote 6).

In analysing the respondents' views on temperature in the past 30 years, and whether they had observed changes, results from the survey data indicated that the majority of the farmers, based on the likert scale[16] (Table 6.2 above) strongly agreed that temperature had increased. Many respondents during in-depth interviews and FGDs as well as interviews with stakeholders who support small-scale irrigation farmers reported increase in temperature with the assertion that the weather was getting warmer than before. Among the issues reported by

[16] The mean score on the likert scale was or is 4.85

respondents was that they had witnessed that the sun scorches due to an increase in sunshine intensity. Others also perceive the heat emanating from the high temperatures as being unbearable causing discomfort. Many of the respondents are therefore of the opinion that the sunshine intensity has led to an increase in temperature in their localities thereby increasing the day as well as evening to midnight temperatures. They further report that the situation is made worse as a result of low moisture in the atmosphere due to low humidity. A farmer in Tanga (Excerpt 2), comparing current temperature trends to the past based on his lived experience with increasing temperatures and the unbearable nature of the heat, said that:

"…the heat nowadays is unbearable. "I recollect about 15 years ago when it was time to harvest our crops, especially millet, you cannot freely open your palms because of the cold conditions. But these days it is not the case, we do not even wear shirts when we come outside because of the heat. It is more comfortable not wearing a shirt (quote 7).

In relating the unbearable nature of the sun to the irrigation scheme, a farmer (Excerpt 7) reported that:

"…The temperature is also unbearable. You can see that we are in the middle of February and the sun is scorching. This phenomenon normally leads to high evaporation in the dams leading to a further reduction in the amount of water which is already not enough for us" (quote 8).

A participant during FGD with male irrigation scheme farmers also supported the above view when he indicated that:

"…the temperature has changed as well. The harmattan season which used to be so cold is not so anymore. The heat is unbearable. I can say that since the end of the rainy season, we have been experiencing very hot conditions; we do not experience the cold conditions like in our youthful days" (quote 9).

The views of the participants above point to a lived experience discourse, invoking bodily sensation where the farmers talked confidently about how they perceive temperature and justified their personal position on temperature and for that matter climate change through their personal experiences and first hand interactions with the localised weather conditions in the community. They therefore talk about temperature and how it has changed in their lifetime by using terminologies which connote the 'past' and 'present'. The personal experiences of the farmers led to narratives in relation to temperature, such as unbearable

nature of the sun, hot conditions and high evaporation, which they contend impacts negatively on their livelihood. The farmers therefore relate temperature to their own local and social realities based on lived everyday experience instead of relying on other sources of information to talk about the temperature. Actually they talk about how unbearable the heat is, so I would say it is a bodily sensation discourse, which can be seen as a sub-category to lived experience discourse.

The majority of farmers in the study areas, however, during in-depth interviews and focus group discussions found that the increased temperature has occasioned lower humidity and declining moisture compared to the past, thus accounting for the unbearable heat patterns illustrated by the respondents. The scenario depicted by farmers seems to be complemented by meteorological data from the Manga Meteorological Station for Bawku West District, which indicate that both the mean annual minimum and maximum temperatures have been increasing steadily in the region and since 1981 to 2015 in the Bawku West District (see Figure 4.2, 4.3). This also conforms with the RCC (2003) and Blench (2006) reports that the annual average temperature recorded for the Upper East Region in the dry season from the Navrongo synoptic station is 28°C from December to February at minimum limits and the highest at 45°C between March and May.

The above perception by farmers and data from the Ghana Meteorological service is in conformity with observations made by different authorities that climate change will result in an increase in global temperatures and that the semi-arid areas will be hit more and more often by increased temperatures. This is in line with some authors projecting that due to GHGs and aerosols emissions and the drying of the Sahel in the late 20th century, the African continent has experienced an increase in temperature by 0.5°C (IPCC, 2007; Oliver-Smith, 2009a; Held et al., 2005; Biasutti and Gianni, 2006). See also Brown and Crawford (2008) and RCC (2003).

From the analysis on temperature, the discourses that emerged were that temperature has become unbearable, the sun was scorching, local conditions have become hot and the harmattan has become warmer due to increased sunshine intensity. The impact of this was that living conditions have become uncomfortable. Drawing on a natural science Discourse, the discourses related to temperature from the analysis have a relationship with the wellbeing and livelihood of farmers depicted in discourses about high evaporation, low humidity and low moisture. The relationship between these discourses is that it leads to a reduction in the

water level in the dam, which affects negatively the crop production of the farmers in the irrigation schemes and adaptation strategies and for that matter have a negative impact on their livelihood. All these discourses emerged out of the dominant discourse on being exposed to high temperature, thus drawing on a lived experience discourse. From the analysis, farmers use words like 'past' to refer to years past where they believe the temperature was good and supported their wellbeing and livelihood and 'present' to refer to current trends where they think the temperature has become harsh and impacts negatively on their livelihood. A lived experience discourse on temperature can therefore be seen as intersecting with an economics discourse because they see the present climatic conditions as having an adverse impact on their livelihood activities.

6.3.2. RAINFALL INDICATORS

Rainfall indicators on how respondents perceive climate change produced responses that showed that respondents are more responsive and abreast with rainfall than temperature. This could be due to the fact that farmers perceive rainfall to be a major factor for the success or otherwise of their farming activities with regards to both rain-fed and irrigation farming. Respondents were more articulate in predicting rainfall patterns as compared to temperature. They used various factors, based on certain natural happenings, spiritual connotations and behaviour of certain tree species, to predict the rainfall pattern. Farmers also based their predictions of rainfall on their farming experience and indigenous knowledge learnt over the years in their communities. Regarding natural happenings, respondents used factors such as coldness or hotness of the weather, how the air blows, that is whether the air is warm or comes with some cold, speed and direction of the wind and sky and cloud formation as well as movement, to predict whether there will be rain or not. A respondent (Interview excerpt 1) touching on the coldness and the movement of the wind to predict the rains commented that:

"..... the only way I use to predict changes in the weather is that as we are in February the weather should have been a bit cold and there should be air but as you have observed the weather is still and the air blowing is dry which presupposes the rains will not come at the right time, which should be April. Judging from the weather pattern, the rains will come late and stop early and this affects all our farming activities" (quote 10).

Similarly, another respondent (Interview excerpt 10) relying on the behaviour of the wind and certain tree species said that:

"…as you have seen the way the wind is blowing gently and nicely, if it should continue that way for six weeks then the rains will be good and we will get a good harvest. Also, if mangoes fruit well then there will be enough rain because the mango tree relies on a lot of moisture to fruit well and when that happens, it means the humidity is high and will result in good rain" (quote 11).

The assertions above by respondents portray an interplay of a lived experience discourse and indigenous knowledge Discourse. The indigenous knowledge Discourse and lived experience discourse in the responses are based on the fact that respondents use the behaviour of climatic indicators which they have observed, studied and have experienced in their lifetime in the community to predict the rainfall pattern. This lived experience over the years leads to the farmers developing their own knowledge which they use to predict the rainfall pattern in their localities.

With regards to the African Traditional Religion discourse or connotations to predict the rains, the farmers mostly referred to the power of God and rainmakers in the community who they believe have the power to 'call' rain. The rainmakers, they claim, are given special powers by God and the gods to be able to 'make' rain. For instance, during a FGD with men in Tanga, a respondent drawing in the power of rainmakers remarked that:

"…it's difficult to predict the weather. We do not possess that knowledge; those who have spiritual powers can predict it, especially the rainmakers. I can say that the little we use to determine whether the weather would be favourable to support farming is through the way the weather behaves. If we have very cold conditions and the wind is blowing well in the dry season then we believe that in the rainy season the rains will be good and we will get good harvest" (quote 12).

The responses of the farmers show an intersection between an ATR discourse with an indigenous knowledge Discourse. The indigenous knowledge in this regard was gained through the farmers' experience and the continuous interaction with their environments which is passed on from generation to generation. This means that farmers do not only base their prediction of the environment on spiritual issues but supplement it with the knowledge which they have gained through their farming experience.

The indigenous knowledge gained by farmers through their farming experience to predict the weather was also seen in the way farmers based their predictions of rainfall on the behaviour

of certain tree species especially ebony, Shea and mango. These trees traditionally provide fruits which serve as sources of food especially during the dry or lean season when food reserves starts to dwindle. They therefore are very important to indigenes in the Region, especially the Shea which also has additional economic value for the local people. During in-depth interviews a farmer narrated that:

"…I use the fruits from our trees. When the ebony and Shea trees fruit well then God is giving an indication that there will be enough rainfall for our cropping season and this translates in the activities in the irrigation scheme because we would get a reasonable amount of water for our farming" (quote 13).

The analysis indicates that predicting changes in the climate, especially in terms of rainfall, is influenced by their belief systems as epitomised in relying on people they see as their spiritual leaders imbued with the power to make or predict the weather. They also use natural occurrences to predict the rain and, finally, farmers rely on their experiences with their environment and indigenous knowledge handed down to them by their forefathers and on their farming experiences to predict the weather. The findings are in consonance with other studies in Kenya where community members use traditional methods of weather forecasting which include the behaviour of ants, bird songs and timing of tree flowering to decide when to prepare lands and sow seeds (Guthiga and Newsham, 2011). Similar results are seen in studies of Northern Ghana where farmers were able to predict the wet season in the midst of climate variability by observing the flowering of the shea nut tree, migratory patterns of birds and position of the constellation Pleiades (Benneh, 1970; Ofori-Sarpong, 2001).

The analysis indicates that the means through which farmers predict the weather complement each other and therefore intersect in interesting ways through discourses where spirituality and religious Discourses are intertwined with indigenous knowledge Discourse. Farmers also relied on the discourse used by meteorologist (science Discourse) through the radio and television to predict the rains. Farmers who have access to these media outlets reported that they listened to the weather forecast especially during the wet season to get information about the rains. Farmers who reported using this means of information on the weather report that the time they cultivate and plant their crops are inspired by what the Meteorologists say.

The majority of respondents reported that rainfall has decreased or declined in all measures in terms of amount, intensity and length. Results of survey data (Table 6.2 above.) in descending order indicate that respondents recognized and agreed that currently there is late

onset of rains, decreased length of rainy season, decreased rainfall amount and erratic and decreased rainfall intensity. The majority of farmers from the survey disagreed that there was early onset of rain and agreed that they experience long dry spells as a result of low rainfall amounts and a decreased in the length of the rainy season. The survey analysis is consistent with findings from focus group discussions, in-depth interviews and narratives where respondents agreed that in recent times rainfall has become more erratic, unpredictable and highly unreliable, low in volume and have reduced in length based on the number of months of rain. They also agreed that the timing and onset of the rains have shifted with the onset being late.

The observation of respondents was summed up by a respondent in Tanga (Interview excerpt 2)

"…there are changes with regards to rainfall. The volume of rain has decreased significantly. The rains used to fall for about four months. We even use to harvest and thrash millet whiles we still had rains instead of sunshine to dry and store our produce. The fact is, the rain now delays with regards to onset; it starts well and when it's time for the crops to mature, a period they need more water, then the rains will stop abruptly" (quote 14).

The respondents indicated that, in some years, it benefits them whilst in other years the rains rather destroy their crops because the rains fall at a period when the crops do not need water and rather sometimes stop abruptly at the time the crops need water. They also contend that the low volumes of rainfall leads to low amounts of water collected in the dams and this leads to scarcity of water, which affects their irrigation farming activities. A female respondent, during a FGD in Tanga, in talking about the erratic nature of rainfall remarked that:

"…the weather in this community has been changing. The rains are unpredictable. It favours us in some years and fails us in other years but the failure is more because the rains do not come at the time we actually need it. Of late, when we plant the rains do not fall as expected and, in most instances, at the time the crops do not need the water it comes heavily thereby destroying the crops" (quote 15).

A respondent (Interview excerpt 1), in talking about the volume of water in the dam to justify the low rainfall amounts or volumes, asserted that:

"…if we are not able to water our crops in the evening, then the crops wither and we don't get enough rains to fill the dam. So it's a major problem for us. The water is always scarce" (quote 16).

Respondents were able to recount years in which the rains were beneficial to them and years in which it was bad or destructive to their crops

The manifestation of rainfall variability is common in the study area. Respondents, based on a temporal perspective, reported that the rain used to start in late March or early April in the past but in recent times it has shifted to late April or early May giving an indication of the late onset of rain. They remarked that the rains stop in October instead of extending to November which was the norm in the past. This implies that the rainfall duration is shortened which affects farming activities. A respondent, during interviews, confirmed this when he remarked that:

"Well, if it is changes to the climate, I have seen that it has changed a lot. First and foremost, with respect to rains, there are changes. Every year we see changes. It is erratic and we cannot predict the rainfall pattern. The month we expect the rains, it does not come and if at all it comes as we expect it, it stops abruptly thereby disrupting and militating against the growth of our crops. …the last time we had rains was 15th October, 2016 and today is 12th February, 2017 and we still have not had a single drop of rain. The rains are not to stop at this time but that is the reality staring us in the face" (quote 17).

The revelations by the participant is supported by Laux *et al.* (2008 cited in Laube et al., 2012), who in their statistical analyses of rainfall patterns in the last 60 years, have indicated that the onset of the rainy season has shifted from April to May and dry spells during the rainy season have increased in West Africa.

During focus group discussions and interviews, respondents revealed that the variability in rainfall started about a few decades ago. Even though they were not explicit, they indicated that the 1990s to date have shown marked variability in the rainfall pattern. In an interview with the Red Cross Director in Zebilla, whose organization supported the construction of an irrigation scheme in Tanga and continues to provide technical assistance to farmers in the area, I learned that between the years 1961-1968 the weather was quite predictable; however, in his opinion, from that period to date, the weather has become unpredictable and erratic, especially with regards to rainfall. Similar observations were made by farmers; they were of

the opinion that the rainfall was no more sufficient to support farming activities in a manner that will ensure food sufficiency.

A case in point was in 2007 when torrential rainfall destroyed their crops and irrigation facilities. This is supported by UNDP (2009) and Adu-Boateng and Oppong (2011) when they reported that in 2007 the three northern regions of Ghana - the Northern, Upper East and Upper West Regions - witnessed torrential rainfall leading to flooding and that the rains followed two months of below average rainfall that had already impacted on the farming activities in the northern part of the country. They asserted that the catastrophe affected a number of small-scale irrigation schemes in that part of the country, which had their infrastructure destroyed, thereby affecting the livelihoods of users of irrigation schemes. During FGDs, respondents in buttressing the variable nature of rainfall in Tanga also reported that in 2016 the dam nearly dried up due to poor rainfall in 2015. They said that in 2016 the rainfall was better but did little to improve the water situation in the dam. To them, the low water volume of the dam was a cumulative effect of low rainfall amounts over the years, which they say keeps on fluctuating.

Another indicator of rainfall mentioned was floods. Survey data indicated that participants were not sure whether it was frequent or not. However, in the qualitative data, floods were mentioned by farmers and stakeholders to have occurred in the late 1990s and in 2007 after torrential rain falls resulting in the destruction of crops and other valuable infrastructure including small scale infrastructure in the study areas. They attribute these floods as being intermittent but believe that it was a strong indicator of climate change. Majority of the participants, however, were of the view that since the flooding of 2007, they have not experienced a similar one; however, what they observe now is long dry spells resulting from low rainfall and high temperatures, leading to drier conditions which hampers the viability of irrigation schemes due to decline of water in the reservoirs and this invariably affects crop productivity.

The observations and perceptions of respondents about rainfall patterns in the study areas are in consonance with meteorological data from the Ghana Meteorological Agency collected from the Manga Meteorological Station in the Upper East Region (see Figures 4.4 and 4.5) which indicated that rainfall was reducing in the region. This was also corroborated by several authors who said that the rainfall pattern in the UER is erratic, irregular, patchily

distributed and characterized by extreme drought and floods (Derbile, 2010; Blench, 2006; RCC, 2003).

6.3.3. WIND AND OTHER CLIMATIC CONDITIONS

Windy conditions were used as an indicator of climate change. Participants were of the opinion that winds have become stronger in recent times than before. Survey results showed that participants, in talking about climate change with respect to their localised environment, agreed that there has been an increase in strong wind events. In-depth interviews and focus group discussions with participants also reported strong wind conditions which they perceive as having a strong bearing on rainfall. They mentioned that, the strong wind conditions have been caused by a change in the vegetation cover because some tree species are being lost due to logging by indigenes and outsiders. Farmers perceived that strong or increased wind intensity during the rainy season 'drives' away rain. They explain that when the clouds are thick the strong winds dispel the clouds, which they blame for the low rainfalls they have been experiencing.

Participants mentioned increased rate of transpiration, increased rate of moisture loss in the soil and increased soil erosion as a consequence of the increased winds, coupled with high temperature. Participants blamed low crop productivity on the negative impacts created by the increased wind intensity. To buttress the impact of wind on low rainfalls, a participant (Interview excerpt 1) remarked that:

"…as for the rains, we don't get enough these days. The rains don't reach us nowadays'. When the rains are about to come we experience a lot of wind which drives away the rains" (quote 18).

The narration of the farmer is as a result of her interaction with her environment hence relates the behaviour of the rains and the wind to her personal experience through a lived experience discourse.

Another climatic factor that respondents spoke about was the *harmattan*. In the assessment of the farmers, the harmattan now sets in early and brings along with it cold nights but with heat and hazy conditions in the afternoon. The farmers blame the harmattan for causing erosion due to the strong winds that accompany it, thereby affecting their farming activities and livelihoods. The farmers also blamed the harmattan for the low levels of water in the dam. They are of the opinion that the harmattan brings along dry wind with little moisture, which

leads to rapid evaporation of water in the dam and is also responsible for bush fires because it dries the vegetation cover of the area making it susceptible to fire.

6.4 DISCURSIVE CONSTRUCTIONS ON PERCEIVED CAUSES OF CLIMATE CHANGE

After discussing with participants about their perceptions of climate, I proceeded to discuss with them the perceived causes of climate change. The causes of climate change in scholarly literature has been grouped into two, the first being human activities that alter the composition of the global atmosphere and the second being climate variability attributable to natural causes (IPCC, 2001, 2007; UNFCC, 2007). The human-induced activities causing climate change are largely attributable to increased concentration of GHGs emissions of carbon dioxide (CO_2) from industrial production, which leads to burning of fossil fuels, exhaust fumes from cars, land use change, just to mention a few. Moreover there are other agricultural activities such as intensive cattle rearing, chemical fertilizers, cow dung and deforestation resulting from the industrial revolution in the mid-18th century, which alters the composition of the atmosphere leading to global warming. This era has been described as the anthropocene (Ravkin, 2011) hence the description as man-made or anthropogenic climate change (Hulme, 2001; IPCC, 2007). The natural cause on the other hand is seen as a result of external forces as such as changes in solar energy and volcanic eruption, which also naturally increases GHG concentrations (IPCC, 2001).

In discussing the causes of climate change, I expected a discourse on anthropogenic causes backed by scientific explanations to be salient. Though some of these filtered into the discussions prominently, such as felling or cutting down of trees, the connection between CO_2 concentration and climate change was not established in the discourse. Farmer participants did not see the burning of fossil fuels, use of chemical fertilizers, use of cow dung, deforestation and land use change as major contributors to CO_2 concentrations in the atmosphere leading to global warming and climate change. This could be due to the fact that most subsistence farmers are not formally educated and therefore rely on other factors to explain climate change (Yaro, 2013).

However, results of the quantitative survey indicated that farmers saw emission of fossil fuels (16.7%) as a cause of climate change, thus primarily drawing on an anthropogenic discourse; most likely, this attribution was due to explanation of the terms to farmers during the survey.

The survey results showed that participants saw man-made causes as being dominant, followed by natural factors and disrespect for belief systems (Table 6.4).

Table 6.4: Farmers' views on the causes of climate change

Causes of climate change	Frequency	Percent
Disrespect for belief systems	73	86.9
Indiscriminate felling of trees	84	100.0
Bush burning	82	97.6
Emission of fossil fuel	14	16.7
Natural factors	50	59.5

Source: Field Survey (2017)

Stakeholders including officials of ACTIONAID and Red Cross Society, Ghana on the other hand, indicated indiscriminate felling of tress, use of chemical fertilizers, and bad farming practices such as slash and burn as major contributors to climate change, but they did not see spiritual factors as being a cause. This view is most likely due to the fact that the stakeholders had higher levels of education and have been working with issues related to climate change for some years and are therefore exposed to the scientific explanation regarding the causes of climate change.

From the discussions and interviews with small-scale irrigation farmers, their perceptions on the causes of climate change revolved around these discourses: A Religious/Spiritual Discourse centered on ATR discourse which is divided into two parts (based on God's own plans and ways) and a more spiritual (as a result of cultural beliefs) based on the way we relate to God and disobey him and his creation. Secondly, there are Anthropogenic Discourses (man-made), which are centred around the environment (which is not surprising because the farmers rely on the environment for their survival and their relationship and experience with the environment. This experience is coupled with the indigenous knowledge they have gained over the years, which, to a large extent, influences how they frame and construct the causes of climate change). The discourse categorizes related to this has been outlined in section 6.3.1. These discourses emerging from the study such as, religious and

spiritual beliefs are interrelated in the explanation on the causes of climate change; they are reinforced and shaped by one another (as will be seen in the analysis that follows).

The common theme and discourses in the study areas on the causes of climate change were felling of trees and bush burning, disregard for taboos, farming in sacred grooves, killing of donkeys, and acts of God which participants claimed they had no control over. It should be noted that many of the respondents gave the causes of climate change not based on one particular discourse but from the different perspectives on the causes of climate change. This study is, therefore, of the view that the causes of climate change given by respondents is based on their farming experience, indigenous knowledge, sources of information and religious beliefs which contributes to them forming an opinion on the construction of the causes of climate change at the local level.

6.4.1. RELIGIOUS DISCOURSE ON THE CAUSES OF CLIMATE CHANGE

The Religious Discourse which is a dominant discourse has ATR, Christianity and to some extent Islam as the small discourses. Among these the ATR discourse dominates. The perceived causes of climate change from an ATR discourse perspective was discussed in two segments based on Mbiti (1977 cited in Schuman et al., 2018) that the interwoven nature of humanity and religion indicates that natural occurrences and for that matter nature in itself, inextricably form an important part of African Traditional Religious Beliefs. The first aspect of this discourse as perceived by small- scale irrigation farmers indicates the causes of climate change as a natural phenomenon or occurrence made possible by God; this perception appeared in both the quantitative and qualitative data. In the quantitative survey, 78.4% of the respondents were of the opinion that climate change was caused by natural factors through God's own desire. During in-depth interviews, the discursive constructions of most respondents were that the causes of climate change were attributable to an act of God. They were of the view that climate change is natural and have always occurred. They were certain that since God created the universe the climate has been changing but in recent times it has changed for the worst. They therefore believe that climate change is a natural phenomenon controlled by God's own desires and wishes. They were of the view that God superintends over the universe, controls the temperature and decides what to do with the weather and, therefore, decides whether there would be rain or not. Results from FGDs also attested to the natural causes of climate change as perceived by respondents from the survey and in-depth interviews. Participants mostly made reference to God's wishes as being responsible for

climate change. Respondents also held the belief that climate change was a punishment from God due to disobedience and wickedness on the part of community members. A participant, during in-depth interviews in Tanga (Excerpt 10) on the cause of climate change gave the following explanation:

"I think it is caused by God because he is the owner of the universe. He owns the sun as well as the water so he can determine how to distribute them to us" (quote 19).

The same respondent also indicated that the actions of community members have incurred the displeasure of God hence the changing climate. He summed it up in this way when he said that climate change:

"…… to me, it is a punishment from God and why do I say this? There are places we are not to farm yet we do that. For example we are not to farm on the path leading to the water body because it is the path of some spirits who use it to enter and come out of the water" (quote 20).

A participant, during FGD with men in Tanga, validated the view that climate change was caused by God when he said that: *"It is God's work. He knows why the climate is changing and we cannot question him" (quote 21).*

From the analysis, farmers in attributing the causes of climate change to an act of God also believed that climate change is occasioned by their own activities which are not in line with their indigenous cultural and spiritual practices, thereby incurring the displeasure of God. They, therefore, blamed their own behaviour for the causes of climate change, thereby exonerating God from some of the causes of climate change. The view that climate change is an act of God and for that matter it is a natural phenomenon are held widely by discussants and respondents in the study areas, even though such perceptions are not supported by scientific explanations. The perceptions on the causes of climate change taking this dimension are not peculiar to North-Eastern Ghana. For instance, a study conducted among sedentary farmers in the Savannah zone of central Senegal by Mertz et al (2009a) indicated that farmers have good knowledge and are aware of climate change and variability. However, they tend to assign economic, political and social factors as the reason for climate change, which is a departure from scientific explanations on causes of climate change. Likewise (Yaro, 2013) in his studies on perception and adaptation to climate change in Ghana by both small scale and commercial farmers indicated that small scale farmers attribute change in

climate to social and religious reasons. The perceptions of respondents are partly due to their limited formal education, which makes it difficult to ascribe scientific explanations to climate change. This view is supported by Yaro (2013) when he argued that the unscientific views on the causes of climate change among subsistence farmers in some parts of Ghana was as a result of their low level of formal education and their reliance on superstition to explain natural events because that was their only source of information.

The second segment based on an ATR discourse on the causes of climate change looks at how the respondents, through their cultural and religious beliefs, are attached to and revere aspects of their natural environment and animals they see as sacred. They attribute the causes of climate change to damage they do to God's creation and disobedience of certain traditions which they see as an offence to God. The respondents' believe that it is their role to take care of the sacred elements and the natural environment in their communities and that failure to do so leads to climate change as a form of punishment. This notion is in line with Smith's (2007) assertion that the land is a sacred space that the creator has entrusted to indigenous and local communities to take care of. Therefore, the power to do that resides with them. The respondents, therefore, see themselves as caretakers of the environment and nature based on their religious beliefs. From the study, it was observed that African traditional religious beliefs, indigenous knowledge and experience of farmers were the basis on which they construed the causes of climate change from a spiritual and religious perspective.

Respondents, during focus group discussions and interviews, were of the view that current changes in the climate were a result of peoples' non-adherence to the customs and cultural norms of the society which has its roots in the traditional beliefs and practices passed down to them from their forefathers. The majority of the respondents indicated that many people have abandoned their indigenous ways of worshipping and venerating their ancestors. Respondents and discussants mostly mentioned wickedness towards one another in the community, killing of donkeys, disrespect for taboos and beliefs, farming in sacred groves and the paths of the gods, felling of sacred trees, disrespect for the gods and not paying or offering sacrifices to the gods.

From the interviews and discussions, participants mentioned that the value attached to human life was no longer as important as it used to be. A respondent (Excerpt 5) mentioned how people in the community are wicked to one another when she said that:

"We are very wicked to ourselves, especially in the cover of darkness, thinking that we are hiding but God who is omnipresent and sees all that and as a result decide to punish us" (quote 22).

Another respondent (Excerpt 2) revealed the nature of wickedness when he said that:

"We have become wicked as human beings in Tanga. We kill one another, we don't respect humanity and this incurs the wrath of God leading to climate change. Human life is sacred and since God creates us we have to respect his creation" (quote 23).

From the above statements, respondents are of the view that people are going against God's commandments, which enjoins people to protect and safeguard human life hence the punishment being the harsh climatic conditions being experienced in the study area. The view of the respondents have spiritual and religious connotations which mandates them to be kind to one another and it is this value which they belief is no more respected in the society thereby incurring the wrath of God.

Small-scale irrigation farmers in this study do not only mention the attitude of human beings towards each other as the cause of climate change but also mention the killing of animals they consider as sacred and possessing supernatural powers as another perceived spiritual cause of climate change. A common discourse among majority of the respondents was the killing of donkeys, which I refer to as the *'donkey discourse'*. The donkey, from the observation of the researcher and from interviews, is a traditional animal which plays an important role in the economic activities of the people. The donkeys are used for carting farm produce from the farm to their homes or market; it is used to transport goods of traders, for carting fire-wood, carry water for domestic use and for construction purposes and it is also essential in helping farmers adapt to climate change. This is done by aiding in carrying water during shortages from dug-outs to the farms in the irrigation scheme as well as manure to fertilize their lands. The donkey, therefore, plays an important role in the lives of the people and the small scale irrigation farmers. The donkey is revered in the community and killing it for no apparent reason is seen as a sacrilegious offence. A farmer (Excerpt 6) showed the reverence and spirituality attached to the donkey when he remarked:

"…another cause for the change in climate is the killing of donkeys. You know the donkeys help us a lot so they are sacred animals and we are not supposed to kill them without any reason. But these days we are so callous towards them and God is punishing us for that. They

are like human beings. Formally if you kill a donkey, you sacrifice the head to the gods" (quote 24).

From the remarks, the community believes that because the donkey has spiritual powers, to kill a donkey, one has to get permission from the elders and, if granted, the head of the donkey is sacrificed to the gods to appease them so that they do not visit their wrath on the community, which includes causing harsh climatic conditions. The non-adherence to this rule or custom was perceived as a major cause of climate change. The donkey is even compared to human being,s which shows the level of spiritual and social importance attached to it.

In relation to the '*donkey discourse*', some respondents believed or alleged that because of the supernatural powers possessed by the donkeys, some people kill them and use them for rituals to acquire evil powers, which they use to harm others they perceive as enemies. To them this is not in line with the desires of God. A respondent (Excerpt 11), who held this view, stated that:

"…another reason [about the cause of climate change] I have heard, but it is only God who knows whether it is true or not, is the killing of donkeys for witchcraft purposes. Some people purport that the donkeys have supernatural powers so others kill them to acquire these powers which they use to harm others and because of that God is punishing us. This is an allegation and I cannot verify that since I do not possess such 'eyes'" (quote 25).

The respondent's assertion that he does not possess such '*eyes*' mean that he does not have the spiritual power to confirm that. It is the belief that some people have the power to identify people who are witches in the community. The respondent who made this remark was not certain that such issues exist but the general belief in the community was that such incidence exist and it is a common discourse which community members belief in. The uncertainty in the remark could also be due to the fact that the respondent was a Christian who might not wholly believe in traditional doctrines but was aware that such beliefs were common in the study area.

Disrespect for traditional forest groves, called '*tingban'* meaning shrine in the local Kusaal language, also emerged as a cause of climate change in the Tanga. These groves were reserved areas used as places of worship where offerings and sacrifices were offered to the gods by the elders for the prosperity and safety of the community. The groves were/are considered as the dwelling place of the gods who served as intermediaries between the people

and God. The prayers and sacrifices offered in the shrines were carried by the gods to God and they even interceded on behalf of the community to God. The groves, according to respondents, also accommodated spirits, which protected the community from evil and misfortunes. The roles played by the '*tingban'* made the groves sacred and people were not allowed to farm in them or cut the tress in them for fire-wood. The '*tingban',* apart from playing very important cultural and traditional roles in the community, were also significant in the protection of the natural vegetation and resources, niches and traditional ecological species in the community. The preservation of the sacred groves was also critical in ensuring favourable climatic conditions of the area by reducing the concentration of carbons in the atmosphere through carbon sequestration. They helped in the conservation of water resources especially water catchment sources, attracted rainfall and beautified the environment aesthetically. According to the participants, in recent times people have defied the traditional beliefs and disrespected these sacred groves by having engaged in farming activities in the groves. A participant, who has witnessed this phenomenon, during a FGD session with men in the community, narrated that:

"…to me, farming in sacred groves and shrines have also led to climate change. The gods are responding with such measures. The reasons why farming in the sacred grooves and shrines causes these changes is that the gods assist God in his activities and in farming there we are driving away the gods from their habitat and killing their children (the trees). In such a situation, God will certainly be angry with us and the punishment is the harsh climatic conditions we are experiencing. In fact, the trees in the groves are God's children so if we succeed in cutting them down, what do we expect God to do to us?" (quote 26).

In furtherance to the above analysis, respondents and discussants pointed to disregard for taboos pertaining to not cutting down certain tree species such as Ebony tree (*Diospyros crassiflora*), Shea tree (*Vitellaria paradoxa*) and African locust bean or dawadaw (*Parkia biglobosa*)[17] which were considered sacred, for climate change as shown in plate 6.1 below.

[17] These tree species are found dotted in the community but are mostly considered as sacred if they form a grove around places designated as a shrine (tingban) in the community. A white calico or white smock fabric is tied around the trunk of one of the tress to signify the place as a shrine and the trees as sacred (see arrow in plate 6.1below). A few of such tree species though not forming a grove are also considered as sacred or gods in the community and white calico cloth or white smock fabric is also tied around their trunk to signify them as such.

Plate 6.1: Sacred grove containing ebony tress (Diospyros crassiflora)

They associated such trees with the ability to attract and 'call' rain. They mentioned that such trees have been cut down for farming activities and fire-wood. They blame the disrespect for the sacred groves (shrines) and taboos and for that matter the lack of fear for the gods on the emergence of modern religions (Christianity and Islam). The adherents of modern religions did not have regard for the traditional customs of the community. They considered certain traditional and cultural beliefs as ungodly (devilish) and, as such, disrespected them including the reverence of the shrines and the taboo of not farming and

cutting down certain tree species. A respondent, who was a Christian, did not exonerate himself from blame when he remarked that:

"Another cause is that we have no regard for taboos. Formally, there were trees that we were barred from cutting down. But we have no regard for such taboos any longer. People even fell those trees and use them as fuel wood. We do not respect and fear the gods any longer… I attribute this to new religions such as Christianity and Islam, whereby we the new adherents have no regard for custom any longer… We go and pray and continue to do evil things. So to me, it is a punishment from our ancestors. You know there are some trees which call rain and when we cut them down, certainly God has no choice than to fight us and the end result of that fight is the change we are seeing in the climate" (quote 27).

The research is, therefore, of the opinion that small-scale irrigation farmers still hold on to long age traditional beliefs in the community. Even though some have converted to the new religions, they still believe that the gods are powerful and desecrating their places of worship and abode has serious repercussions for the community including the climate. From the narratives and from a critical discourse analysis view, the emergence of the new religions led to a discourse of blame by some farmers who tend to assign the causes of climate change to the emergence of the new religions and the actions of their members which, to some participants, do not correspond to the status quo in the area in terms of religious practices. They note that religious conversion brought about the abandonment of these critical traditional practices. This therefore shows that there is tension between believers of ATR and adherents of Christianity and Islam, which I suggest might be due to a tilt in religious power that in the past was exclusively enjoyed by leaders of the ATR. The people in the area have been made to think that ATR is founded on devilish acts while the new religions are backed by God.

The study found repeated narratives where participants associated climate change to farming on the paths of the gods. Participants indicated that there are certain areas in the community, which are designated paths of the gods, which they use to visit certain places in the community. The paths of the gods included the paths leading to the '*tingban'* (sacred groves) and the paths leading to water bodies in the community. Many of the respondents argued that the gods and spirits use these paths to enter the water bodies to quench their thirst and into the shrines which are their dwelling places so farming in these areas impede the movement of the gods and spirits. The effect of these actions, according to the respondents, is the change in

climate experienced in the study area. Climate change associated with farming on the paths of the gods was captured by a respondent (Excerpt 10) who said that the cause of climate change:

"…is a punishment from God. And why do I say this? There are places we are not to farm, yet we do that. For example, we are not to farm on the path leading to the water body because it is the path of some spirits who use it to enter and come out of the water. Another issue is that we farm at sacred groves where there are some spirits as well. For example, some of the trees there take in water and enable rains to fall. There is a spirit there which is believed to have the power to call rain" (quote 28).

A male discussant, during a FGD in the community, added that a lack of interaction between the gods and people in the society because of the activities outlined by the respondent above is a cause of climate change by remarking that:

"Another cause is, we have farmed on the pathways and areas meant for the gods thereby blocking their pathways. In so doing the gods are not able to visit us and those we live with have also abandoned us. So what we are experiencing is a consequence of that" *(quote 29).*

The assertion indicates that people in Tanga believe that the gods are part and parcel of the community and have a spiritual interaction with them so their absence accounts for the changing climatic conditions.

From the analysis, discussants and respondents link climate change to non-adherence of traditional belief system and disrespect for particular taboos in relation to actions towards the natural environment. They acknowledge that the disrespect and non-adherence to the traditional belief system and taboos have led to the destruction of flora and fauna located in the reserves (Groves) and vegetation along water bodies. The farmers further described the environment as being bare as a result of felling of trees and farming in the groves and pathways of the gods and spirits and attributed the unfavourable climatic conditions, which they say, is impacting negatively on their farming activities to reduced moisture in the atmosphere thus negatively affected rainfall in the study area. The farmers, who hold these views, are therefore aware that destruction of flora and fauna causes climate change. However, they attribute it to religious and spiritual factors instead of science. These perceptions on the cause of climate change are not only peculiar to the study area but shared by people in other parts of Ghana and Africa. For example, small scale farmers in southern

Ghana in a study conducted by Yaro attributed climate change to religious and moral reasons (Yaro, 2013). Similarly, Mertz et al. (2009a) found out that farmers in central Senegal assign social reasons instead of scientific reasons.

This study argues that the reverence and sanctity accorded the '*tingban'* and areas leading to water bodies considered as the home of the gods was a means through which the local people protected and conserved the natural environment. My study suggests that the indigenous people, based on their experience with their environments, have used these belief systems to maintain the natural resources and climate of the area. The introduction of new religions in the area and the disregard for taboos marked the end of many of these traditional beliefs and opened up the areas for farming and other human activities. The idea of not farming along the water bodies was to conserve the water catchment areas. The trees in the '*tingban'* reduce the exposure of the water bodies to direct sunlight thereby reducing evaporation. The felling of the trees in the groves to make way for farming also took away the roles played by the trees as conservation of the natural climate (climate modifier) and enabling the reduction of the concentration of carbon dioxide in the atmosphere, thereby endangering the flora and fauna located in those reserves and adjoining ecosystems. It is noticeable that all the measures that the traditional beliefs have put in place are related to science discourse even though the local farmers assign spiritual reasons to them. The changes that emerged as a result of the departure from these traditional beliefs may have had an impact on the environment and climate in the study area such as increase in temperature, low rainfall, decrease in surface water and water in the dams and the drying up of the water catchment and marshy areas, thereby contributing significantly to changes in the climatic conditions.

Disrespect for the gods and abandoning or not paying sacrifices was also mentioned by respondents as a cause of climate change in the study area. The respondents reported that the gods are no more held in high esteem seeing taboos that were observed for the gods are now broken with impunity. For instance, a female respondent (Excerpt 11) said that:

"…in these modern times we do not respect taboos. For example, I am a woman and there are some places am not supposed to step foot when I am menstruating, yet we disobey and go there and this can lead to the gods getting angry with us and cause the climate to change adversely as a punishment to the whole community. Even if one person disobeys these taboos, it can affect the whole community. For example too, as part of our customs we are forbidden

to go to the sacred groves as women to swear, yet we do that so the gods will certainly punish the whole community for our disrespect" (quote 30).

Disrespect for the gods, according to the respondents, was also seen in the abandonment or people not being willing to offer sacrifices to the gods. According to the respondents, it was a traditional and customary practice in the past for community members to come together after the rainy season and offer sacrifices and thank the gods for a good harvest and for more blessings in the following year. According to them, this practice is dying out. To them, the issues they are having with the climatic conditions and weather variability is a consequence of their inaction towards the communal sacrifices. The sentiment of the respondents was captured by a respondent (Excerpt 13) in the following remark:

"We don't respect the gods anymore. In the days of our fathers when they harvest they send millet or maize to the Tindana (Earth priest) who collects them and sell them to buy animals such as goats and sheep and use the rest to brew 'pito'[18]. He then gathers all the members of the community, offers sacrifices to the gods and thanks them for a good harvest and prays to them to grant us more blessings the following year. But this practice is dying out because people are no more willing to contribute towards the sacrifices so the gods are angry. In view of that, the change we are witnessing is their wrath upon us" (quote 31).

The abandonment or lukewarm attitude by members of the community towards these traditional sacrifices coincided with the introduction of the new religions which saw these practices as not being in conformity with the wish of God thereby breaking the traditional communal worship and bond which hitherto existed.

6.4.2. ANTHROPOGENIC DISCOURSE

The causes of climate change in this study were not limited only to spiritual and religious discourses based on the African Traditional Religious beliefs of the Small Scale Irrigation Scheme farmers. Many of the respondents and discussants attributed the causes of climate change to anthropogenic or man-made factors as a result of the impacts of human activities on the environment, thereby taking the blame entirely away from God and the gods (super natural forces). The participants and discussants attributed climate change to issues such as deforestation and population growth, which has put pressure on the environment due to

[18] Pito is a local alcohol beverage common in northern Ghana made from sorghum.

competition for natural resources as the man-made drivers of climate change in the study area. Participants, even though accepting responsibilities for climate change through their own activities, do not mostly link it directly to science or global warming as their knowledge seems to be restricted to their lived experiences around their local environments. A few of the respondents, however, are able to link climate change to science based on their own actions and do not blame other supernatural powers for climate change. Respondents also tend to blame some community members who are engaged in economic activities where their trade relies on some natural resources for the cause of climate change as well as some authorities they perceive as being complacent in the blundering of the vegetative cover for the changing climate in the area.

Many respondents and discussants acknowledged that when they were young or teenagers, the community had lots of trees, and the vegetation cover was thick and green, but that cannot be said to be the case in recent times. They complained that the 'trees are no more'. These groups of respondents attributed climate change to deforestation as a result of felling of trees, bush burning and clearing of grasses leading to the vegetation cover being bare. A respondent (Excerpt 9), who was worried about tree felling and bush burning as the cause of climate change, said that:

"When I was young, the community had a lot of trees making the vegetation green. But now, the community is like a desert. Lots of tress have been cut down. Also, bush burning is now a common feature. Hitherto, the fire service will take you on but that is not so now. Our former chief was a strong defender against these acts but he was not getting the support from the district assembly" (quote 32).

Another respondent (Excerpt 3), who linked climate change to drying up of water bodies as a result of felling of tress, complained that,

"Another cause is that we have succeeded in felling a good number of our trees. For example (pointing at a location), there used to be a dug out here which served as a swimming pool for us when we were young men but the trees around have all been cut down and the dug-out which could have collected rain and send back same to produce rain has dried up and filled with sand" (quote 33).

Respondents are therefore convinced that the cutting down of trees have been detrimental to the environment because it reduces the moisture in the atmosphere, thereby reducing rainfall

and increasing temperature. In furtherance of these, respondents and discussants acknowledged the support of others but also blamed some authorities for the environmental menace, which contributes to climate change in the study area. The response from interview Excerpt 9 captures this when the respondent blamed the district assembly while at the same time commending the chief of the community for trying to safeguard the environment by preventing the felling of trees. These sentiments were further re-echoed by respondents who also blamed other authorities in addition to the district assembly. A respondent (Excerpt 8) expressed her sentiments when she remarked that:

"I have also heard that felling of trees can cause the climate to change and if that is something to go by then it could be true because we prevented them from cutting down trees. But about three years ago, some government officials came with some people and they cut down a lot of trees, which could also be a causal factor" (quote 34).

Similarly, another female respondent (Excerpt 5*)* said that:

"Formerly, we were not allowed to cut trees, even women were barred from cutting tree branches for fuel wood. But these days, trees are cut down indiscriminately. For instance, last year some strangers came here and they were given the opportunity by our elders to cut down trees and turn them into lumber. They were mostly Chinese. They really raked havoc to our vegetation. All these activities have a negative impact on the climate because we were taught by our parents that trees help in rainfall" (quote 35).

This indicates that some respondents are well aware that the phenomenon has an impact on climate change but seem powerless to stop it since powerful officials are perceived to be involved in the act of felling trees, especially for commercial purposes.

The issue of officials permitting the cutting of trees for commercial purposes was corroborated by an official of the Red Cross Society in the Bawku West District, who observed that felling of trees has been a major contributor to climate change. The situation has been worsened by the emergence of timber merchants who are cutting down rose word with the excuse that they have been granted permission by the requisite state agencies. The official was quoted in the following words:

"The major cause of climate change is the felling of trees. For instance, I was not particularly keen on some people who were doing logging around the communities but they came with a legal permit from the government (Forestry Department) granting them the

rights to do logging. So they were interested in rose wood and when they cut the rose wood they have to cut down more trees to enable them cart the rose wood out of the forest reserves and already we are in the semi-arid zone so you can imagine the repercussions for the environment. So the felling of trees is the major cause of the changes in the climate we are witnessing. The big trees have all been cut down" (quote 36).

Not only are government officials in collaboration with timber merchants blamed, other community members who rely on firewood for their activities are also seen as major players in tree felling as well as cause of climate change. A participant amply captured this view in the following words:

"Also, we cut down trees for fuel and the worst offenders are the pito brewers and cooked food sellers. Tress brings about rain; they create the conditions for rain to fall. Trees blow air upwards, so when we cut them down, it allows heat to permeate the environment and reduces moisture in the air thereby preventing the rains from falling and increasing temperature" (quote 37).

The issues espoused above indicates that community members have accepted blame but also blamed state agencies for the man-made causes of climate change which is driven mainly by economic motives of the authorities in charge of protecting the environment. My field visits attest to the fact that the vegetation cover was depleting and various tree species have been cut down for construction and other purposes as well as for firewood.

Another issue that was mentioned as a man-made cause of climate change was population growth. I believe this was mentioned because community members felt that population growth was under the control of man, and God does not punish anyone for having more children. Population growth was said to have increased the pressure for resources in the community including land and water for both rain-fed and dry season irrigation farming. A male discussant, during a FGD who held this view, said that.

"I think it is due to population increase which has led to people clearing the vegetation for farming purposes. The population too has put pressure on our irrigation schemes since more people scramble for land and water... leading to competition for livelihood sources" (quote 38) .

The competition for livelihood sources, this study suggests, account for the issues of deforestation since people have to clear forested areas for farm lands and also compete for water for dry season farming purposes. For this reason, population growth can be said to be inextricably linked to the depletion in the vegetation cover as depicted in this picture (Plate 6.2) captured during the field work.

Plate 6.2: Depleted land cover in Tanga (Bawku West District).

Respondents also mentioned the use of chemicals for farming, which has led to farmlands becoming dry. A respondent who held this view also added that the use of the chemicals does not only cause climate change but does not also promote sustainable farming. A respondent (Excerpt 3) during an interview said that:

"In reality, as a child and now an adult, I believe what is causing the change is the use of a chemical called 'condem'[19] *which we use to kill weeds and some pests. If you use the chemical on your field, and it comes to growing the crops, it has a negative impact on the soil and hence the weather. When the chemical is used on your field, no matter the quantity or amount of water you use on the farm, the next day or two the field becomes dry as if you have not watered the field at all. If it used in marshy areas, the chemicals eventually dries up the*

[19] Condem is a weedicide popularly used by farmers to kill weeds in their field.

area and prevents moisture from collecting there. This reduces evapotranspiration which is needed for rainfall. The chemical has also made it difficult for us to dig in our farms to get water to supplement for inadequate water from the dam. I believe the chemicals end up drying up our fields and reduce the availability of water in the fields" (quote 39).

The views expressed above by respondents and discussants correspond with the IPCC's (2007) assertion that, human beings have always influenced the environment like any other living organism. In the analysis, respondents and discussants have expressed views on climate change which correspond to scientific literature on the causes of climate change, though they do not mention scientific terms directly. Respondents used words and phrases such as 'low or high humidity', 'felling of trees allowing heat to permeate the environment', 'reduction in moisture', 'reduction in evapotranspiration', and 'drying up of marshy areas' to indicate that they know the effects of deforestation, land use changes and use of chemicals on the natural environment, and for that matter the cause of climate change. Felling of trees, use of chemicals and land use changes in the community have led to the loss of vegetation cover and environmental degradation, taking away the benefits that a good vegetation cover and forest resources provide. These benefits include carbon sequestration, watershed protection, water catchment protection, wildlife conservation, and the maintenance of a conducive microclimate to support flora and fauna of the community. The impact is not only on the environment but also affects the socioeconomic wellbeing of the citizens in the community as it impacts on their livelihood. The broad impacts of land use changes, resulting from human activities, lead to global warming which is considered widely as the main cause of climate change (anthropogenic climate change). This view corroborates with the IPCC (2007) when they noted in their report that the Industrial Revolution in the mid-18th century gave sufficient evidence to the impact of human activities on global climate change. They were of the opinion that human activities during the said period contributed greatly to climate change through combustion of fossil fuels for industrial as well as domestic use. These fossil fuels, according to the report, generate greenhouse gases and aerosols, which alters the composition of the atmosphere.

Climate change, resulting from land use changes through human activity as identified by participants, could be linked to the changes in attitudes from generation to generation in relation to how people relate with the trees and other natural resources in the community. In the interviews, participants kept referring to the past and to their fathers and forefathers and how they related to the environment as compared to present times. Respondents'

reminiscence the past reports that the vegetation cover was thick and compared it to other places in southern Ghana with thick forest reserves and, therefore, blames their current actions for climate change.

A respondent (Excerpt 13) noted that:

"I have observed that members of this community do not listen to advice. We have cut down almost all the trees which were supposed to contribute to rainfall. When this dam was constructed, it was surrounded by lots of trees and we referred to the dam site as Kumasi[20]. But all the trees have been cut down so when you walk to the dam there is no more vegetation to even protect the dam. It is just bare land now" (quote 40).

The bond to the environment seems to have waned with the younger generation who do not revere the forest as done in the past. The reason for this could be driven, in part, by the motivation of the younger generation to accumulate wealth through logging, the need to have farmlands as a result of population growth, and the lack of fear for the gods driven by the emergence of new religions. According to a respondent, who held on to the assertion that generational gap contributed significantly to climate:

"*Our fathers said in years past, bush burning and felling of trees were not common but today, it is a very common phenomenon in this community. So I think that is a major cause. Formally, we used to prune the trees and they grow later but now, we just cut them down totally. Also, the grasses use to serve as wind breaks but now, we just burn them for no apparent reason. Because of that, the winds we experience nowadays are dry without moisture and that increases the temperature and reduces the amount of rain we get" (quote 41).*

The above quotation shows that cutting of trees was a controlled mechanism, which did not necessitate the total destruction of the trees and grasses. However, in recent times, people cut down and burn grasses without regard for their replenishment.

The analysis shows that the perception of causes of climate change is multifaceted. In the discussions, all the discourses on climate change are linked and intersect with each other. In the analysis it could be seen that activities on the natural environment, especially the felling

[20] Kumasi is the capital city of the Ashanti Region of Ghana and is referred to as the garden city of Ghana because of its thick vegetation cover. Migrants from northern mostly refer to areas they have travelled in that region as Kumasi.

of trees and disregard for taboos were seen as major drivers of climate change. Belief systems are therefore still very much seen as a major cause of climate change. Even though activities that lead to deforestation and depletion of natural resources in the community have been seen as a major cause of climate change, the major disagreement is that some participants and discussants link the changes to natural causes, while others see them as the work of the gods and ancestors of the community due to disrespect and disregard for them (ATR perspective), while a third category of interviewees see the changes as man-made (anthropogenic). The causes of climate change from this study are therefore based on the lived experiences of the participants with their environments and the knowledge system they have formed over the years. The lived experiences of the small-scale irrigation farmers, therefore, informs the indigenous local knowledge they have by way of beliefs which try to conserve the local ecological system. The erosion of these indigenous knowledge systems, which have roots in their belief systems, accounts for the reasons they assign to climate change. The views are in consonance with Guba and Lincoln (1994: 110-111) that "realities are apprehendable to the form of multiple, intangible mental constructions, socially and experientially based, local and specific in nature (although elements are often shared among many individuals and even across cultures), and dependent for their form and content on the individual persons or groups holding the constructions".

6.5. SUMMARY

The perception and discursive construction of climate change by farmers, based on their observations over more than two decades and data from the meteorological authority in the Upper East Region, indicate that a majority of the interviewees were aware that the climate was changing. Farmers identified several sources of information on climate change, which consciously or sub-consciously influences how they perceive climate change. The sources of information were grouped into internal and external sources of information. The internal sources of information included the personal experiences of the farmers, information from religious places, family members, social groups, neighbouring farmers, friends and community meetings. The external sources included information sourced from the media especially through the radio, television and mobile phones as well as from officials of NGOs/CBOs and extension officers. The sources of information from the study reinforce each other and enable co-learning thereby leading to diffusion of knowledge and other farming practices and adaptation strategies.

On perceptions and discursive constructions of climate change the farmers referred to low, erratic and seasonal variability in rainfall, rise in temperature and increased winds as a result of environmental degradation. Small-scale irrigation farmers also identified traditional methods of predicting the weather, which included the fruiting of Shea and Mango trees and the movement of the clouds and wind direction and speed. These predictions were mainly rooted in the indigenous knowledge of the people, which they have learnt over the years as well as on their traditional religious and spiritual beliefs.

In this chapter I discussed the causes of climate change where respondents acknowledged that climate change was real but espoused different and varied opinions on its causes. While some respondents used scientific explanations, though not explicitly, others took a more religious and spiritual tone while yet again others saw it as a natural occurrence caused by God and that the climate has always changed. Those who held spiritual and religious views attributed it to disrespect of the gods, not adhering to taboos as a result of the emergence of new religions which have eroded the importance and reverence attached to sacred natural places. A majority of interviewees linked climate change to land use changes caused by human activities such as felling of trees. This was also the view held by other stakeholders.

CHAPTER 7: EFFECTS OF CLIMATE CHANGE ON LIVELIHOODS AND INDIGENOUS ADAPTATION TO CLIMATE CHANGE BY SMALL-SCALE IRRIGATION SCHEME FARMERS IN BAWKU WEST DISTRICT

7.1. INTRODUCTION

West Africa is considered to be one of the regions likely to be the most affected by climate change. Vulnerability in West Africa, including Ghana, is a result of its geographical and climatic features dominated by the savannah which is susceptible to climate change (Laube, 2007). Africa, which contributes less to climate change, is regarded as the continent which might be the most severely affected by climate change due to its reliance on agriculture, and it is estimated that by 2020 between 75 and 250 million will encounter water shortages due to climate change and also hampered water availability for irrigation. According to most authors, this scenario will affect food security and crop revenues, and those affected the most will be small- scale farmers ((Boko et al., 2007; Challinor et al., 2007). The adverse impact on their livelihoods therefore necessitated the call for measures to be taken to adapt to the adverse effects of the climate change with emphasis on their own local knowledge, which this study considers to be a good mechanism for farmers' to overcome the vulnerabilities they face in their irrigation farming activities. This chapter therefore considers findings and discussions of small-scale irrigation scheme farmers in the Bawku West District and the perceived and discursively constructed impact of climate change on their irrigation schemes as well as their living conditions (Livelihoods). This also includes the measures they have adopted on the basis of their indigenous (local) knowledge to overcome these adverse impacts and to ensure that they livelihoods, though affected, do not derail their ability to earn a decent living.

7.2. DISCURSIVE CONSTRUCTIONS ON THE EFFECT OF CLIMATE CHANGE ON THE IRRIGATION SCHEME

The farmers recognized that there was a relationship between climate change and variability on their irrigation scheme and the agricultural activities in the scheme, which impacts on their livelihoods. They agreed that climate change has had an adverse impact on their irrigation scheme and the facilities offered by the scheme. The effect of climate change stressors on the

irrigation scheme are destruction of irrigation scheme infrastructure, drought leading to water scarcity, soil erosion and infertility, siltation of the dam and increased crop diseases and pests. From the survey results depicted in Table 7.1 below eight major effects of climate change on the irrigation scheme are illustrated. The eight adverse impacts of climate change on the irrigation scheme can be grouped into impacts on the irrigation scheme infrastructure, water and soil and issues on crops and plants. The adverse impacts of climate change and the grouping is consistent with studies in Africa which indicated the vulnerability of the continent to the impacts of climate change on infrastructure including water systems, health, settlements and the natural ecosystem (IPCC, 2007; IFAD, 2008; UNDP, 2009; Adu-Boateng and Oppong, 2011). Climate Change from the narratives is therefore seen as the 'villain' (blamed for hindering livelihoods) and farmers and the irrigation scheme are the 'victims' (they suffer the adverse effects of climate change).

Table 7.1: Effects Climate Change observed by small-scale irrigation Farmers on the Irrigation Scheme (measured on a likert scale)

Effects of climate change on the irrigation scheme	N	Min.	Max.	Mean	Std. Dev.
Destruction of irrigation infrastructure	84	2	5	4.74	.583
Decrease in volume of water	84	2	5	4.80	.510
Declining and loss of wetlands	84	1	5	4.18	1.099
Increase pests and crop diseases in the scheme	84	1	5	4.50	.912
Soil erosion seems to be a much bigger problem	84	1	5	4.10	.900
Siltation has increased	84	1	5	3.61	1.222
Soil is becoming infertile	84	1	5	4.37	1.050
Declining vegetation cover	84	1	5	4.02	1.414

Source: Field Survey (2017)

Note: Likert scale scores strongly agree=5, Agree=4, Not Sure=3, Disagree=2, and strongly disagree=1.

Results of survey data from table 7.1 above indicate that respondents strongly agree that the destruction of irrigation infrastructure and decrease in volume of water were the major effects of climate change on the irrigation scheme with scores of 4.74 and 4.80 respectively. These farmers reported that these two major issues impacted negatively on the smooth operation of the irrigation scheme and by extension on their farming activities. Other critical, adverse impacts on the irrigation scheme mentioned during the survey were increased pests and crop diseases in the scheme (4.50), soil becoming more infertile (4.37), declining and loss of wetlands (4.18), soil erosion becoming a bigger problem (4.10), declining vegetation cover (4.02) and increased siltation (3.61). All the issues mentioned during the survey collectively contribute to the irrigation scheme not functioning at its optimal level as one problem has a bearing on the other or leads to exacerbation of the other. For instance, loss of vegetation cover and wetlands as well as increased siltation in the irrigation scheme can or leads to a decline in water volume even if rains fall in the required amounts. This is well demonstrated during the in-depth interviews and FGDs.

The findings of the survey (questionnaire administration) above are corroborated by findings from qualitative data consisting of in-depth interviews and FGDs. A majority of farmers were of the view that the infrastructure in the irrigation scheme has been destroyed as a result of floods and that water levels have also been on the decline as a result of low rainfall and high temperatures. They also mentioned the other factors which were amply captured in the survey results. When a question was posed on the impact of climate change on the irrigation scheme a male respondent during a FGD with regards to infrastructure said that:

> *"The irrigation scheme has also suffered from floods in 2007 which destroyed a lot of facilities at the scheme. The spillway, canals, walls and pumps of the dam were virtually destroyed. This has affected our activities till date. The floods also led to the siltation of the dam. A lot of sand and debris were washed into the dam, so the dam cannot hold a lot of water" (quote 42).*

The quotation above by the male farmer is in consonance with findings in the UER by authors who reported that irrigation infrastructure witnessed a major destruction during the floods of 2007 and 2009 (UNDP, 2009; Adu-Boateng and Oppong, 2011). The destruction of some irrigation infrastructure is depicted in plate 7.1 below.

Plate 7.1: Damage to Irrigation Infrastructure in the Irrigation Scheme.

Besides the damage to irrigation infrastructure, a majority of the respondents reported a decline in water levels in the reservoir of the dam. They were of the view that the reservoir of the dam has not been able to hold enough water or did not receive enough water due to several factors. The decline in the volume of water which was strongly agreed by farmers in the survey data was attributed to a decrease in the rainfall volumes and rising temperatures leading to evaporation. A respondent (Excerpt 3) on the issue of decline in rainfall indicated that:

"The impact of climate change in the scheme is very adverse. It is creating a lot of problems for the scheme. The first thing is that it has led to a reduction of water in the scheme as a result of low rainfall and evaporation due to excessive heat. This has led to water rationing in the scheme" (quote 43).

Other reasons adduced by the respondents for the decline in the water levels in the dam were declining and loss of wetlands. According to the respondents, wetlands were a common feature in the study area in the past, especially around the irrigation scheme, and this provided a fertile atmosphere for reduced heat and hence less evaporation. However, in recent times that has not been the case and they also attribute the loss of wetlands to a decline in the vegetation cover hence loss or decline in vegetation cover is also being blamed for the decline in the water levels in the dam because the absence of trees also increases evaporation

due to increased temperature leading to a decline in the volumes of water in the dam. The views expressed are amply captured by a respondent when answering a question on the impact of climate change on the irrigation scheme. Representing the problem through a hybrid of anthropogenic and Indigenous Knowledge Discourse on low water volumes and the experience of the farmer on the dam, the respondent (Excerpt 4) said:

> *"The major problem is low amounts of water in the dam as a result of the low rainfall. Another impact is that the harmattan winds also affect the quantity of water in the dam, this is because we have succeeded in burning the bush and felling the trees which will help reduce evaporation but in the absence of trees when the wind blows we lose a lot of water from the dam" (quote 44).*

On the issue of impact of climate change on loss and declining wetlands another respondent (Excerpt 9) indicated that:

> *"The major impact is that it has led to the drying up of marshy areas in the farms, as you can see {pointing to a spot in the field}, it used to be a marshy area but the whole place is dried up now, we used to get water there and nurse our seedlings there but its virtually dried up leading to competition among farmers" (quote 45).*

The farmers further said that the lack of vegetation makes the scheme vulnerable to wind and excessive rain because the trees which hitherto served as wind breaks were no more existent and the results of this is that it leads to a lot of sand and debris being collected into the dam, leading to siltation and choking of the dams thereby reducing the depth of the reservoir making it impossible to hold the maximum volume of water it was constructed to hold even when the rains are 'good'. A male farmer who was actually worried about the situation during a FGD said that:

> *"The floods also led to the siltation of the dam. A lot of sand and debris were washed into the dam, so the dam cannot hold a lot of water" (quote 46).*

The issues elaborated above have also been blamed for soil erosion and soil infertility in the catchment area of the irrigation scheme as well as the proliferation of pests and diseases affecting crops in the irrigation scheme which affects farming activities and their livelihoods. Plate 7.2 below shows a picture of the dwindling level of water in the Tanga irrigation scheme.

Plate 7.2 Dwindling Water Levels in the Reservoir of the Tanga Dam.

From discursive constructions of impacts by climate change on the irrigation scheme elaborated above it appears that respondents strongly agree that climate change is a threat to the existence and sustenance of the scheme. The impacts of climate change which include destruction of infrastructure in the scheme, dwindling water levels, siltation of the dam and other challenges translates into the livelihoods of the farmers who depend on the irrigation scheme in the Tanga community, and this is explored in the next section which assesses the impact of climate change on the livelihood of the farmers. In section 7.2 the discourse of lamentation intertwines with a Discourse of natural science, both drawing on a big Anthropogenic Discourse and a Discourse of Indigenous Knowledge about the future of the irrigation and for that matter the livelihoods farmers.

7.3. DISCURSIVE CONSTRUCTIONS ON THE EFFECT OF CLIMATE CHANGE ON THE LIVELIHOOD OF IRRIGATION SCHEME FARMERS.

The relationship between climate change and livelihoods was clearly demonstrated by the small-scale irrigation scheme farmers in the study area. They were able to display the impacts of climate change on their wellbeing due to its impacts on their farming activities in the irrigation scheme. The change in climate therefore affects their activities and for that matter stimulates adaptation strategies and practices among the small-scale irrigation farmers. As mentioned in section 7.2 above, the major climate stressors that affect their irrigation scheme are water scarcity as a result of low rainfall or drought in some years and flooding in others. These circumstances destroy irrigation infrastructure, loss of vegetation and wet lands

affecting the scheme as it leads to the siltation of the dam and finally soil erosion and infertility, and these stressors cumulatively impacts on livelihoods.

Table 7.2: Effects of Climate Change on livelihood of Small- Scale Irrigation Farmers

Effects of climate changes on livelihood	Low	Medium	High	Total (%)
Increased in droughts and crop failure	1 (1.2%)	7 (8.3%)	76 (90.5%)	**84 (100.0)**
Declining crop yields	1 (1.2%)	9 (10.7%)	74 (88.1%)	**84 (100.0)**
Post-harvest losses	4 (4.8%)	20 (23.8%)	60 (71.4%)	**84 (100.0)**
Erosion and soil fertility	1 (1.2%)	32 (38.1%)	51 (60.7%)	**84 (100.0)**
Poverty (Low income) and food shortage	6 (7.1%)	9 (10.7%)	69 (82.1%)	**84 (100.0)**
Rising cost of farming	5 (6.0%)	23 (27.4%)	56 (66.7%)	**84 (100.0)**
Destruction of farm roads and homes	21 (25.0%)	31 (36.9%)	32 (38.1%)	**84 (100.0)**
Siltation of water bodies	12 (14.3%)	36 (42.9%)	36 (42.9%)	**84 (100.0)**
Destruction of vegetation cover	13 (15.5%)	23 (27.4%)	48 (57.1%)	**84 (100.0)**
Rural-urban migration	53 (63.1%)	20 (23.8%)	11 (13.1%)	**84 (100.0)**
Lack of potable water	23 (27.4%)	24 (28.6%)	37 (44.0%)	**84 (100.0)**
Extinction of some crop varieties	14 (16.7%)	26 (31.0%)	44 (52.4%)	**84 (100.0)**

Source: Field Survey (2017)

Farmers also mentioned the impacts they had experienced over time in consequence of climate change and variability in the area. The effects of climate change as perceived by the farmers are depicted in table 7.2 above, and its manifestation in the daily lives of the respondents is also shown in table 7.3 below.

Table 7.3: Manifestation of the impact of climate change on livelihood

Manifestation of the impact of climate change on livelihood	Increased	Same	Declined	Total (%)
Food availability	21 (25.0%)	7 (8.3%)	56 (66.7%)	**84 (100.0)**
Income from farming	17 (20.2%)	12 (14.3%)	55 (65.5%)	**84 (100.0)**
Crop varieties	3 (3.6%)	50 (59.5%)	31 (36.9%)	**84 (100.0)**
Crop yield	7 (8.3%)	17 (20.2%)	60 (71.4%)	**84 (100.0)**
Human health	47 (56.0%)	20 (23.8%)	17 (20.2%)	**84 (100.0)**
Ability to access social services	29 (34.5%)	24 (28.6%)	31 (36.9%)	**84 (100.0)**
Ability to provide basic needs of family	13 (15.5%)	21 (25.0%)	50 (59.5%)	**84 (100.0)**
Ability to buy farm inputs	9 (10.7%)	10 (11.9%)	65 (77.4%)	**84 (100.0)**
Availability of family labour	12 (14.3%)	16 (19.0%)	56 (66.7%)	**84 (100.0)**

Source: Field Survey (2017)

Among the issues raised as manifestation of the impact of climate change on their livelihood are crop failure, decline in income and rising poverty, which had a ripple effect on their farming activities and standard of living. The situation enumerated by farmers creates a situation of vulnerability among the farmers due to the fact that they end up not having the necessary and required resources to meet their daily basic needs.

The major effect of climate change reported by respondents (90.5%) was crop failure as a result of increased drought, low rainfall and high temperatures leading to low water volumes in the dam. With issues of crop failure most respondents also linked it to increasing erosion and soil infertility. The above scenario culminates in declining crop yields which was reported by 88.1% of the respondents. A question to find out the impact of climate change on their farming activities during in-depth interviews elicited the following response which supported what was obtained during the survey analysis when a male respondent (excerpt 3) said that:

> *"The climate change has adversely affected the amount of yield I get. The yields cannot let us meet our basic needs adequately and also curtail our ability to purchase farm inputs needed for rain-fed agriculture thereby exacerbating the poverty further" (quote 47).*

From his remarks a tone of hardship and deprivation with regards to meeting the daily needs of life as a result of low yields can be seen; he thus applies a discourse of lamentation in constructing the untold hardship that climate change has caused on his livelihood. Other links from the survey results which can be linked to low yields were post-harvest losses, which was reported by 71.4% of farmers, siltation of the dam (42.9%) making it difficult to get enough water for the irrigation farming cycle and destruction of vegetation cover (57.1%) which hitherto served as wind breaks and also prevented sand from silting the dams and affecting water levels. The net effect of the above impact of climate change is the unavailability of a minimum of food requirements for most households.

The net and final impact of climate change which I have drawn from the survey, FGDs and an in-depth interview results is decline in income and rising poverty with its attendant effects. The study shown in the survey in table 7.2 revealed that incomes had declined, and from table 7.3 above which shows the manifestation of the impact of climate change almost two-thirds of respondents corresponding to 65.5% indicated that their income from farming in the irrigation schemes had also declined. They were of the view that due to low productivity they were not able to sell much to earn enough money to meet their daily needs and that of their households. Farmers were of the view that their standard of living was declining and they had to spend money on food to the neglect of other needs of the family as depicted by a male respondent (excerpt 6) who indicated that:

> *"The first impact is that it leads to low crop production especially onions and tomato production. At the time we needed water for the crops the dams had weaned in terms of water. It has really affected our finances making it difficult to meet our own needs and that of my family" (quote 48).*

The above statement by farmers (6) draws on an overarching Climate Change Discourse constructed discursively through a lamentation discourse of not getting enough water for their crops combined with a household economy discourse inadequate finances to satisfy family needs.

This situation was further lamented by male farmers who complained about how low productivity had eroded their incomes but linked it to their wives, which sounded intriguing. According to most of them their wives who supported the household income by cultivating vegetables in the schemes cannot adequately do so because their vegetable farms have also

been affected by the inadequate water syndrome and pests and diseases. The lamentation of the male farmers was captured by a male farmer during a FGD when he said that:

> *"We always run out of food and money because the yields are no more enough and we have wives and children to cater for. In fact our finances are always eroded. The activities of our wives too in the irrigation schemes have been of immerse benefit to us and our households because they engage mostly in vegetable cultivation which they sell to support the family but the problem is that there is a proliferation of pests and diseases and shortage of water which are wreaking havoc on the vegetables leading to loss of crops, this has impacted negatively on their incomes leading to a ripple effect on the upkeep of the whole household especially with regards to taking care of our children's need especially with regards to their educational needs such as books and other learning materials. "Can't you see that we the men are even looking miserable" [amidst laughter] (quote 49).*

The text or quotation signifies that the study reflects a patriarchal society where the power relations favour men, although the efforts of women are being recognized. This accounts for the reason why women are not discriminated against when land allocations are made in the scheme. The laughter that accompanies the respondents submission shows that in the past according to cultural norms it was not acceptable for women to be seen as breadwinners let alone for a man to be *'miserable'* because his wife's finances has dwindled and as such cannot support the family as expected. The above quotation draws on a major (big D) Climate Change Discourse which talks about its impacts on households. Drawing from that are other minor (small d) discourses of the household economy discourse combined with a needs discourse especially with regards to incomes to cater for the family and children needs as well as a gender discourse showing the role women play in the household economy and a lamenting discourse of the plight of the household occasioned by loss of crops.

In general, a majority of the respondents were of the opinion that limited access to money made it difficult for them to meet their household needs especially that of their children as intimated by a female farmer during FGD who said that:

> *"...It has led to a reduction in our income, so supporting the family especially providing the needs of our children have become difficult" (quote 50).*

Other associated impacts of climate change as depicted in tables 7.2 and 7.3 on the farmers include rising cost of farming, rural-urban migration of the youth, inability to buy farm inputs and inability to hire labour.

In conclusion, the above mentioned impacts of climate change on livelihood are a problem affecting about two-thirds of respondents who acknowledge that climate change is a big problem. Farmers therefore acknowledge that climate change stressors make their livelihoods vulnerable, which therefore calls for a response. The identification of the impacts of climate change by the respondents is therefore a sine qua non for them to adopt strategies to deal with or adapt to the impacts of the changing climatic and environmental conditions which the next section explores.

From the above analysis the Big D Discourse centred on major issues which are the religious/spiritual Discourse, science-based natural phenomenon Discourse and indigenous knowledge Discourse. The small d discourse therefore was around areas of everyday discussions on the overreaching Big D discourses based on Gee's (2011) assertion as language in use. In summation the small d discourses are seen as a sub-set of the Big D Discourses,

7.4 INDIGENOUS KNOWLEDGE AND ADAPTATION TO CLIMATE CHANGE BY IRRIGATION SCHEME FARMERS.

The adverse impacts of climate change as expressed by farmers cannot be left in isolation as it impacts on their living and wellbeing. In view of this, and as part of its objectives, the study found that farmers employ strategies and measures on the basis of their local knowledge to deal with challenges posed on them by climate change so that they can sustain their farming activities from the irrigation scheme. Indigenous or local knowledge is seen as the most important resource which people use to overcome their vulnerabilities and solve their problems. The importance of local knowledge as part of social capital has been identified by several authors as the most important asset which reinforces the other assets. For instance Bourdieu (1986) reiterated the importance of social capital when he said that its importance lies in the fact that it facilitates collective ideas and actions among people, in this instance the farmers, and therefore serves as an avenue to strengthen the adaptive capacity of the farmers. He indicates the significance of social capital when he asserted that social capital affords members of a group with the credentials which entitles them credit in the various senses of the word and this is guaranteed by the backing of the collectively owned capital. Also Dulal

et al. (2010:14) in citing Bebbington (1999) and Adger (2003) said that social capital "enables the society to effectively interact with other capital assets and appropriate institutions, like the state, civil societies and financial institutions that can help formulate livelihood strategies that would enhance their ability to cope with extreme weather conditions". Indigenous knowledge has been used over the years by local people to solve specific problems due to their intimate knowledge with their environment. In this study I adopt the view that indigenous knowledge is not wholly local but a fusion with any external knowledge, which is appropriate to help farmers deal with the impacts of climate change. From this school of thought, Dove (2010) noted that the concept of indigenous knowledge goes beyond its tenets premised on localization, continuity and homogeneity. He further said that the production of indigenous knowledge involves the interaction between local communities who have their own practices and beliefs and external agents or stakeholders who have their own practices and beliefs culminating in the production of new knowledge through experimentation and changes in production technologies. In this regard, Stiglitz (2000) acknowledges that the variety and complexity of human society requires the localization of knowledge. That is the process of allowing, adapting and using knowledge created by others (external) to the local environment. Agrawal (1995:422) therefore said that:

> *"Certainly, what is today known and classified as indigenous knowledge has been in intimate interaction with western knowledge since at least the fifteenth century. In the face of evidence that suggest contact, variation, transformation, exchange, communication, and learning over the last several centuries, it is difficult to adhere to a view of indigenous and western forms of knowledge being untouched by each other".*

The above issues will therefore guide the discussion on the ways the farmers adapt to the effects of climate change using their own knowledge.

From the survey results 94% of farmers adapt to climate change using indigenous knowledge while 6% do not adapt to climate change, using their local knowledge. The farmers who adapt to climate change using indigenous knowledge indicated that they practice a number of local farming methods and strategies whilst also admitting that they do not wholly rely on their local knowledge but employ other strategies from outside, which can help them deal with impacts of climate change. Out of the 6% who said they did not make any adjustments to their farming practices mentioned that their inability to adjust was due to inadequate

financial resources, lack of information on adaptation strategies and inadequate knowledge on local strategies. The next sections look at how farmers use indigenous strategies to deal with climate change impacts.

7.4.1 INDIGENOUS KNOWLEDGE AND WATER CONSERVATION MANAGEMENT

The need to adapt to water issues arises from the fact that rainfall has been unreliable, leading to low water volumes in the dam and this impacts adversely on crop production. Farmers or households adapt to water inadequacy in several ways using their local knowledge as shown in Table 7.4 below.

Table 7.4: Indigenous Knowledge and Water conservation management

Water conservation management	Frequency	Percent
Planting early maturing crop varieties	67	79.8
Mulching	72	85.7
use of dug-outs and ponds	48	57.1
Rain water harvesting	46	54.8

Source: Field Survey (2017)

From the survey results above 79.8 percent of farmers indicated that due to low water levels they have resorted to planting early maturing crops varieties. This they say was a move from the traditional varieties which they hitherto were planting. This was corroborated during interviews and FGDs when the respondents noted that they plant early maturing lettuce, onions, green pepper and tomatoes. For instance during a FGD with male farmers a respondent said that:

"We have also resorted to planting early maturing crops especially tomatoes, green pepper, lettuce and onions" (quote 51). This they said was introduced to them by their extension officer and that they were also found in the Agro-based shops in the District capital, Zebilla.

Another strategy used by farmers to conserve water in the irrigation for cultivation of crops was mulching; this was supported by 85.7% of farmers. Mulching is a strategy used by the farmers to deal with high temperature which has an effect on seedling survival and growth. It

enables the maintenance of even soil temperature, protects the soil from erosion, conserves moisture and suppresses weed growth. It is therefore done to prevent water loss through evaporation. From the interviews and discussion, mulching involves the local farmers using dry leaves and cutting grasses or straw to cover the surface of the soil or plant basing so that the above advantages can be achieved. The materials can be used together or in isolation. Other advantages of mulching are that it improves the water and nutrient holding capacity of the soil and prevents the breakdown of soil structure. During the interview a majority of farmers in Tanga said they used this method to protect their seedlings from the high temperature and to aid in germination. A farmer during an interview vividly captured this when she explained that:

> *"We mulch the seedlings by putting grasses over them to prevent them from drying as a result of the scorching sun. We do that for about a week, also that period we come early and water the crops to provide them with moisture. In the case of onions after removing the grasses we allow them for a month before transplanting them" (quote 52).*

From the quotation it can be inferred that mulching the seedlings is a crucial element in their survival and farmers pay very critical attention to it because failure to do so will lead to them losing their crops as a result of water scarcity. From the quote a minor discourse of horticulture and cultivation can be inferred drawing from a bigger indigenous knowledge discourse.

Small dugouts or ponds constructed in the farms were other indigenous strategies used by the irrigation farmers to supplement water shortage in the dams and also conserve water for irrigation purposes. From the survey results, 57.1% of farmers reported that they use this strategy to ensure that their crops do not wither as a result of water rationing. The farmers during in-depth interviews and FGDs also supported this view. During the interviews and discussions, the farmers indicated that the process of digging the dugouts was a tedious process, but they had no choice but to engage in that to save their crops. They said that this has been handed to them by their forbearers and they have continued with it. A female respondent during FGDs said that:

"What we do is to dig wells in the fields or areas around the field where we think we can get underground water to aid in the watering of the crops. The problem with digging of the wells is that in most cases we do not get water especially in the farms, so we mostly move farther away, so if you are not strong and energetic it becomes difficult for you to undertake well digging as an adaptation measure" (quote 53).

Similar views were espoused by most farmers but they still see it as the most important strategy to deal with water shortages in the dam. Some farmers even had multiple dugout or wells to support their farming activities. The picture below shows some dugouts in the Tanga irrigation scheme.

Plate 7.3 Images of Small Dugouts used by Irrigation Scheme Farmers in Tanga.

Closely related to this is the fact that farmers also indicated that they do rain water harvesting as local adaptation strategy to deal with water unavailability. They contend that they dig ponds near the farms which harvest water during the rainy season, and they use the harvested water during the dry season to supplement what they get from the dam. This was supported by 54.8% of farmers. The picture below shows a pond constructed for such purposes.

Plate 7.4 Pond constructed to harvest water to supplement water from the dam.

Finally, water rationing was another conservation measure instituted by the farmers through their water WUA to deal with water shortages. The farmers said that they agreed to a water rationing timetable to be provided with water every other day for their crops so as to save the dam from drying up entirely. The rationing was scheduled depending on the farmer's location so that every farmer benefits from it, whether you are near the source of water or further away. These they combine with other water acquisition and conservation techniques or strategies as mentioned above. This was epitomised by a quotation from a female farmer (Excerpt 12) who said:

> *"The water is rationed every other day so that water can replenish a bit since we are of the view that the bed of the dam is able to also produce some quantities of water.*

This is done so that we can all enjoy from the water and this affects the quantity we can produce" (quote 54).

Rationing according to the farmers is done at the critical stage of the growth of the plants when they need water to mature well as indicated by this male farmers during a FGD: *"We also ration the water, we sometimes have to supply the farms every other day to prevent the crops been starved of water at the critical stage of their growth when they need water to mature well and produce good harvest" (quote 55).* These assertions by farmers go to show the importance of having adequate water during the dry season so that crops do not wither in the wake of water shortages.

7.4.2 INDIGENOUS KNOWLEDGE AND TEMPERATURE MANAGEMENT

Temperature is one of the indicators that work against the farmers in the irrigation scheme. This applies in particular to high temperature which farmers said impacts on their farming activities as outlined in chapter six. This is also buttressed by McCarthy et al., 2001; Arnell, 2004; IPCC, 2007; Funk et al.,2008 when they indicated that temperature and precipitation have a direct influence on agricultural production and as such are the two most important variables when dealing with agricultural production. Among the effects of high temperature as iterated by farmers are that it leads to evaporation which affects the water levels in the dam as well as wilting their crops as a result of the increased intensity of the sunshine. Since these issues affect their farming activities I explored how they adapt to these conditions using their indigenous knowledge. Survey data results outlined the measures they use to adapt to high temperatures as depicted in table 7.5 below which was also complimented by results from in-depth interviews and FGDs.

Table 7.5: Indigenous Knowledge and Adaptation to High temperature

High temperature	Frequency	Percent
Cover cropping	67	79.8
Mulching	76	90.5
Shading	52	61.9
Planting/growing trees	47	56.0

Source: Field Survey (2017)

As indicated in table 7.5 above, 79.8 percent indicated that they resort to planting certain types of crops they refer to as cover crops to shield their main crops from direct sunshine. Cover crops that they grow were specifically for the benefit of the soil and the main crops they grow rather than harvesting them for food. The cover crops shield against extreme temperature and their main crops such as onions, tomatoes and other leafy vegetables. During observation it was seen that most farmers cultivated maize at the margins of their beds to protect their main crops from the harmful effects of direct sunlight. It must be noted that though maize take a long time to mature they are planted or cultivated due to their ability to shield the other crops.

In addition, 90.5% of farmers revealed that they use mulching as a traditional method to curtail the adverse effects of extreme temperature and also conserve water as already discussed in section 7.4.1. Closely related to this is another indigenous method referred to as shading. This involves the farmers putting up peaks and rooftop which is then covered with grasses or straw to prevent the rays of the sun falling directly on the crops. This is done when the crops are about maturing so as to prevent crop failure as a result of wilting. This was corroborated during in-depth interviews when a male respondent (Excerpt 3) noted that:

"We resort to mulching especially the young seedlings and those who have the labour do shading where they build or put up shade to protect budding crops from the rays of the sun" (quote 56).

From the quotation above, shading as a method is labour intensive since you have to build a number of shades throughout your farm, thereby making it difficult for most of the farmers to practice it. This is evident in that 61.9% of framers indicated that they engage in shading.

Finally, from the survey results 56% of farmers reported that they resort to the planting of some varieties of trees, to cope with the rising temperature in the study area. According to most of the farmers, they grow these trees and grasses to deal with temperature and reduce evaporation. They said that this was a water conservation mechanism. The common tree they plant at the dam site was palm tree which they believe protects the banks of the dam. They also indicated that they plant Vetiver grasses, which are planted along the edges of the water channel, mainly to stabilise the soil and prevent erosion; it helps in water purification and slows the run-off of water and sediment control in the irrigation scheme and enables the retention of water for longer periods thereby guaranteeing higher crop yields. Drawing on a discursive construction of cultivation and applying an indigenous knowledge discourse a female farmer (Excerpt 5) during an in-depth interview noted the importance of the palm tree and Vetiver grass in this quotation:

> *"We were also able to buy Vetiver grass which we planted around the bank to protect the banks of the river and prevent it from siltation. We also planted some palm trees to protect the dam" (quote 57).*

The importance of these plants lies in the fact that farmers seeing the need for them had to contribute money to purchase them so that they can cultivate it as a means to conserve water and also deal with the impact of extreme temperature. The above quotations on indigenous knowledge in temperature management are discursive constructions of cultivation applying an indigenous knowledge Discourse of how crops have been shielded against the harmful effects of temperature in the past and present.

7.4.3 INDIGENOUS KNOWLEDGE AND SOIL CONSERVATION

One of the most important ways to enhance farming is to ensure that the soil is fertile. Soil fertility is therefore a sin qua non for improved crop yields; as a result this study considered critically the soil conservation practices farmers in Tanga have used over the years to ensure that their soils are still fertile in the irrigation scheme for farming purposes. As discussed in section 7.3 and 7.4, most farmers attributed poor soil fertility as a major challenge in their farming activities. Soil fertility and conservation becomes more critical in this study if you take into account the soil structure of the UER as a whole. As discussed in Chapter three, the soil structure or geology of soils in the area are inherently infertile, and this is further deteriorated due to poor soil management, tree felling and changing climatic conditions. As

elaborated in Chapter three the soils are inherently infertile ((RCC, 2003; GSS, 2013). The region lies within the Guinea and Sudan Savannah belt and the common soil types are Lixisols, Acrisols, Luvisols, Gleysols and Lithosols (EPA, 2002; RCC, 2003). The soils are generally shallow and low in inherent soil fertility and weak with low organic matter content. The soils are mostly coarse in texture. In view of the above, the vulnerability exposed by soil infertility has led to farmers going through social and institutional processes over the years to come out with their own measures (local knowledge) to cope with the risks posed by soil infertility. As noted by Birkman (2006:19) vulnerability deals with looking at both exposure to risks and coping capacity to hazards. Table 7.6 below from survey results therefore indicates the indigenous measures used by farmers to deal with soil infertility.

Table 7. 6: Indigenous Knowledge and Soil conservation management

Soil conservation management	Frequency	Percent
Use of animals droppings	79	94.0
Use of farm yard manure	78	92.9
Composting	64	76.2
Crop residue management	54	64.3
Mixed cropping	52	61.9

Source: Field Survey (2017)

As shown in Table 7.6, farmers employ a number of local knowledge strategies to improve upon the fertility of the soil in the Tanga community. To explore how this was done I asked farmers 'how they deal with soil infertility in the irrigation scheme through their indigenous knowledge. Responses from the survey, in-depth interviews and FGDs pointed to the fact that they resort to using more of what they have learnt from their forbearers whilst employing other orthodox means to enrich the fertility of the soil. The commonest method they employ from the orthodox means was the use of fertilizer which most farmers said was expensive. They also concede that the use of indigenous soil enriching methods was suitable because it leads to higher yields and at the same time does not destroy the soil as well as pollute the water body. The high cost associated with the use of inorganic fertilizer was corroborated by a respondent (Excerpt 1) when asked about the soil fertility management said that:

"With this we buy fertilizer (Inorganic) to put on our farms and we don't have the money that's why our crops fail" (quote 58).

She further indicated that they use cow dung and other animal droppings as traditional methods to fertilize the land.

The response of the above respondent was also evident in the survey, in-depth interviews and FGDs results. From the survey results in table 7.6 above, 94 percent of farmers indicated that they use animal droppings. The use of animal droppings according to the farmers entails the collection of chicken, goat and sheep droppings as well as cow dung in small quantities using family labour which they spread on the farm to improve upon its fertility. A respondent during FGD with me amply captured this when he said:

"Okay, we use our farmyard manure that is cow dung, other livestock and chicken droppings which we spread on the farms and plough to mix with soil to improve upon the fertility. We also use it when the crops are growing. We just spread it on the beds" (quote 59).

This shows that the use of animal droppings is an essential component of their indigenous strategies but this is becoming difficult because the farmers do not keep large livestock, and labour is becoming more difficult because their wards have travelled out of the community. Coupled with this is that they do not also have money to hire labour. A farmer lamenting over this phenomenon said that:

> *"The only issue is inadequate funds and lack of labour to help us use certain adaptation measures especially the collection of livestock and chicken dropping to enable us spread on the farms" (quote 60).*

The picture below shows a heap of animal droppings to be applied on the fields.

Plate 7.5 Heap of Animal Droppings to be applied on the farm.

The Survey, In-depth Interviews and FGDs also showed that farmers use farm yard manure which from the interviews indicates that the manure comes in two categories: manure from what they get from the *Naagang (*Kraal) and *Tampugre* (Refuse Dump). In the survey results 78% of farmers indicated that they use this form of local manure. I will therefore proceed to show how the farm yard manure is produced for improving upon soil fertility in the Tanga Community, using their local knowledge as also obtained during In-depth Interviews and FGDs. I will first of all discuss the manure prepared from the *Naagang* (Kraal). The *Naagang* is either built within the homestead or just immediately outside the house so they can monitor the activities of cattle raiders or thieves as depicted in the picture below.

Plate 7.6 Naagang (Kraal) within the Homestead.

The manure produced from the *Naagang* normally involves the mixture of cow dung with decomposed plant residue from the farm. During the rainy season the farmers plant millet, maize and groundnuts and after the harvest the stalks of the maize and millet as well as the vine of the groundnuts and dirty water and food residue are deposited or poured into the kraal. The stalk and groundnut vine serves as a form of bedding for the cows and at the same time as a means of producing manure. The urine of the cows and dirty water and other food residues poured into the kraal mixes with the urine of the cow and the plant residue and over a period of time it decomposes into organic manure which the farmers apply on their farms to improve its fertility. The major problem complained by most farmers was their inability to rear many cows due to financial constraints and the lack of labour to help them in their farms; this mostly disables them when it comes to producing enough manure from the *Naagang*. The

farmers noted that they prefer the organic manure but due to the above mentioned challenges they resort to the use of inorganic manure as indicated by a farmer during FGDs with male farmers who indicated that:

> *"The problem is that majority of farmers do not own livestock or have just a few and as such do not get enough cow dung and other livestock droppings to do the compost or do not get enough farmyard manure for their farms. Coupled with this is that in the absence of these animals you need people to gather the raw materials for you and most farmers cannot afford to hire such labour hence the reason why some still rely heavily on the inorganic manure. Even majority of us who do the compost use the inorganic fertilizer as well because the organic manure is not always enough" (quote 61).*

The next issue is composting, a process which produces compost. Compost according to Seyedbagheri (2010:1) "is a soil amendment produced through the metabolism of an organic substrate—a surface on which organisms grow—by aerobic (oxygen-requiring) microbes under controlled conditions". Compost is a primary source of nutrients for crops and in some instances compliments fertilizer nitrogen to provide more sustainable farming systems (Seyedbagheri, 2010). The most common types of composts are traditional composts made up of manure and plant residues (Van der Wurff et al. 2016).

It should be noted that most farmers use 'compost' to refer to all forms of farmyard manure. The other type of farmyard manure which farmers prepare and use is known as the *Tampugre* (Refuse dump), which is a 'local form of compost'. The *Tampugre* involves the collection of waste products including leftover food, vegetable stocks and leaves, cow dung, droppings from sheep, goats and poultry and poured into a refuse dump which in the Kusaal is called *Tampugre* and it is usually located in front of the house. The organic manure produced from the refuse dump is similar to that produced from the kraal. This is because the waste materials from the household and other organic droppings from livestock are mixed together to undergo total or partial decomposition. The decomposed organic manure is then applied to the farms to increase their humus content thereby enriching the fertility of the soil. A male farmer (Excerpt 7) described this when he narrated that:

"We do local compost which we spread in our farms, this we learnt on our own because we do not have enough livestock to enable us get enough of their droppings for our fields. We also use livestock and bird droppings. We do the tampugre (Local Compost) in the house and collect them and spread in the farm" (quote 62).

The picture below depicts a typical *Tampugre* near a family farm.

Plate 7.7 Picture Showing a *Tampugre* (Refuse Dump) with Organic Matter.

From the Survey Results, In-depth Interviews and FGDs most of the farmers use these two forms of organic manure to enrich their soils for crop production in the irrigation scheme. The results from the survey overwhelmingly indicate that 92.9% of respondents use these indigenous methods to enrich their soils and they contend that it is better than using inorganic fertilizer which to them tends in the long run to kill useful organisms in the soil. When I asked them, in a FGD with male farmers, which type they prefer, a participant said: *"The organic manure; the inorganic one kills useful organisms in the soil" [several voices speaking] (quote 63).*

From the response it could be seen that most of the farmers see the inorganic manure prepared on the basis of their local knowledge as the best to preserve and maintain soil fertility, but they have no choice but to sometimes rely on organic fertilizer to ensure that they get better yield, irrespective of its repercussion on the soil and dam. From informal discussions with farmers they alluded that they learnt this way of making manure from their grandparents and parents and they intend to continue to hand it down to their children through the process of socialization. Gyekye, (1996) made a similar point when he observed that the family in Ghana function as an agent of socialization, and as such the family transmits traditional values and knowledge to its younger ones. The transmission and accessibility of local knowledge and internalization for sustainable livelihood is also done through the family.

Composting is another strategy used by farmers to conserve and enrich the soil in the irrigation scheme in Tanga. Of the farmers participating in the interviews, 76.2% said they use this strategy to enrich the fertility of their farms. Compost is referred to the farmers as *pohum* which literally means 'fertility' and it is an improved version of the *tampugre.* Composting is a typical example of a discourse of knowledge hybrid (indigenous knowledge and scientific knowledge) since most farmers indicated that they learnt it from fieldworkers (external agencies) mostly working with NGOs and Agricultural Extension Officers. Farmers also posited that they learn from each other. An official of the Red Cross Society in Zebilla who has been working with irrigation farmers in an interview said that:

> *"Today due to the activities of some NGOs such as ACTIONAID, ADDRO (Anglican Diocesan Development and Relief Organization) and SPRING Ghana, most of the farmers have been taught how to do composting and they use this to enhance the fertility of their soil in the fields" (quote 64).*

He further illustrated that in his estimation this approach helps the farmers a lot better than the two farmyard manure types elaborated earlier. Another male respondent (excerpt 3) during an in-depth interview reaffirmed the above statement on the external agencies when he narrated that:

> *"To deal with this (soil infertility) we use animal droppings and composting. ADDRO and ACTIONAID taught us how to add value to our compost which has enabled us to get more as compared to hitherto. Farmers even sell extra compost to other farmers due to the enhanced knowledge and skills" (quote 65).*

The preparation of compost (*Pohum)* involves digging of a pit and filling it with cow dung, other animal droppings and crop residue and then covered with soil, it is then left during the rainy season for the rain water to provide moisture for it for decomposition. Another method is to continually pour dirty or unwanted water on it to provide the same medium as the rain water to aid decomposition. A male farmer (excerpt 10) illustrated or described the process of composting in the following words:

> *We do compost (Pohum), we dig holes in our houses and use donkey carts and collect residues of maize and millet as well as vegetables into the hole. After sometime it gets rotten and we use that as manure which we spread in our farms. The compost is far better than the inorganic manure (Fertilizer) but it is tedious exercise so most farmers do not have it because you have to hire labour to help you dig the hole and also look for refuse, because of this other farmers rely on the organic compost. You see this place which looks like cow dung that is the compost. It is big hole and the whole place is filled with manure. We learnt this skill from ACTIONAID, hitherto we use to throw away our rubbish and livestock droppings. We also use livestock and bird droppings (quote 66).*

The pictures below illustrate a hole containing compost and a heap of compost to be applied to a farm.

Plate 7.8 Covered pit containing compost and a heap of compost.

From the above narrative it can be seen that though compost is a tedious exercise and process, most farmers would have preferred that approach because it gives them higher yields than the other types of organic manure.

Another major complaint about organic manure, especially compost use, comes from the female farmers who complain that they were starved of the manure by their husbands who prefer to use it for rain-fed farming and also on their fields and are given some if there are surpluses. A female farmer illustrated this when she intimated that:

> *"It's the cow-dung we know but because it is not always available in large quantities our husbands rather use them and we are left to our fate. Also much of the organic manure like compost and the cow-dung are used in the fields for Rain-fed agriculture since they see that one to be more profitable. We are only given the chance to use this manure on our fields if there is enough" (quote 67).*

The scenario is not surprising since power relations in the study area and for that matter the region tends to favour men and as such men have a powerful voice and influence in resource allocation (Eguavoen, 2008).

The farmers also said that they do what they describe as crop residue management as an indigenous strategy to manage soil fertility. During the survey interviews, 64.3% of farmers admitted they use this method and when I asked them how that was done, the farmers described the process by narrating that it involves leaving the residue of plants cultivated in the rainy season especially maize, millet and groundnut vines in the field. This is then ploughed with bullocks during the dry season to mix with the soil, and they then water the land to ensure that it decomposes to fertilize the soil before they proceed with their irrigation farming activities. They also said that it was also a method to prevent or reduce soil erosion.

The famers also mention that mixed farming or cropping was a method to manage soil fertility and mixed cropping was supported by 61.9% of respondents. During in-depth interviews some famers said that they were taught by an organization from Bolgatanga but could not remember the name. This therefore is a classic example of knowledge integration and co-learning. When I enquired whether the farmers get support to adapt to climate change, a female farmer (excerpt 12) mentioned that:

> *"Yes, some people came from Bolgatanga and asked us questions about our farming and problems. They gave us technical assistance by way of extension services as to our methods of farming (They advised us to do mixed cropping instead of relying on onions alone) as it is a soil conservation and fertility management" (quote 68).*

This accounts for why most farmers plant leguminous crops which adds nitrogen to the soil to enhance its fertility.

7.4.4 INDIGENOUS KNOWLEDGE AND PESTS AND DISEASES MANAGEMENT

From the field survey data, in-depth interviews, FGDs and observation, a major challenge confronting farmers was the issue of pests, insects and diseases affecting their crops. The common pests and diseases affecting the crops according to the farmers were insects and worms which mostly attack the leaves of the crops by feeding on them; this in turn affects the growth of the crops, and they also talked about termites which, from my observation, indicated that they build their termites mound or homes from which they cause damage to the roots and stem of the seedlings and matured plants, especially onions. The farmers also mentioned other diseases affecting their crops. These diseases were mentioned in the local name. The diseases are *Dindezure* which means 'chameleon tail' due the way the affecting crop looks like which to them makes the leaves of the crops, especially onions, get coiled like a chameleon tail. Another disease they mentioned was *Gbinpoha* which means 'rotten buttocks' in English. According to the farmers the disease affects the plant through the roots and it leads to the crop getting rotten, hence the name *gbinpoha* because they see the roots as the 'buttocks' of the plant, and as such if it is rotten they are right to call the disease 'rotten buttocks. The situation of pests and crop diseases normally results in low productivity which affects the yields of farmers and invariably their income levels negatively. Results of survey data show the responses of farmers regarding the impact of pests and crop diseases affecting them in percentage terms and the indigenous strategies they use to deal with the pests and diseases. The table below (7.7) shows the responses of farmers regarding the measures they use to manage the pests and diseases.

Table 7.7: Pests and diseases management

Pets and diseases management	Frequency	Percent
Use of ash on crops	77	91.7
Use of fresh cow dung to spray on crops	36	42.9
Pricking out	67	79.8
Hand picking and crushing	68	81.0

Source: Field Survey (2017)

From the survey results the use of ash on crops and spraying of fresh cow dung on crops was classified as local pesticides. Farmers from the in-depth interviews, FGDs and observation used certain materials from their local environment based on their indigenous knowledge and interaction with their environment to prepare local pesticides to deal with the harmful effects of the pests and diseases, and from observation this has gone through from one generation to the next. From the sampled population of 84 respondents, 91.7% use their crops to repeal pests and diseases whilst 42.9% use cow dung to spray on their crops. The percentages are based on multiple responses. The responses from survey data on the local pesticides was in line with observations, reports from in-depth interviews and FGDs. The farmers reported that the use of these methods is not as effective as they thought because it works effectively for some time and then they lose their potency. They believe that the pests have found a way to deal with the local pesticides they use on the crops. Ash from wood from observation and literature is alkaline, which aids the growth of plants and also serves as a natural pesticide serving as a repellent against pests when used in the farm, hence its use by farmers who do not rely on any scientific basis but rather see it as knowledge handed down to them by their forbearers. A participant during a FGD with women on the use of ash narrated that:

> *"In this our scheme we use ash on the crops to combat the diseases and insects but I must say it is not very effective, after a few days the insects return. I presume they wait a while for the ashes to lose their potency and they attack again" (quote 69).*

To buttress the above assertion another participant during FGD with male farmers intimated that:

> *"Hmmm with the vegetables we use ash to sprinkle on them, it works for some time but it is not effective. After a few days the insects come back and eat the leaves and the wilting continues. The pests and diseases have found a way to deal with the local methods and even the chemicals we buy to use" (quote 70).*

Similarly, the farmers also believe that the cow dung, which they said they mix with water to sprinkle on the crops, has some odour which wards off insect pests and kills the diseases, but they were also of the view that the potency of the cow dung reduces as a result of a reduction in the stench. This was attested by a female farmer during a FGD who mentioned that:

> *"We also crush cow dung and mix it with water which we sprinkle on the plants to ward off the pests. It wards them off for some time but when the odour which wards*

them off reduces in potency they come back to attack the crops. In fact our major headache is with the pests and diseases" (quote 71).

Plate 7.9 Pictures showing a pan of ashes and a female farmer sprinkling ashes on onion.

Plate 7.9 Ashes being used on the farms to ward off pests and diseases.

From the above narratives it can be observed that farmers' opinions were that the local pesticides were partially effective in dealing with the insect pests and diseases as noted by a majority of farmers. As observed by most of the farmers in the above discussions, the pests have formed some immunity against the local pesticides even though they do not explain it in scientific terms. The immunity against the local pesticides by the pests in this study can be explained in terms of changes in the climate such as the erratic rainfall pattern, increased temperature and drought. This has changed the feeding or eating pattern of the pests, which hitherto fed on plants they avoided when the climatic conditions were better. The pests have also developed resistance to the local pesticides as a result of continuous application of the local pesticides.

This notwithstanding, during the interviews some farmers attested to the fact that they use the local pesticides, especially ashes on their vegetables. A female farmer (excerpt 13) corroborated this when I asked about the effectiveness of the local pesticides. She mentioned that:

"When it comes to the vegetables there are some worms which attack them and as for that one I use ashes to sprinkle on the leaves and this is effective in killing them because of the alkaline in the ashes" (quote 72).

In view of the fact that majority of the farmers expressed that the local pesticides where not wholly effective, I asked them whether they employ other pesticides or insecticides to deal with the effects posed by the pests and diseases. A majority of farmers indicated that they use pesticides and insecticides from orthodox sources to help fight the pests and diseases. They mentioned that these pesticides and insecticides are mostly used to fight the *dindegzure (Botrytis disease)* and *gbinpoha (onion root rot),* which according to them and observations are very resistant to the local pesticides. The farmers indicated that they normally buy these orthodox chemical from the agro-chemical shops in Zebilla. The commonest insecticide they mentioned was DDT (Dichloro Diphenyl Trichloroethane) which is a poisonous organochloride substance with insecticides properties. According to the farmers they mix the DDT with water and sprayed on the crops with a knapsack sprayer. A female farmer (excerpt 12) echoed this view during an in-depth interview when she attested that:

"As for me I just rely on the DDT. There are certain diseases that I have tried using my own knowledge but it did not work, even some of the pest and diseases are also developing resistance to the orthodox insecticides and pesticides" (quote 73).

From the above quotation it can be seen that the farmers also claim that the orthodox chemicals are not also working as expected. A farmer (excerpt 10) complained about this in this quote:

"I just rely on the DDT. I have used my own knowledge but it did not work. Some of the pest and diseases are also developing resistance to the orthodox insecticides and pesticides. For instance we have some diseases affecting onions such as Dindegzure (chameleon tail) and Gbinpoha (rotten buttocks) none of the methods have been able to handle them, so when they attack your onions just forget it because you would lose all your produce" (quote 74).

It thus seems that the orthodox chemicals are developing acceptance at the same level as local pesticides in terms of dealing effectively with the pests and diseases. Another challenge faced by farmers was the cost involved in buying the agro-chemicals to try to deal with the pests

and diseases. The problem of cost was described by a male participant during a FGD when he said that:

> *"The major problem limiting our ability to adapt is poverty. The inputs are expensive; we are not able to buy" (quote 75).*

In the same vein, a male farmer (who is an adherent to ATR) during a FGD also spoke about the cost of the inputs and at the same time liked it to the will of God such that if you cannot afford the chemicals you leave the crops in the 'hands' of God. He narrated it in this way during the FGD:

> *"We buy chemicals which we spray on them, especially DDT. If you do not have money to buy the pesticides and insecticides, you leave your crops to the mercy of God" (quote 76).*

The above quotation indicates an interesting discursive struggle between DDT (modern chemistry) and God (religion) as well as indigenous knowledge learnt over the years, such that when modern chemistry and indigenous knowledge fail in solving the problem, they commit the survival of their crops to God. From the narratives, indigenous knowledge and modern scientific knowledge have been used side by side though with mixed success. This therefore means that there is 'co-operation of knowledge' instead of competition or a clash of knowledge. In the analysis above there is a discursive construction based on the Big D discourse where indigenous knowledge, religious and chemical pesticides or scientific discourses come to the fore.

Pricking out diseased crops or plants is yet another indigenous strategy used by farmers to prevent total destruction of their crops. This involves pulling out and dealing with crops for which both local pesticides and orthodox agro-chemicals have not been effective in handling the pests and diseases. The farmers explained that if the diseased seedlings are not pricked out and destroyed they would end up infecting the healthy seedlings or crops with the disease. From the survey results, 79.8% of farmers indicated that they practice this method of dealing with diseased crops. In-depth interviews and FGDs supported findings from the survey when majority of participants indicated that they employ pricking out as a strategy to prevent total infestation of the total farm leading to crop losses. A female famer (excerpt 12) illustrated this finding when she attested that:

"There are certain diseases that I have tried using my own knowledge but it did not work, even some of the pest and diseases are also developing resistance to the orthodox insecticides and pesticides. As for those which get rotten from the roots we have no cure for it, when you find one you simply prick it out because allowing it will lead to the infestation of others" (quote 77).

The farmers were of the view that the two major diseases identified thus *dendegzure* and *gbinpoha* are particularly resistant to both the local and modern pesticides and therefore the best way to deal with their infestation on your farm was to prick them out.

Finally, one of the indigenous strategies for the management of pests and diseases in the study area was the method of hand picking and crushing insects. This was confirmed by 81.0% of farmers who said they do this during the survey. This was also affirmed by farmers during FGDs and in-depth interviews. From my observation, farmers resort to hand picking and crushing insects because the use of both local and modern pesticides have not been effective in dealing with the pests and so they resort to such manual and tedious method to protect their crops. A male farmer (excerpt 2) captured the issue of hand picking and crushing of insects when asked about alternatives to the local pesticides when he said that: *"We also do hand picking, by picking insects with our figures and crushing them" (quote 78).* He was of the view that just like how human beings develop resistance to certain things the pests and diseases have also developed resistance to the local and modern strategies they employ so from inference they have to killed so they do not come back to destroy the crops

The above analyses show that the management of pests and diseases in the irrigation site was constructed discursively as a blend of both traditional knowledge and modern science with both strategies employed, using these methods providing mixed and unsatisfactory results which therefore accounts for farmers losing a fair amount of their crops to the pests and diseases.

7.4.5 INDIGENOUS KNOWLEDGE AND HARVESTING AND STORAGE

Post-harvest losses are a major threat to food sustainability affecting availability and affordability of food. This study suggests that a major cause of post-harvest losses may be explained by the ways in which food is harvested and stored. In view of this a survey was carried out to explore which indigenous methods they use to prevent post-harvest losses. The result of the survey is depicted in table 7.8 below. The results of the survey indicated that

farmers employ the use of ash to store their produce and they also resort to drying of their crops and vegetables, as well as airing of their crops, mostly onions, and a few of the respondents said they use medicinal leaves to store their produce.

Table7.8: Indigenous Methods used in Harvesting and storage of Crops by Farmers

Harvesting and storage	Frequency	Percent
Use of ash	74	88.1
drying of crops/vegetables	72	85.7
Airing of crops	70	83.3
Use of medical leaves	5	6.0

Source: Field Survey (2017)

The information and narratives obtained during in-depth interviews and FGDs supports the above information obtained from the farmer survey results. First and foremost with the use of ashes to store their crops, 88.1% of farmers affirmed this. Through in-depth interviews and FGDs the farmers said they mostly store vegetables using this method. According to the farmers the vegetable crop which can be stored using this strategy was okro. The famers mostly store the okro using this method by cutting them into pieces or leave them whole after which they mix the okro with ashes and dry them. This strategy therefore involves the use of ashes and drying at the same time. They said that when this is done and the okro dries up it can be stored for over a year. The farmers who mostly cultivate the vegetables said that they sell some of the vegetables and use some for domestic cooking and that this was mostly done by women. A male participant during FGDs pointed out this fact when he said that:

> *"Also for okro we cut them or leave them whole and dry them, we mix them with ash and dry them. When we dry they can be stored for a year. We sell some and use some domestically" (quote 79).*

Interestingly, from the In-depth interviews and FGDs on the use of ashes to store crops the women seem to be vociferous and this is unusual in patriarchal society where men tend to dominate. They see the assets of the women as their own because in most instances the production of vegetables is in the hands of the women. From observation the women sell the vegetables and declare the proceeds to their husbands who then give instructions as to how the monies should be used.

Drying of vegetables or crops in the sunshine was another method used to store most vegetables. This was attested by 85.7% of farmers. The farmers noted that due to the fragile nature of the leafy vegetables and to prevent post-harvest losses, they sell them either at the farm gate or in the market and the rest are stored for future use. This strategy was to help them cushion the family before the next rainy season as well as getting vegetables' for soup while they wait for the rains. The drying method involves the vegetables being dried in the sun. This strategy was echoed by a female respondent during a FGD when she mentioned that:

> *"...We store the vegetables and okro by drying them in the sun. For instance if we dry bra and okra we can keep them for over six months. That's what we rely on during the dry season for our soup. We also sell some to support ourselves" (quote 80).*

Exposing crops to airing conditions was another indigenous strategy used by farmers to store their crops, especially onion which was the major crop farmed in the study area because of its economic value. The process of storing onions according to the farmers involves the airing of the crops in clean room such that they do not get rotten because one rotten onion can destroy the rest of the produce. During the survey 83.3% of farmers ascribe to the use of this method. Majority of farmers explained how this method was done but I will dwell on just a few examples. From in-depth interviews a female farmer (excerpt 11) describing how they store onions said that:

> *"In the case of onions when you harvest it you look for an airy room, clean it nicely and spread the onions on a zanamat (locally woven mat from straw or stalks) then from time to time you re-spread to make sure they all get enough air to prevent them from rotting. If you also have the means you built a separate room for it without windows and doors, you weave a mat and use it as doors and windows and during the day you raise them up to enable the onions get enough air. Do not allow oil and salt to touch the onions or it will get rotten, that is why we put them in a separate room. We open the windows and doors to provide them with enough air" (quote 81).*

Similarly, during a FGD with women and adding an economic motive to why they store onions, a discussant narrated that:

> *"For onions we store it by drying them in a clean room which is well ventilated. We keep checking and repositioning them to make sure that every part is exposed to air to*

prevent it from getting rotten. Those that get rotten we remove them out and dispose it off. We can store for up to six months. We sell the onions if we feel that the price has appreciated" (quote 82).

The farmers indicated that they remove rotten onions during storage and throw them away to prevent them from infesting the rest. The farmers also indicated that they do not rely solely on the indigenous strategies to store onions because in the past some NGOs built them silos but they were woefully inadequate for the farmers to use to store the onions as few farmers had access to them at a time. During discussions with male farmers a participant narrated that they were provided silos by an NGO when: he revealed that:

"...Yes for the storage of onions. They were built by an NGO but I cannot remember the name. They built for us two structures (silos) with airy rooms, in the rooms slaps which look like beds were provided for us to spread the onions on but it is not enough for all the farmers" (quote 83).

A female discussant also mentioned that though the silos were built for them by an NGO, they had stopped using them because it cannot serve all the farmers. From observations and inference, the farmers' decision not to use the said built silos was to prevent conflicts among the farmers. Plate 7.10 shows a picture of the built silos by the unnamed NGO.

Plate 7.10 Built silos for farmers in Tanga.

From the above discussions on harvesting and storage using indigenous knowledge, it can be seen that a greater motivation to store crops or produce has more to do with an economic

motive. This is because from the discussions we see an additional economic rationale than just for storage purposes, and a different discourse of profit making is implied as they refer to the importance of storing crops, hoping for better prices. This indicates that though they mostly act as small scale or subsistence farmers, they also ideologically believe in profit making, which I describe as 'profitization of livelihood adaptation strategies using indigenous knowledge'. This is seen in the farmers' discursive construction of livelihood opportunities, given that to the farmers, storage and selling of crops when prices are good was the only means to use assets at their disposal to guarantee a successful farming activity during the rainy season. They therefore make use of their social assets in the form of local knowledge blended with scientific knowledge through various institutions in the community to leverage the physical assets (Land, irrigation facilities), the natural assets (God's natural endowments), human assets (skills, experience and intelligence) and financial assets to enhance sustainable livelihood adaptation strategies. Therefore to ensure sustainable livelihood adaptation there is the need to enhance the social, human and financial assets of the farmers or irrigation scheme users to facilitate the adaptation of sustainable strategies through localization of knowledge to improve the profitability of their farming activities.

7.5 CHALLENGES OF APPLYING INDIGENOUS KNOWLEDGE ON CLIMATE CHANGE ADAPTATION

The use of indigenous knowledge has been acknowledged as an important resource to propel development especially in developing countries like Ghana. The World Bank (1999) acknowledges this when it posits that indigenous knowledge is one of the most important assets for local people to create value and hence adapt to their environment to ensure sustainable development and livelihoods. The Bank went further to advice that developing countries can further propel their development by using knowledge developed in the development countries without forgetting the knowledge at their backyard. They therefore focus on localization of knowledge. Based on this, the study went further to investigate the perceptions of farmers on the challenges in applying indigenous knowledge in providing solutions to the challenges they face in their irrigation farming activities. To ascertain this, a survey, in-depth interviews and FGDs were carried out. The results of the survey are shown below in table 7.9.

Table 7.9 Challenges of applying Indigenous Knowledge on Climate Change Adaptation

Challenges of applying indigenous knowledge on climate change adaptation	N	Min	Max	Mean	Std. Dev.
Lack of government support	84	1	5	4.85	.630
Inception of government based adaptation strategies	84	1	5	4.52	.871
Known by few (elders do not pass them on)	84	1	5	4.18	1.184
Intrusion of western knowledge (marginalized)	84	1	5	4.11	1.299
It is not reliable	84	1	5	3.57	1.301
Disappearance of traditional farming system	84	1	5	3.65	1.594
Specific to a given area, not applicable everywhere	84	1	5	3.94	1.484
Difficult to use/apply	84	1	5	3.55	1.339
Threatened by increase in the use of modern technology	84	1	5	4.36	.977
Death of indigenous knowledge custodians (not written)	84	1	5	4.13	1.190
Connected with local beliefs and taboos	84	1	5	3.62	1.289
Cannot be justified and proved	84	1	5	3.55	1.375

Source: Field Survey (2017)

From the survey results it can be seen that some of the factors are interrelated and those will be analysed together. The results of the survey shows that majority of participants agree that lack of government support (4.85 mean score) was a major challenge affecting the application of indigenous knowledge in adapting to climate change. This is related to factors such as the inception of government based adaptation strategies (4.52), threat by the increase in the use of modern technology (4.36) and the intrusion of western knowledge (marginalization) (4.11). These are interrelated because government tends to support western knowledge and the use of modern technology from the western developed countries, while paying little attention to local knowledge. This is because they the government is of the belief that the indigenous farming strategies which aid adaptation cannot be justified and proven by science as mentioned in the survey. In finding out from participants whether they get support from

government in the farming activities, a majority of farmers were in consonance with results from the survey but a few farmers mentioned that they do get support. A male participant (excerpt 3) said that:

> *"...DADU officials came around to ask us about our problems in the site. They only write down our concerns and that was all. It is routine exercise they carry out every year and the story remains the same. We use to have an extension officer who assisted us a lot but sine he retired we have not had a replacement, so no assistance is coming from any source" (quote 84).*

A political dimension of the lack of support from government was mentioned by a participant during discussions with female farmers. According to the discussant:

> *"People normally come around to find out our problems at the scheme especially during electioneering years and make promises to us. After the elections we do not see them again till the next four years when they want votes" (quote 85).*

The behaviour and actions of politicians and government officials as enumerated above by the female discussant has led to a lack of trust in politicians and government on the part of the farmers. Some farmers even complained that some officers, whether government or non-government officials, only come to write down their concerns, and after that the farmers do not see them again, and they further said that some even take money from them with the promise of providing them assistance, and after that they disappear.

With regards to the few who said they get assistance from government officials, they actually mentioned that the assistance mostly come in the form of technical assistance. A male farmer (excerpt 10) narrated as follows:

> *"Yes we get extension services from Department of Agriculture but he is now on retirement and no replacement has been brought, actually the support from DADU is purely technical" (quote 86).*

According to farmers the technical assistance involves the use of modern methods of farming and use of modern tools which is in tandem with the results of the survey results. Also the farmers from the interviews had more assistance on indigenous farming practices from NGOs than from the government. They mentioned that organizations such as ADDRO, ACTIONAID and the RED CROSS provide them with more assistance, especially in the area

of sustainable farming and compositing as discussed earlier. For instance a female farmer (excerpt 12) who could not remember the name of the organization which assisted them in indigenous farming strategies said that:

> *"Yes, some people came from Bolgatanga and asked us questions about our farming and problems. They gave us technical assistance by way of extension services as to our methods of farming (They advised us to do mixed cropping instead relying on onions alone) and soil conservation and fertility management (the making of compost); in fact they taught us the modern method of composting. When it comes to managing the pests and diseases affecting our crops we have not had any support in that area. I do not know the name of the organisation" (quote 87).*

The analyses above suggest that government should take a critical view to integrate local knowledge into its climate adaptation strategies by looking at the strengths and weaknesses of indigenous adaptation strategies and then integrate it with appropriate modern adaptation strategies through a process of localization of knowledge (see Stiglitz, 2000) thereby resulting in a hybrid of knowledge as acknowledged by Kristjanson et al, (2009). This would call for a combination of indigenous and scientific knowledge through co-learning and coproduction instead of marginalizing local indigenous knowledge as it can serve as a good resource to deal with the impacts of climate change.

Other aspects of the challenges of indigenous knowledge application to adapt to climate change is that it is known by a few members of the community - mostly the elders - who fail to pass on the knowledge to the younger generation. This situation was supported strongly by a mean score of 4.18. From the survey results and informal interactions, certain elders within the community are reluctant to share their experiences, knowledge and skills on the use of indigenous farming techniques to adapt to climate change to members of the community except some selected trusted members in the community. The above assertion is closely related to another factor which has to do with the death of indigenous knowledge custodians. This situation scored 4.13 and it presupposes that the death of a custodian of indigenous knowledge means that he is buried with that knowledge and it would not be accessible to the younger generation. This is because most of the indigenous knowledge practices are not documented as opposed to scientific knowledge which is widely published in the scientific community and as custodians of indigenous knowledge do not widely share their knowledge, it becomes more precarious for the community when they pass on.

Also related to the above is the fact that local knowledge is specific to a given area thus limiting its scope of application. It is not applicable everywhere. This challenge scored 3.94. For knowledge to gain acceptance and trust it must be applicable everywhere and produce desired outcomes. Most of the indigenous practices were favoured by a few participants from a specific area due to the fact that the knowledge was owned by a few people who passed it on their confidants, and this reduces application in the entire study area. This was the case where some farmers said that they do not use certain indigenous methods used by farmers in other sections of Tanga. It therefore goes to say that indigenous knowledge is specific to a group of people, who embrace and use it in their farming practices. This is supported by Ellen and Harris (2000) when they said that indigenous knowledge was rooted in place (local), reinforced by trial and error, transmitted orally, functional, dynamic and shared in a fragmentary manner between individuals within a population. Another challenge complained by farmers was that indigenous knowledge is not reliable, which was agreed by farmers with a mean score of 3.57. The unreliability of indigenous knowledge has been amply captured on the indigenous strategies used to deal with water conservation, soil management and pests and diseases management when most farmers said that it was not effective, hence their reliance on scientific methods which they thought were superior. The sentiments borne by the farmers could be due to the fact that indigenous strategies have been used overtime but did not yield the desired results consistently; also most indigenous strategies are not documented as opposed to the scientific knowledge, so overtime they have lost confidence in its efficacy. Another point was also that indigenous knowledge was known by a few elders, and the power relations determined who they should teach this knowledge to (Refer to sections on this chapter on indigenous adaptation strategies).

Finally, indigenous knowledge on how to adapt to climate change was connected to local beliefs and taboos with a score of 3.62 which have not been proved scientifically. Participants from chapter six specifically said that indigenous knowledge was connected to spiritual beliefs and the performance of certain rituals which were not in consonance with Christianity and Islam which has come to take over from ATR. They see some of these things as superstitious, so the *tingban* which used to be revered is no longer revered as it used to be in the days of their forefathers. According to them the gods are now being desecrated even though they concede that the taboos used to serve as a means of preserving the vegetation cover of the community and protecting water bodies as enumerated in chapter six. This has also led to the disappearance of traditional farming systems which was agreed with a score of

3.65. The farmers were of the opinion that if taboos were disregarded and the modern methods of farming were preferred by the government, certainly the traditional farming methods would continue to give way to farming methods which they deem to be scientific. The above analyses on other challenges of indigenous knowledge on farming methods and adaptation to climate change falls in line with what Ellen and Harris (2000) outlined as the characteristics of indigenous knowledge as being experiential rather than theoretical, rooted in place (local), reinforced by trial and error, transmitted orally, functional, dynamic, empirical (embedded in the socio-cultural setting and not easily codifiable) and shared in a fragmentary manner between individuals within a population and mostly distributed unevenly between them (i.e. no one person, authority or social group knows it all, it is part of a power-relation structure and can be managed in a manner that excludes some members in the community from acquiring it).

7.6 SUMMARY

This chapter looked at the effects of climate change on the irrigation schemes and on livelihoods as well as the indigenous adaptation strategies employed by farmers to deal with the impacts of climate change in Bawku West District. From the study and literature the UER which is located in West Africa lies within the Savannah belt and it is susceptible to climate change which is estimated to affect the livelihoods of millions. The impact of climate change on livelihoods calls for measures to be undertaken to adapt to its negative consequences. Indigenous knowledge has been seen as a valuable resource to respond to such adverse consequences. With regards to the effects of climate change on the irrigation scheme and its facilities, the farmers stressed that climate change has led to the destruction of irrigation scheme facilities such as the canals, banks and spill way. They also mentioned low availability in the reservoir of the dam, due to water scarcity as a result of low rainfall, droughts and siltation of the dams coupled with soil erosion and the proliferation of pests and diseases.

On the issue of climate change impacts on livelihoods, I demonstrated through analysis of farmers' discursive constructions that climate change adversely affects living conditions as a result of its impact on farming activities. The stressors of climate change affect the crop yields. The farmers mentioned that the impacts of climate change on their livelihoods include crop failure, decline in income due to reducing yields, which has a ripple effect on their

standards of living and ability to cater adequately for the basic needs of their families, thereby creating a spiral of vulnerability within the household.

The next aspect I looked at in this chapter was indigenous knowledge and adaptation to climate change in the irrigation scheme by farmers, which in my opinion was necessitated by the impacts of climate change on their livelihoods. Indigenous knowledge which has been seen as a means of adapting to climate change has been employed over several years to solve local farming problems. The study discussed discursive constructions of indigenous knowledge strategies used in water management, which had to do with management of the low water levels in the dam. To overcome this, farmers employed methods such as planting early maturing crops, mulching and the use of dug-outs and rain harvesting. In adapting to high temperature, which has an impact on water levels and growth of plants, the use of cover crops to mulching and planting of trees was used. Soil conservation was yet another issue discussed in this chapter. To adapt to the challenges of poor soil fertility farmers resorted to the use of animal droppings, composting, use of farm yard manure such as the *naagang and tampugre* which farmers preferred to the use of inorganic chemicals because to them the inorganic chemical 'spoils' the soil and water bodies. Pests and diseases management which was another aspect of indigenous adaptation method showed that the use of local pesticides and orthodox chemicals produced mixed results. Some farmers felt that the local pesticides were not effective while others felt that it was, and the same sentiments were echoed for the orthodox chemicals as I prefer to call them. This therefore presents a struggle between competing discourses when it comes to pest management in the Tanga community. Also harvesting and storage was yet another issue looked at from the lenses of indigenous knowledge. From the study and discussions I observed that harvesting and storage came with a profit motive on the part of farmers who sell and store their produce, waiting for when the prices are 'right' so that they can make more profits, especially with onions.

The final issue I discussed in this chapter has to do with indigenous knowledge and the challenges of applying indigenous knowledge to climate change adaptation. Though indigenous knowledge has been identified as very crucial in dealing with climate change it was also confronted with challenges as to its use. Among the challenges were that it lacked governmental support which leads to marginalization because indigenous knowledge was not seen as scientific, and as such modern forms of technology were favoured. It was also acknowledged that it was known by a few who choose whom to transfer the knowledge to, and therefore the death of a custodian of traditional knowledge can lead to its loss in the

whole community because it was not documented. There was therefore an issue of power relations with regards to its transfer because he custodians of such knowledge determined to whom they should transfer that knowledge. Indigenous knowledge was also seen to be specific to a given geographical area and also fraught with taboos, making its applicability very difficult.

CHAPTER 8: DISCUSSION OF FINDINGS AND CONCLUSIONS

8.1 INTRODUCTION

This chapter presents the discussion of findings and conclusions drawn from the study. The chapter links the findings from the study to the literature review. The chapter begins by introducing the objective of the study which was premised on the topic "Climate Change and Sustainable Livelihoods Adaptation. User Perspectives on Community Managed Irrigation Schemes in North-Eastern Ghana". The assumption is that climate change affects the livelihoods of people engaged in the activities under study. Indigenous knowledge is deemed as a measure to help curb the vulnerability of the farmers and from the study this was aided by external knowledge through localization of knowledge. To achieve what I set out to find I had asked the following research questions: (1) How do users of the scheme perceive climate change and its causes and how are these perceptions constructed discursively? (2) To what extent do users of the schemes in the UER relate the impact/changes on their livelihoods to climate change? (3) How has indigenous/local knowledge on climate change stimulated and diversified farmers' adaptation strategies to climate related shocks? The thesis draws inspiration from Fairclough's version of CDA and Gee's discourse analysis which labels discourses into Capital D and Small d discourses. The combination of these discourse approaches enabled the visualization and labelling of discourses based on the discussions and interviews held with the farmers through in-depth interviews, FGDs and farmer survey questions.

In the thesis I adopted a conceptual framework based on the fact that adaptation to climate change has no specific theory and as such an interdisciplinary approach should be adopted. Based on the above discussions I adopted a conceptual framework that combines or integrates models and components of climate change, vulnerability, indigenous knowledge, sustainable livelihood approach and adaptive capacity to illustrate and analyse how these concepts are intertwined and interrelated to shape how adaptation strategies are evolved to ensure livelihood outcomes of small scale irrigation farmers in the Upper East Region. The study is strongly anchored on the argument that the adaptive capacity of the community is dependent on the knowledge base (Indigenous knowledge), assets, institutions and processes that the communities possess to deal with climate induced changes.

The chapter therefore starts with the discussion of findings anchored on the research questions I set out to investigate. This is followed by the conclusions, the contribution of the thesis to on climate change research and considerations for future research.

8.2 DISCUSSION OF FINDINGS ON FARMERS' PERCEPTIONS ON CLIMATE CHANGE AND ITS CAUSES

This aspect of the thesis agrees that climate change and variability have gained attention in international discourse because of the potential and real impact climate change has on the lives and living conditions of people who live on their immediate environment for survival. Studies have shown that increased investments in irrigation projects have not sufficiently yielded the desired results and the profound negative effects are felt more in sub-saharan Africa where the majority of the populace depend on small-holder agriculture for their livelihood and climate change invariably affects their existence because of water scarcity for agricultural purposes. The effect is that climate change has impeded efforts to reduce poverty in the said region and this has been agreed by (UN, 2006; Slater et al. 2007; Assan et al. 2009; Yanda and Mubaya, 2011). Therefore to understand this the study set out to explore how farmers get information about climate change, their perception about climate change and the perceived causes of climate change. The essence is that their perceptions about climate change and its causes have implications on adaptation to the phenomenon which is a cardinal preposition of this study.

The findings of the study revealed that farmers in the study area are aware of climate change and its likely causes which concur with studies from Africa (West et al 2008, Mertz et al. 2009a; Ifejika et al. 2010; Fosu Mensah et al. 2010; Yaro 2013). The study revealed that in terms of the awareness of climate change, farmers provided sources of information where they heard and learnt of climate change. All the respondents demonstrated that they have witnessed climate change. The findings show that the sources of climate change information were personal experiences of farmers, the media, family members and friends, social groups and agricultural extension officers. The sources of information enabled the farmers to form an opinion on climate change. The findings revealed that though the majority of farmers rely on their personal experiences as a result of their own knowledge, they share that with other farmers in the form of co-learning and at the same time also learn from the media and other officials who come to talk to them about climate change. The sharing of knowledge on climate change is passed on from generation to generation through the process of

socialization and knowledge flow or diffusion. The findings indicate that the knowledge from external sources is based on scientific knowledge. The farmers therefore consent that the combination of scientific sources of information and those of local expertise through lived experiences reinforce each other in a manner so as to influence the narratives on how the farmers perceive and construct climate change discursively.

On farmers' perceptions about climate change in Tanga, the findings of the study revealed that farmers' perceptions on climate change were based on their lived experiences and this was a reflection of their intimate relationship with their local climatic conditions (Kurukulasuriya and Rosenthal, 2003; Boko et al., 2007). The changes they narrated ranged from economic, environmental, social and political issues but largely manifested in their local climatic conditions and local knowledge. The farmers clearly identified the indicators of climate change which included unpredictable rainfall pattern, high temperatures, changing wind conditions, change in vegetation cover among others. The findings of the study indicated four predominant discourses (capital D) on how farmers perceive climate change with accompanying small d discourses based on Gee's categorization of discourses (Gee, 2014; 2015). The major discourses identified are religious or spiritual Discourse, natural science-based natural phenomenon Discourse, indigenous knowledge Discourse and anthropogenic Discourse.

In talking about the changes they perceive on the basis of the identified indicators, the farmers perceptions were largely influenced by their local worldview and therefore attributed the changes to God, gods, spirits and in a few instances to anthropogenic causes such as GHG emissions. These attributions are buttressed by (Kumausour et al. 2011; Mertz et al. 2009a) where they noted that the unscientific perceptions of farmers about climate change may be influenced by the fact that many subsistence farmers are mostly poorly educated and mainly rely on superstition to explain natural events since that is their only source of information.

The findings on the perceived causes of climate change by farmers revealed that farmers perceptions on the causes of climate change mostly revolved around a spiritual or religious Discourse mostly dwelling on ATR where they attribute the causes of climate change to be God's own plan and a punishment from God for our disobedience and desecration of his creation as well as an anthropogenic discourse centred around the environment and land use activities. Farmers recognized that climate change is caused by land use activities through felling of trees, bush burning and GHG emissions. Other perceived causes included disregard

for taboos, farming in sacred groves and punishment from the gods. Though the perceived causes of climate change was mostly attributed to religious and spiritual beliefs, farmers also mentioned anthropogenic causes through the activities of man such as bush burning, felling of trees and land use changes due to pressure on land for other purposes as a result of population. Though farmers mentioned these causes, they did not back it with scientific explanations, they rather attributed it to supernatural causes. The attribution of most farmers on the causes of climate change based on the supernatural makes sense because farmers in the study area make meaning of the world around them by relying on their local beliefs and orientation. The findings are in tandem with the view of Yaro (2013) that most subsistence farmers in Ghana are not formally educated and therefore rely on superstition and other social factors to explain the causes of climate change. The findings also show that the discourse on the causes of climate change was diverse and not based on one perspective. The study attributes this to farming experience of farmers, lived experiences, sources of information and religious beliefs which shapes their local knowledge and informs the adaptation strategies they adopt. From the findings it can be seen that indigenous knowledge as well as religious and cultural factors are strong in opinion formation and actions and therefore can be leveraged as a form of 'spiritual capital' to enhance adaptation and sustain livelihoods of farmers which the next sub-section discusses.

8.3 DISCUSSION OF FINDINGS ON THE EFFECTS OF CLIMATE CHANGE ON FARMERS LIVELIHOODS AND INDIGENOUS ADAPTATION TO CLIMATE CHANGE

This section merges research questions (1) and (2) to enable the researcher to provide a link between the impacts of climate change on the livelihoods of farmers and how their vulnerability to climate change has stimulated and diversified the farmers' adaptation strategies to climate change affecting their irrigation farming in the Tanga scheme using their indigenous knowledge. The vulnerability of West Africa, including Ghana, to climate change is because of its geographical location and climatic features which is dominated by the Savannah which cannot stand variations in climate (Laube, 2007). The challenge posed by climate change is further compounded by its unreliable nature. Small-scale irrigation scheme farmers in Tanga face multiple stresses with climate change being a conspicuous one. The farmers from the study recognize that climate change has an impact on their irrigation scheme's optimum performance and as such on their livelihoods. Unpredictable rainfall and

rising temperatures have been identified by farmers as the major factors affecting the performance of the scheme and food crop production. Among the effects of climatic stressors on the irrigation scheme from the study are destruction of irrigation infrastructure, drought leading to water scarcity, soil erosion, siltation of the dam and increased crop diseases and pests which have major effects on crop production. The study findings show that the impacts of climate change on the performance of the irrigation scheme can thus be grouped into three adverse impacts on the irrigation scheme infrastructure, impacts on water and soil and issues on crops and plants growth. This grouping is consistent with studies in Africa which indicated that climate change has an adverse effect on infrastructure including water systems, settlement, health and the natural ecosystem (IPCC, 2007; IFAD, 2008; UNDP, 2009; Adu-Boateng and Oppong, 2011). Climate change is therefore seen as the 'villain' and the farmers the 'victims'. These impacts on the irrigation scheme translate directly to livelihoods impairment. From the study the major impact of climate change on the scheme were destruction of irrigation infrastructure and decrease in water volume. These two issues impacted negatively on the smooth operations of the irrigation scheme and farming activities. The adverse effects of climate change on the irrigation scheme such as siltation of the dam, loss of vegetation cover, destruction of infrastructure among others all work in tandem to impede smooth operation of the irrigation scheme. Findings of the study show that the discursive constructions of the impacts of climate change on the irrigation scheme were largely a discourse of lamentation.

Apart from the impact of climate change on the irrigation scheme as a system, the study identified that the impacts of climate change on the irrigation scheme has a direct impact on the livelihoods of the scheme users. This is because if the scheme does not function and operate at an optimal level, it affects irrigation farming which is a core livelihood activity of the farmers. Farmers generally accepted that climate change impacts their livelihoods and clearly demonstrated that it affects their farming activities in the scheme. Among the effects are that their crops do not get the needed water leading to low or poor production, diseases and pest infestation, wilting of crops, lack of nutrients for crops as a result of soil erosion and drying up of crops as a result of rising temperatures. The study revealed that climate change has been a major cause of crop failure, decline in income of farmers, rural-urban migration leading to a reduction in labour force among others. These effects directly lead to food insecurity and rising poverty. This translates into hunger conditions among farmer households and inability to meet basic needs such as clothing, inability to access social

services and other necessities of life. The results of the study conforms to findings within sub-Saharan Africa (Slater et al. 2007; Assan et al. 2009; Yanda and Mubaya, 2011) that climate change impacts will hamper agricultural production in sub-Saharan Africa by the end of the 21st century especially among rural populations who rely on small-holder agriculture for their livelihoods and that this may hinder the hope of reducing poverty in that part of the continent. This therefore calls for frequent rehabilitation of the scheme and appropriate training manuals for farmers so that they can maintain and sustain the scheme in the face of climate change stressors. The effects of climate change on the livelihood of the farmers was further exacerbated by the fact that the majority of the irrigation scheme farmers held less than a hectare of land as there was competition for land by farmers; similarly farmers' household size of 5 and above leads to households not being able to meet their basic needs coupled with the difficulty of sharing land holdings among members. The threat to livelihoods by climate change from the study is one that the tone of the farmers can be described as that of 'lamentations'. The farmers therefore applied a discourse of lamentation to construct the untold hardship that climate change has occasioned on their lives. The threat to livelihood from the discussions is therefore shaped by poverty as a result of farmers not earning enough income from their farming activities due to low crop yields thereby affecting their expenditure pattern. The findings of the study further revealed that the impacts of climate change as constructed draws from a big D climate change Discourse with small d discourses of lamentation, household economy, needs and gender showing the role of women in the household economy because the cultivation of leafy vegetables is left mainly in the hands of the women and this they sell to cater for the immediate needs of the family, especially the children.

The next issue in this section of the discussions looks at indigenous knowledge and adaptation to the impacts of climate change in the study area. The study found that farmers employ various strategies and measures using their local knowledge to deal with challenges occasioned by climate change to sustain their farming activities in the irrigation scheme. Social capital has been identified as the most important asset which reinforces the other assets or capitals (Bourdieu, 1986; Bebbington, 1999; Adger, 2003; Dulal et al., 2010). Indigenous knowledge which is part of social capital has been used over the years by local people to solve specific problems due to their intimate knowledge with their environment. The importance of social capital is its ability to effectively facilitate ideas through co-learning and build adaptive capacity of individuals and groups (Bourdieu, 1986; Dulal et al., 2010). The

study findings revealed that indigenous knowledge has been used by the farmers to solve climate change related challenges for decades. Indigenous knowledge as identified in the study was not wholly local but a fusion with other appropriate external knowledge to produce 'hybrid knowledge' through the process of localization of knowledge. The finding is supported by studies in Africa and other parts of the world. Dove (2010) supported this view when he concluded that indigenous knowledge goes beyond its doctrine premised on localization, continuity and homogeneity. Similarly, Stiglitz (2000) supported the idea of localization of knowledge when he said that the variety and complexity of human society requires the localization of knowledge. That is the process of allowing, adapting and using knowledge created by others (external) to the local environment. The findings of the study revealed that farmers belonged to various social groups and networks such as the WUA, community associations, religious groups and other informal associations where they shared and received information about climate change and adaptation measures. Membership of the social groups contributed significantly in building the social capital of the farmers. In spite of the challenges posed by climate change farmers revealed that they took a number of measures and strategies to adapt to the impacts of climate change in the scheme.

Farmers in dealing with low water volumes in the dam, which adversely affected crop production, took a number of adaptation strategies utilizing indigenous knowledge systems of water collection and conservation management. The findings revealed that the widely used measure to deal with water inadequacy was the planting of early maturing crop varieties which was not previously cultivated. These included early maturing lettuce, onions, tomatoes and green pepper which was introduced to them by the agricultural extension officer and they were also readily available in the agro-based shops in Zebilla the District Capital. The cultivation of these varieties resulted in stabilizing and increasing the crop yield of some farmers resulting in positive livelihood outcomes for the farmers. Mulching was also employed by the farmers to curtail water losses as result of high temperatures and to ensure seedling survival and growth by protecting them from direct sunlight and heat. Mulching ensured the maintenance of soil temperature, protection of the soil from erosion, conservation of moisture and suppression of weed growth. This strategy enabled the retention of water in the soil. Another strategy farmers adapted though tedious was the digging or construction of small dug-outs or ponds in the farms. Farmers used the water obtained from the dug-outs to irrigate the crops and this largely helped in preventing crop failure. Farmers also harvested rain water as a strategy to deal with water shortages and this they use during the dry season to

irrigate crops. Water rationing was another strategy the farmers adopted to conserve water in the dam. It was revealed that water rationing as a strategy greatly contributed to the judicious use of water from the dam by the farmers which means that in the face of scarcity, people are able to maximize and optimize the use of the available resource. The rationing schedule was done according to location of farms based on the collective and democratic decision of the farmers. The strategies adopted by farmers to deal with water scarcity contributed significantly to the stabilization or improvement in crop yields in some instances thereby sustaining the livelihoods of many of the farmers.

High temperature was yet another climatic stressor or challenge faced by farmers. High temperatures affected water levels as well as crop survival. Findings from the study show that farmers having adequate knowledge about the dangers posed by high temperatures have evolved various indigenous adaptation strategies to deal with it. The farmers are reducing their vulnerability to high temperature which affects crop production in several ways. These strategies include cover cropping, mulching, shading and planting of trees. The cover cropping involves planting of some crops (cover crops) to shield against extreme temperature. These cover crops were planted mainly to shield the main crops rather than for consumption. Maize was the common cover crop cultivated by the farmers. Mulching was also a strategy to guard the crops against extreme heat. The discussion on mulching has been enumerated above on the strategies to conserve water in the scheme. Shading as a local knowledge strategy involved the erection of shade made with grass over the crops to shield them from sunlight in order to avoid moisture loss and drying up of crops. Finally findings of the study revealed that farmers planted some varieties of trees and grasses at the banks of the dam to deal with water loss through evaporation. Common among the trees and grasses planted were, palm trees and Vetiver grasses along the edges of the bank. The Vetiver grass is important because it stabilizes the soil and prevents erosion. It also helps in the purification of water and slows down run-off of water and acts as a sediment control thereby reducing siltation of the dam. The local knowledge system therefore adopted by the farmers prevents crop failure due to direct sunlight and heat. It also enables the retention and purification of water thereby enhancing crop survival and yields.

Another challenge posed by climate change in the irrigation scheme was soil infertility which calls for soil conservation management. Farmers who possess their own knowledge systems adequately adapted to this phenomenon using several strategies. The soil structure in the study area is generally poor and infertile and this has been exacerbated by climate change.

This has been a major reason for low crop yields experienced by farmers in the irrigation scheme. The indigenous knowledge strategies employed by the farmers include the use of traditional manure thus animal droppings and farmyard manure, crop residue management and mixed cropping to improve soil fertility. The study also revealed that farmers use new contemporary forms of organic manure (compost) which is enriching and improving soil fertility and enhancing crop productivity. The study found out that aside these forms of organic manure, farmers also apply inorganic manure to enrich the soil. The commonest being inorganic fertilizers which they said were expensive as compared to traditional manure. The findings shows that farmers preferred the organic manure because it enriches the soil more and does not contain harmful chemicals that destroy the soil and pollute the water in the dam. The use of animal droppings, farmyard manure and crop residue were essentially indigenous strategies handed down to them from generation to generation through the process of socialization by family and other members of the community. This concurs with Gyekye, (1996) who observed that the family in Ghana functions as an agent of socialization by transmitting traditional values and knowledge to its younger ones. Composting and mixed cropping on the other hand has traits of both indigenous and external knowledge. Contemporary composting and various crops to mix with traditional crops to enhance soil fertility were introduced to the farmers by external agents thus the agricultural extension officers and NGOs. Composting was lauded by farmers as being more effective in improving soil fertility when applied. From the discussion it can be seen that some of the adaptation measures are a blend of indigenous knowledge and external knowledge which is more scientific. This fusion and the way farmers discuss it is a typical discourse of hybrid knowledge. The use of traditional organic manure and compost through the facilitating role of NGOs and agricultural extension officers has led to some successes in crop production either by increasing or stabilizing crop productivity of irrigation scheme farmers leading to favourable livelihood outcomes.

The study also demonstrates clearly that farmers utilized local knowledge to combat diseases and pests affecting their crops. The local knowledge system used to combat diseases and pests include spraying crops with cow dung, pricking out, use of ash on crops and hand picking. These strategies are wholly based on the local knowledge acquired by farmers over the years and which they also hand down to younger generations in order to ensure the survival of their indigenous practices. The findings reveal that the strategies used to fight the diseases and pests have helped to reduce the vulnerability of the farmers to the incidence of

crop diseases and pest infestation. The findings reveal, however, that though the local strategies employed by farmers to fight the diseases and pests are helping to reduce their vulnerabilities, the local pesticides and chemicals are not very effective in dealing with the pests and diseases. This situation has led to farmers believing that the pests in particular have found a resistance to the local methods employed. In order to deal with the situation, many farmers have resorted to the use of orthodox chemicals. The commonest being DDT which they mix with water and spray on the crops. The use of orthodox chemicals was also deemed not to be very effective. The situation has led to farmers using both the local and orthodox strategies side by side with mixed results in terms of crop yield stabilization and increase. In as much as farmers resort to orthodox chemicals the cost of the chemicals is another barrier to its use by farmers who in some instances cannot buy them. The study found that when local knowledge and modern chemistry fail farmers they commit the survival of the crops to God and this has dire implications on their livelihoods.

This study reveals that farmers in reducing their vulnerability to post-harvest losses, which is a major threat to food availability and affordability, employ various indigenous strategies to store the harvested produce. The strategies include drying of crops, especially vegetables, applying ash on some crops, especially okro, and drying them so as to prevent them from getting rotten, use of medicinal leaves and airing of crops, especially onions. The local strategies were very effective in preventing post-harvest losses but become difficult to apply when the harvest is in large quantities because the strategies are labour intensive and the raw materials such as ash and the medicinal leaves are also difficult to get in large quantities. A seminal problem identified was also the lack of or inadequate modern storage facilities to store especially onion which was the main crop of value cultivated by all farmers in the Tanga irrigation scheme. The situation sometimes forces farmers to sell off their onions at ‘give away’ prices to customers or middlemen, who take undue advantage to exploit farmers because of the weaknesses or difficulties in storing onions when produced in large quantities. This study demonstrates that the motivation to store crops is driven by economics, which is to make profit at a later date when the prices of the produce might have soared. This I describe as ‘profitization from livelihood adaptation using indigenous knowledge strategies’. Storing of crops and selling at a later date was the only means through which farmers used the asset at their disposal to earn extra income to cater for their household needs and guarantee successful farming in the rainy season and following irrigation season.

This study has shown that indigenous knowledge is important in the facet of local development and as such should be accorded the needed attention. The importance of local knowledge to development has been highlighted by several authors who describe it as an important resource that presents multiple opportunities for local development and an effective source for holistic management of natural resources by enhancing conservation and sustainability of natural resources (Antweiler, 1998; Kristjanson et al. 2009, Silittoe and Marzano, 2009 Dove, 2010; Soh and Omar, 2012) as such the local embeddedness of indigenous knowledge provides it with relevance, power and applicability as well as with agency and efficacy in addressing bottlenecks of local development (Briggs, 2005). Despite the importance of local knowledge as a major social capital, its use and application faces a number of challenges. This study reveals that the use of local knowledge has been marginalized and more attention is given to western scientific knowledge and modern technology as well as government initiated adaptation strategies. Indigenous knowledge is neglected based on the notion that it cannot be justified and proven by science and that it is based on superstition and religious beliefs. With this notion of local knowledge farmers do not receive assistance with regard to using and improving their local strategies to enhance climate change adaptation. In instances where they are engaged by external agents and government officials, indigenous knowledge was not always featured in the discussions. Their concerns were only taken when there is support for some government or NGO sponsored projects which are targeted at farmers. The behaviour of government officials and external agents towards the farmers' local knowledge derails the ability of farmers to leverage their indigenous resources for adaptation and this also limits their knowledge base when it comes to adding and improving the local knowledge they possess.

8.4 DISCUSSION OF IDENTIFIED DISCOURSES AND CLIMATE CHANGE ADAPTATION

As suggested by Gee (2000) discourses are socially and culturally formed but historically changing historically. The way discourses acts to produce meaning through the use of language should be embedded in the cultural and historical location of those meanings (Gee, 2000).

Discourse therefore denotes how language is used in social interaction. Discourse describes our reality, at once depicting and delimiting our understanding of the world and our place in it. Discourse analysis is important in climate change research because it helps us to better

understand how people interpret social issues and how we may shape social responses to these issues.

Research has shown the important role discourse plays in shaping opinion and perceptions of climate change, and the manner in which climate change is perceived and constructed discursively has major implications for the responses chosen for climate change mitigation and adaptation. This section discusses the various discourses that emerged during this PhD study and its implications for climate change adaptation.

The findings of the study revealed that various discourses emerged from the responses of farmers to show the perceptions farmers have about climate change, the causes and the effects as well as the indigenous strategies adopted by the small-scale irrigation farmers to deal with climate change. The study demonstrated that the discourses that emerged in this study often clash or intersect. The categorization of discourses in the study also indicated major or capital D and minor or small d discourses based on Gee's approach to labelling of discourse (Gee 2014; 2015)

On the perception of farmers about climate change, the study identified the following Big D discourses, some of them however being more dominant than others: (i) Religious/Spiritual big D Discourse with a sub-group of small d discourses such as the African traditional religion discourse (ATR) where farmers perceive climate change and associate it with the actions of God and the gods in the community, due to community members' disobedience and disrespect for the gods; (ii) science-based natural phenomenon Discourse where climate change is perceived as occurring, irrespective of any human activity, hence the farmers see it as naturally occurring even though they agree that human activities also have an impact on climate change; (iii) indigenous knowledge Discourse with its sub-group of a lived experience discourse where perceptions of climate change are based on the farmers' personal experience and actions embedded in local and social realities, and (iv) anthropogenic Discourse where climate change is seen as caused by human activity.

These Discourse categories are drawn upon by the social actors and may be seen as sites of discursive struggle. The science-based natural phenomenon Discourse clashes with indigenous knowledge Discourse in the sense that the foundation of science is based on proof whereas indigenous knowledge has been handed down from generation to generation, in most instances orally. In a similar way, the science-based Discourse clashes with the religious /spiritual Discourse because whereas the former ascribes to scientific proof, the latter relies

on supernatural beliefs. Science-based natural phenomenon Discourse, on the other hand, intersects with anthropogenic Discourse because science has proven and recognises that human activities can lead to the degradation of the natural environment. Indigenous knowledge Discourse seems to intersect with religious/spiritual Discourse, which may be seen from the field study area where an ATR discourse could be based on knowledge that has been passed down from one generation to another, or alternatively could be based on the farmer's experience on what he has been socialized to believe as an action of God.

Among the Religious/Spiritual Discourse on the perceptions of climate change, the ATR discourse dominates the other religious discourses such as Christianity and Islam. This in part is due to the fact that ATR is deeply imbedded in the lives of the local farmers despite some of them embracing Christianity and Islam and therefore still hold on to ATR beliefs about climate change. The three main religions believe in God but ATR believes in the existence of lesser gods who dwell among people mostly in shrines and sacred places such as the grooves; this explains why the dominant perception about climate change from the study is dominated by the major Religious/spiritual Discourse relying more on a minor ATR discourse. The study shows that the four main Discourses on climate change perception intersect and intertwine as well as complement each other even though farmers do not directly interlink them. For instance felling of trees in revered areas as a major driver of climate change from a Religious/Spiritual Discourse aligns with anthropogenic Discourse since felling of trees is a human activity which can lead to climate change.

Findings of the study reveal that the dominant discourses with regards to causes of climate change are the Religious/Spiritual Discourse and Anthropogenic Discourse. The study reveals that the dominant Discourse on the perception of the causes of climate change by the farmers was the Religious/Spiritual Discourse as compared to the Anthropogenic Discourse, but in instances where the farmers spoke about human activities as the causes of climate change they still ascribed religious meanings to it. The Religious/Spiritual Discourse being stronger on the causes of climate could be due to the fact that most subsistence farmers are not formally educated and therefore rely on other factors such as superstition and natural events to explain climate change (Yaro, 2013). On the other hand, stakeholders such as ACTIONAID and Red Cross Society, Ghana in the field study area did not ascribe religion/spirituality as a cause of climate change but attributed it to human activities. Anthropogenic Discourse on the causes of climate change was more dominant among this category of respondents. The views of the stakeholders is most likely due to the fact that the

stakeholders had higher levels of education and have been working with issues related to climate change for some years and are therefore exposed to the scientific explanation regarding the causes of climate change.

The study has shown that the hegemonic discourses on the perception, causes of climate change and indigenous adaptation to climate change are the Religious/Spiritual Discourse and Indigenous Knowledge Discourse. The implication of this for climate change adaptation are that the local farmers already are aware of climate change, its manifestations and impacts and have developed their own indigenous knowledge system to adapt to it. In this regard for any meaningful climate adaptation programme or policy targeting the local farmers, there is the need to take into account the religious beliefs of the farmers. This should be used as a starting point to mobilise the farmers for climate change education and sensitisation so as to promote sustainable climate adaptation strategies. Finally from the study of discourses, indigenous knowledge has shown to be a powerful resource used by the farmers to adapt to climate change. There is therefore a need to integrate indigenous knowledge in climate change adaptation policies. If this is done it will lead to farmers easily embracing policies that deal with climate change and also build the adaptive capacity of farmers. It is therefore my view that if these two Discourses on climate change from the study are used by policy makers, it will result in farmers embracing the other discourses that emerged on climate change in the field study area in a holistic manner to adapt to climate change.

8.5 CONCLUSIONS

This study was to look at climate change and sustainable livelihood adaptation with a focus on how community managed irrigation scheme farmers with small landholdings use their indigenous knowledge to adapt to climate change stressors. The research looked at the perception of farmers about climate change, its perceived causes, impacts on the irrigation scheme and the indigenous strategies used by farmers to adapt to the impacts.

The study concludes that climate change is taking place in the Tanga community and the farmers are aware of it and its impacts. The farmers showed extensive knowledge about the local climate conditions in the study area in the last 30 years, which is as a result of their intimacy with their local environment.

Another conclusion drawn from this study is that farmers have various sources of information about climate change which enables them to form an opinion about it. They associate climate

change mostly to rising temperature, unpredictable rainfall and changing wind conditions. Farmers perceive climate change as being caused by socio-cultural and religious beliefs. They also recognize the anthropogenic causes but still attributed it to religious beliefs instead of scientific beliefs. A religious Discourse therefore dominates the causes of climate change as perceived by farmers with other discourses being science-based natural phenomenon discourse, anthropogenic discourse and indigenous knowledge discourse.

The study suggests from the findings and conclusion on the perceived causes of climate change that there is still a knowledge deficit about the causes of climate change as most farmers related the causes to socio-cultural and religious factors. This calls for the need for education of farmers on environmental and climatic issues to help them better understand the causes of climate change from other perspectives which will go a long way to enable them protect the environment from further harm and enhance farmers acceptance of climate adaptation measures or strategies aimed at mitigating the present and future impacts of climate change. Bridging the gap between farmers perception on the causes of climate change with scientific knowledge as mentioned earlier can be done through education by applying simple technical explanation to the causes of climate change through effective communication, building capacity of farmers through workshops and seminars, employing local materials during training to explain causes of climate change and better extension services. Extension services, capacity building and continuous environment education will help farmers grasp the causes of climate change and protect their environment from further degradation and changes in climatic conditions. This notwithstanding, the study suggests that 'religious capital' in rural communities such as Tanga is a powerful force to mobilize people to sensitize and convince farmers to accept or avoid certain practices which may be beneficial or inimical to the environment. It is therefore recommended that governments and development agencies should leverage 'religious capital' to promote climate sustaining strategies and adaptation.

The study concludes also that climate change is affecting the livelihood of the irrigation scheme farmers and irrigation infrastructure. This is manifested in low crop yields leading to low income accruing to farmers thus exacerbating hunger conditions. This is in line with various findings (IPCC, 2007: Slater et al. 2007; Assan et al. 2009; IFAD, 2008; UNDP, 2009; Adu-Boateng and Oppong, 2011) that the climate is expected to change both now and in the future and that by the end of the 21st century it will affect the livelihood of the majority of agricultural-dependent communities especially in development countries as well as having

an adverse effect on infrastructure including water systems and the natural ecosystem. The impact is further compounded by the fact that farmers have limited access to financial resources, technical assistance and extension services. In this regard there is the need to strengthen access to extension services to enable farmers to have access to proper information about climatic conditions and improved farming practices to increase their adaptive capacity and resilience to the impacts of climate change. The study also recommends the regular rehabilitation of the irrigation infrastructure and regular training on dam management. Farmers should also be hooked to financial institutions such as banks and credit institutions to enable them access financial resources to support their farming activities. Access to financial resources is also key to support adaptation strategies by farmers and it is also instrumental in diversify the livelihoods of farmers.

Another crucial conclusion drawn from this study is that farmers understand the concept of climate change and its impacts on their livelihoods, and based on that they use their indigenous knowledge and practices to adapt to changing climatic conditions, which affect their farming activities. Indigenous knowledge is a powerful resource used by the farmers to deal with their vulnerabilities to climate change and variability. The importance of local knowledge is however not given the needed recognition by development practitioners, and in some cases the farmers themselves. Emphasis is rather put on the use of scientific knowledge. A critical issue is that, though indigenous knowledge practices are becoming less effective because they fail to yield the desired results in the current changing climatic conditions they are still used by majority of farmers in rural communities such as Tanga. Indigenous knowledge is cheaper and readily available in the local environment and known by the farmers as compared to scientific knowledge. It also remains the greenest technology, the reason why less developed countries contribute less to GHG emissions as compared to the developed industrialized countries. The role of indigenous knowledge in societal development and the challenges associated with its use has however been acknowledged by several authors (Dove, 2000; Sillitoe, 2007; Gerke and Ehlert, 2011; Chikaire and Nnadi, 2011; Soh and Omar, 2012; Enns, 2015). The study demonstrated that the neglect of indigenous knowledge can lead to difficulties in implementing certain adaptation strategies and might result in its extinction if prudent measures are not taken to mainstream indigenous knowledge in climate change adaptation policies. Therefore there is the need to bridge the gap between indigenous knowledge systems for adaptation with scientific knowledge as a means to enhance adaptive capacity of local farmers. Neglecting indigenous knowledge in

policy formulation for climate change rather constrains the adaptive capacity of farmers, and this can lead to maladaptation. This study therefore calls for aligning indigenous knowledge and practices of local farmers with modern scientific knowledge by agencies and agents who are into climatic and environmental issues. This could be done through the fusion or synthesis of indigenous knowledge and practices with modern scientific knowledge leading to the production of a hybrid knowledge that will be beneficial to the local actors and ecosystem as a whole. The formation of hybrid knowledge through localization of knowledge will build the capacity of farmers in adapting to climate change, since one type of knowledge cannot solve the myriad of problems faced by people in rural communities in Africa.

The study concludes by saying that indigenous knowledge gained by the farmers has been a major resource which has been used by the irrigation scheme farmers over the years to manage the impact of climate change and to sustain their livelihoods. It is therefore imperative for policy makers and development practitioners to critically consider the role of indigenous knowledge in development and rather support it than gloss over it. The study therefore recommends the integration of indigenous knowledge systems with modern scientific knowledge to produce an appropriate knowledge which will be much more effective to deal with the impacts of climate change

8.6 CONTRIBUTION OF THE RESEARCH

The study makes significant contribution to research in the following ways;

First and foremost the study makes a modest account and documented analysis of climate change issues in the context of Tanga community which was virtually absent and thereby putting Tanga a relatively small community in Bawku West District on the climate change discourse map.

The study has broadened knowledge and provided a comprehensive analysis by taking a critical look at the perceptions, causes and impact of climate change on small-scale irrigation scheme farmers in Tanga. The lived experiences and perceptions on the causes of climate change provided the basis for the adaptation to climate change. The study was able to demonstrate the relationship between climate change and livelihoods of farmers and provided a deeper understanding of the adverse effects of climate change on the livelihood of farmers. The research has empirically shown that though development of small-scale irrigation schemes are themselves an adaptation to climate change and a way to diversify livelihoods,

the strategy itself is also threatened by competing climate change discourses and as such not able to perform at its optimum level. What is essentially happening to the irrigation scheme and the empirical evidence provided by the study on the impact of climate change on the irrigation scheme as well as the adaptation strategies employed by the farmers can best be described as 'adaptation within adaptation'. This is a departure from a lot of previous studies which largely centred on the effects of climate change on rain-fed agriculture. The study therefore provides empirical evidence which indicates that small-scale irrigation schemes in North-Eastern Ghana and farmers are vulnerable to climate related stressors. In view of this there is the need for policy makers and researchers to include small-scale irrigation scheme farmers when designing climate change policies in order to build their adaptive capacity.

The study also provided empirical evidence that the impacts of climate change led to farmers coming up with strategies based on their indigenous knowledge systems to adapt to climate change. The study has demonstrated that the adoption of indigenous knowledge and practices is a major resource use by the farmers to adapt and sustain their livelihoods in the face of climate change challenges. The study has provided empirical evidence to demonstrate that indigenous knowledge is not wholly local but a fusion of local and external knowledge leading to the localization of knowledge. The study highlighted that though local knowledge was important for adaptation and development as a whole its use and application is often neglected and marginalized by development practitioners and therefore do not mostly feature in climate change policies.

Finally, the study has generally contributed to literature on climate change in developing countries. The study specifically contributes to the discourse of climate change in developing countries and adds a discourse angle to earlier indigenous knowledge studies on climate change adaptation. The study also contributes to the theoretical field of climate change mitigation and adaptation by applying a qualitative approach to data analysis.

8.7 FUTURE RESEARCH

Having looked at the findings, conclusions and contribution of the research, the study saw the need to show areas where further studies can be undertaken. The first area of interest from my point of view where further studies can be carried out is an investigation into the challenges of mainstreaming indigenous knowledge into climate change policy at the sectoral and national level. The research among other things will aim at investigating whether

indigenous knowledge has a place in climate change policy in developing countries including Ghana.

Also, in this study the challenges of applying climate change adaptation was discussed but the topic was not exhausted and there is therefore the need for further research into the challenges of using indigenous knowledge and how the challenges can be addressed.

Another area of interest is to explore the mechanisms to strengthen local knowledge for climate change adaptation with a focus on governmental policies, NGOs and other private organizational support as well as support from the research community and institutions.

Finally, there is the need to do a comparative study of climate change adaptation strategies involving rain-fed agricultural farmers and small-scale irrigation farmers to understand the challenges faced by both group of farmers and the different perspectives that might come to the fore.

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APPENDICES

APPENDIX 1

SURVEY QUESTIONNAIRE FOR COMMUNITY MANAGED IRRIGATION SCHEME FARMERS IN NORTH-EASTERN GHANA

Questionnaire Number	
Name of respondent	
Name of enumerator	
Date of interview	
District	
Community	
Time started	**Time finished**

DEMOGRAPHIC CHARACTERISTICS

CODE	QUESTION	ANSWER (√)
DGGENDER	Gender	1. Male 2. Female
DGAGE	Age	1. 30-39 years 2. 40-49 years 3. 49-50 years 4. 50-59 years 5. 60 years+
DGON	Originality/Nativity	1. Born and breed in the community 2. Migrant
DGYIC	Years stayed in the community	1. 30-39 years 2. 40-49 years 3. 49-50 years 4. 50 years+
DGETHN	Ethnicity	1. Kusasi 2. Mamprusi 3. Bissa 4. Frafra 5. Other, specify
DGMS	Marital status	1. Married 2. Single 3. Widow/Widower 4. Divorced/Separated
DGNOC	Number of children	1. None

		2. 1-5 3. 5-10 4. 11 and above
DGHHS	Household size	1. 1-5 2. 6-10 3. 11-15 4. 16-20 5. 21 and above
DGLG	Level of education	1. Basic/Middle 2. Secondary/Vocational 3. Tertiary (specify) 4. No-formal Education
DGR	Religion	1. Christianity 2. Islam 3. Traditional 4. Other, specify
DGOAIF	Occupation apart from irrigation farming	1. Crop farming 2. Livestock farming 3. Fish farming 4. Crop and livestock farming 5. Crop and fish farming 6. Livestock and fish farming 7. Crop, livestock and fish farming 8. Other, specify
DGYIF	Number of years in irrigation farming	1. Less than 10 years 2. 10-19 years 3. 20-29 year s 4. 30-39 years 5. 40 years+
DGFMSS	Farm size in the scheme (plots)	
DGHDAL	How did you acquire the land	
TYCCIS	Type of crops cultivated in the scheme	

SECTION B.
PERCEPTION OF IRRIGATION SCHEME FARMERS ON CLIMATE CHANGE

1b. Have you observed any changes in the weather in the last 30 years? 1. Yes 2. No
2b.What changes have you noticed and the extent of change

Code	**Climate variables**	**Selected variables (√)**	**Extent of change**
PFINCTEM	Increased temperature		

PFDECTEM	Decreased temperature		
PFINCRAA	Increased in rainfall amount		
PFINCRAI	Increased in rainfall intensity		
PFINCLRS	Increased in length of rain season		
PFEARONR	Early onset of rains		
PFLATONR	Late onset of rains		
PFDECRAA	Decreased in rainfall amount		
PFDECRAI	Decreased in rainfall intensity		
PFDECLRS	Decreased in length of rain season		
PFERRRAI	Erratic rainfall		
PFLODRSL	Long dry spell		
PFFLOFRE	Floods seem to be frequent		
PFINCSWE	Increase in strong winds events		

Note for extent of change: Strongly agree=5; Agree=4; Not Sure=3; Disagree=2; Strongly disagree=1

3b. What are the causes of climate change in your community? Tick appropriate cause(√)

CODE	CAUSES	TICK
PFDISBES	Disrespect for belief systems	
PFCADEFN	Indiscriminate felling of trees	
PFCABUBG	Bush burning	
PFEMOFOF	Emission of fossil fuel	
PFCAURBN	Nature	
PFCAOTHE	Others, specify	

4b. Outline sources where you obtained information on climate change?

CODE	**SOURCES OF INFORMATION**	**TICK AS APPROPRIATE (√)**
PFPEXPE	Personal experience	

PFPAFAM	Parents/family members	
PFVILLD	Village leaders	
PFFRINB	Friends/Neigbours	
PFRELIP	Religious places	
PFSOCGP	Social groups	
PFCOMMT	Community meetings	
PFMEDIA	Media, indicate media type:	
PFNGOBO	NGOs/CBOs	
PFEXTOF	Extension officers	
PFOTHER	Others, specify	

SECTION C. IMPACTS ON LIVELIHOOD

1c. what are the effects of climate change on the irrigation scheme which affect your livelihood?

CODE	Effects	Response
IMLDEIF	Destruction of irrigation infrastructure and facilities	
IMLDEVW	Decrease in volume of water	
IMLDELW	Declining and loss of wetlands	
IMLIPED	Increased pests and crop diseases in the scheme	
IMLSIBP	Soil irrigation seems to be a much bigger problem	
IMLSIIN	Siltation has increased	
IMLSOIF	Soil is becoming infertile	
IMLDEVE	Declining vegetation cover	
IMLOTHE	Others, specify	

Note, response: strongly agree=5; Agree=4; Not sure=3; Disagree=2; Strongly Disagree=1.

2c.Whatare the effects of climate change on your livelihood?

Code	Effect	Selected effects	Rank
IML1	Increased frequency of droughts and crop failure		

IML2	Declining crop yields		
IML3	Post harvest losses		
IML4	Erosion and soil infertility		
IML5	Poverty (Low incomes) and food shortages		
IML6	Rising cost of farming		
IML7	Destruction of farm roads and homes		
IML8	Siltation of water bodies		
IML9	Destruction of vegetation cover		
IML10	Rural-urban migration		
IML11	Lack of potable water		
IML12	Extinction of some crop varieties and crops		
IML13	Others, specify		

Risk Rank- High-3; Medium-2; Low-1

3c.What are the manifestation of the impacts of climate change on your livelihood?

Code	Variable	1=Increased 2=Same 3=Declined
IMLFOAV	Food availability	
IMLINFM	Income from farming	
IMLCROV	Crop varieties	
IMLCROY	Crop yields	
IMLHUMH	Human health	
IMLABSS	Ability to access social services	
IMLABBN	Ability to provide basic needs of family	
IMLABFI	Ability to buy farm inputs	
IMLAVFL	Availability of family labour	
IMLOTHM	Others, specify	

D. INDIGENOUS KNOWLEDGE AND ADAPTATION TO CLIMATE CHANGE

1d. Have you made changes or adjustments to your farming practices in response to climate change over the last ten years in the irrigation scheme? 1. Yes 2. No

2d. If your answer to 1d above is no. Why?

Number	**Reason for not adapting**	**yes**	**No**
1	Lack of financial capital		
2	Lack of information		
3	Lack of knowledge		
4	Others, specify		

3d. If your answer to 1d above is yes, what adaptation strategies have your made based on your indigenous knowledge to deal with the following impacts of climate change:

VARIABLE	ADAPTATION STRATEGIES
Water conservation management	1. Planting early maturing crop varieties 2. Mulching 3. Use of dug-outs and ponds 4. Rain water harvesting 5. Others, specify
High temperature	1. Cover cropping 2. Mulching 3. Shading 4. Planting/growing trees 5. Others, specify
Soil conservation management	1. Use of animal droppings 2. Use of farm yard manure 3. Composting 4. Crop residue management 5. Mixed cropping 6. Others, specify
Pests and diseases management	1. Use of ash on crops 2. Use of fresh cow-dug to spray on crops 3. Pricking 4. Hand picking and crushing 5. Others, specify
Harvesting and storage	1. Use of ash 2. Drying of crops/vegetables 3. Airing of crops 4. Use of medicinal leaves (name the leaves) 5. Others, specify

4d. What are the challenges of applying indigenous knowledge and practices on climate change adaptation (rank them as above in terms of importance)

CODE	FACTORS	RANK
INDLAGS	Lack of government support	
INDIGBA	Inception of government based adaptation strategies	
INDKNFE	Known by few (elders do not pass them on)	
INDIWKN	Intrusion of western knowledge (marginalised)	
INDNORE	It is not reliable	
INDDTFS	Disappearance of traditional farming system	
INDSTGA	Specific to a given area, not applicable everywhere	
INDDIUS	Difficult to use/apply	
INDTUMT	Threatened by increase in the use of modern technology	
INDDIKC	Death of indigenous knowledge custodians (Not written)	
INDCLBT	Connected with local beliefs and taboos	
INDCJPR	Cannot be justified and proved	
INDOTHE	Others, specify	

Rank: strongly agree=5; Agree=4; Not sure=3; Disagree=2; Strongly Disagree=1.

4e. What suggestions do you think will enhance indigenous knowledge practice to effectively adapt to climate change?

1.
2.
3.
4.
5.
6.

4f. What other factors limit your ability to adapt to the impact of climate change on your livelihood activities in the irrigation scheme.

1.
2.
3.
4.
5.
6.

E. GOVERNMENTAL AND OTHER AGENCIES SUPPORT FOR IRRIGATION SCHEME MANAGEMENT AND CLIMATE CHANGE ADAPTATION ANDINDIGENOUS KNOWLEDGE INTEGRATION.

1e. Do you receive external support? 1. Yes 2. No

2e. Support from government and other agencies/organisations in managing irrigation schemes and adaptation in your community and form of support.

ORGANISATION	FORM OF SUPPORT	DURATION	FREQUENCY

3e Are these supports free? 1 Yes 2. No

If no what are the conditions attached

CONDITIONS	ORGANISATION(S)
1.	
2.	
3.	
4.	
5.	
6.	

4e. what have been the benefits of the assistance to you?

1.
2.
3.
4.
5.
6.
7.
8.

5e. Have they ever sought your opinion as to how you use your own knowledge to adapt to climate change? 1. Yes 2. No

6e. If your answer to 5e is yes, explain briefly

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

7e. Do you think they incorporate your indigenous knowledge on adaptation and management of the schemes in their planning activities

8e. If your answer above is yes, give reasons

Reasons you think they integrate indigenous knowledge on adaptation and management in policy and planning
1.
2.
3.
4.
5.
6.
7.

9e. What five important assistance do you need from various organisations to enable you adapt to changes in the climate? Please rank your responses in order of importance (1st most important and 5th least important)

9.1e ISSUE (Key)	9.2e WHO (Key)	9.3e RANKING
9.1.1e	9.2.1e	9.3.1e
9.1.2e	9.2.2e	9.3.2e
9.1.3e	9.2.3e	9.3.3e
9.1.4e	9.2.4e	9.3.4e
9.1.5e	9.2.5e	9.3.5e

Key 9.1- Issues: 1. Irrigation maintenance; 2. Climatic information services; 3. Provision of credit facilities; 4. Provision of subsidised farm inputs; 5. Extension Services; 6. Provision of improved seed varieties; 7. Provision traction services; 8. Other, specify.....

Key 9.2- Who: 1. Central government; 2. NGOs/CBOs; 3. Local government; 4. Local community; 5. Private sector; 6. Other, specify.....

10e. What are/were generally the main constraints in adjusting your farming practices to the impacts of climate change?

General constraints in adjusting farming practices to the impacts of climate change
1.
2.
3.
4.
5.
6.
7.

11e. Any additional comment you wish to add

.....

.....

END OF QUESTIONNAIRE AND THANK YOU FOR YOUR ATTENTION AND INFORMATION.

APPENDIX 2

INTERVIEW GUIDE FOR COMMUNITY MANAGED IRRIGATION SCHEME FARMERS IN NORTH-EASTERN GHANA

Name of respondent	
Date of interview	
Interview record	
District	
Community	
Time started	**Time finished**

QUESTION	ANSWER (√)
Gender	3. Male 4. Female
Age	6. 30-39 years 7. 40-49 years 8. 49-50 years 9. 50-59 years 10. 60 years+
Originality/Nativity	3. Born and breed in the community 4. Migrant
Years stayed in the community	5. 30-39 years 6. 40-49 years 7. 49-50 years 8. 50 years+
Ethnicity	6. Kusasi 7. Mamprusi 8. Bissa

	9. Frafra 10. Other, specify
Marital status	5. Married 6. Single 7. Widow/Widower 8. Divorced/Separated
Number of children	5. None 6. 1-5 7. 5-10 8. 11 and above
Household size	6. 1-5 7. 6-10 8. 11-15 9. 16-20 10. 21 and above
Level of education	5. Basic/Middle 6. Secondary/Vocational 7. Tertiary (specify) 8. No-formal Education
Religion	5. Christianity 6. Islam 7. Traditional 8. Other, specify
Occupation apart from irrigation farming	9. Crop farming 10. Livestock farming 11. Fish farming 12. Crop and livestock farming 13. Crop and fish farming 14. Livestock and fish farming 15. Crop, livestock and fish farming 16. Other, specify

Number of years in irrigation farming	6. Less than 10 years 7. 10-19 years 8. 20-29 year s 9. 30-39 years 10. 40 years+
Farm size in the scheme (plots)	
How did you acquire the land	
Type of crops cultivated in the scheme	

FARMERS EXPERIENCE AND OBSERVATIONS WITHIN THE COMMUNITY

1. Please can you tell the changes you have observed in this community over the years, your experience as a farmer, the history of the irrigation scheme and the obstacles you face as a farmer in this community in the past and in recent times?

PERCEPTION AND CAUSES OF CLIMATE CHANGE

1. Can you give an overview of the climate situation in the past 30 years
2. In your opinion what is climate change and its causes?
3. Can you outline and elaborate on traditional ways of predicting changes in the weather?

CLIMATE CHANGE AND IMPACTS ON LIVELIHOOD

4. What is the impact of climate change on the irrigation scheme?

5. In what way does it affect your livelihood activities in the scheme?

INDIGENOUS KNOWLEDGE AND ADAPTATION TO CLIMATE CHANGE IMPACTS

6. Can you describe in detail the measures you took based on your own knowledge to adapt to the impacts of climate change on the schemes based on the following:
   Water conservation management, high temperature, soil conservation management, harvesting and storage and pest and disease management?
7. What factors do you think limit your ability to adapt to climate change using your indigenous knowledge and why?
8. Apart from the adaptation issues in the irrigation scheme do you employ any other means of adaptation to sustain yourself from climate change impacts?

GOVERNMENT AND OTHER AGENCIES SUPPORT AND INDIGENOUS KNOWLEDGE INTEGRATION IN CLIMATE CHANGE ADAPTATION

9. Which government and non-governmental agencies have been supporting you in adapting to climate change and managing irrigation schemes in your community?
10. Outline in detail the management issues they have discussed or taught you to ensure that your dams function well?
11. Outline in detail the assistance they have offered you to adapt to climate change impacts in the irrigation scheme and the benefits of the assistance?
12. Do you think they incorporate your indigenous knowledge on adaptation and management of the schemes in their planning activities
13. Do you think it is important for indigenous knowledge to be mainstreamed in adaptation policy and planning for sustainability of the irrigation schemes
14. What assistance do you need from various organisations apart from what you have been getting?

APPENDIX 3

CHECKLIST FOR FOCUS GROUP DISCUSSION

Date of Interview-	
District -	
Community-	
Group type-	
Name of facilitator	
Time started	**Time finished**

FARMERS PERCEPTION AND CAUSES OF CLIMATE CHANGE

1. Can you describe the climate of this community in the past 30 years
2. What is climate change and its causes?
3. What traditional ways do you predict changes in the weather pattern?
4. How did you learn/hear about climate change

CLIMATE CHANGE ANDIMPACTS ON LIVELIHOODS

5. What is the impact of climate change on your irrigation scheme
6. Do you think that the change in climate has an impact on your farming activities and how
7. What are the impacts of climate change on your livelihoods in recent years?

INDIGENOUS KNOWLEDGE AND ADAPTATION TO CLIMATE CHANGE

8. What measures have you adopted based on your indigenous knowledge to deal with climate change impacts in relation to high temperature, soil conservation management, water conservation management, harvesting and storage and pests and diseases management?
9. The adaptation strategies that you have been using, how did you learn it?
10. What factors/challenges do you think limit your ability to adapt effectively to CC using indigenous knowledge?

11. What measures do you suggest to deal with the challenges above?

GOVERNMENT AND OTHER AGENCIES SUPPORT AND INDIGENOUS KNOWLEDGE INTEGRATION IN CLIMATE CHANGE ADAPTATION

12. Do you get assistance with regards to managing and adapting to climate change in the schemes (Provide list of agencies)
13. What form of assistance do these agencies offer with regards to management of the irrigation schemes and adapting to CC (describe the nature of assistance).
14. How beneficial has their assistance been?
15. Do they seek you own knowledge with regards to how you manage the schemes and adapt to climate change (Expatiate further on this).
16. Do you think they incorporate your I.K in their adaptation policies?
17. Do you think it is necessary to integrate indigenous knowledge with existing policies and programs of government to adapt to the impacts of climate change? Explain response.
18. What other support apart from what you have outlined would you need from government and other agencies to enhance your livelihood and also sustain your schemes

APPENDIX 4

INTERVIEW GUIDE FOR GOVERNMENT AND OTHER AGENCIES OR ORGANISATIONS.

Date of Interview	
District -	
Community-	
Name of institution	
Position/Role	
Time started	**Time finished**

PERCEPTION AND CAUSES OF CLIMATE CHANGE

1. What changes have you identified in the local climate in the last 30 years?
2. Can you give years that?
3. What is climate change and its causes?

CLIMATE CHANGE IMPACTS ON LIVELIHOOD

4. Do you think climate change has an impact on the irrigation schemes in your district?
5. What are the impacts of climate change on the schemes and the district in general?
6. What are the effects/impacts of climate change on the livelihood of small scale irrigation scheme farmers in the district?

INDIGENOUS KNOWLEDGE AND ADAPTATION TO CLIMATE CHANGE

7. Have you identified any indigenous adaptation strategies used by farmers based on their own knowledge to adapt to climate change?
8. What are the indigenous knowledge adaptation measures used by the farmers to adapt to the following impacts of climate change?
   -water inadequacy due to low rainfall
   -high temperature
   -pest and diseases

-soil fertility management

9. The strategies outlined above, do you think they are yielding the desired results to farmers in terms of increasing crop production and sustaining livelihoods?
10. What in your opinion are the challenges of applying the indigenous knowledge practices to adapt to climate change in the irrigation schemes?
11. How can those challenges be solved?

SUPPORT FOR ADAPTATION AND SUSTAINANCE OF IRRIGATION SCHEMES

12. What support does your organisation provide for farmers to manage their irrigation schemes?
13. In what ways do you assist irrigation scheme farmers to adapt to climate change impacts with regards to

    -water inadequacy due to low rainfall

    -high temperature

    -pest and diseases

    -soil fertility management
14. How beneficial has been your support to the irrigation scheme farmers in the light of climate change?
15. In assisting farmers to adapt to climate change and manage their schemes do you engage them on their indigenous knowledge
16. Do you integrate the indigenous knowledge used by farmers with your scientific knowledge?
17. What policies do you have on climate change adaptation and do the policies integrate indigenous knowledge?

18. What do your think are the challenges/constraints on adaptation to climate change by small scale irrigation farmers?
19. What additional support do you think farmers need to deal with the impacts of climate change?

APPENDIX 5

LETTER OF INTRODUCTION

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15th February, 2017.

Our Ref: UDS/FIDS/WA/P04 1162

TO WHOM IT MAY CONCERN:

Dear Sir/Madam,

INTRODUCTORY LETTER
MR. JONAH AMOSAH
(P04.1162)

I write to introduce to you **Mr. Jonah Amosah** who is a Lecturer with staff number P04.1162 in the University for Development Studies, Faculty of Integrated Development Studies, in the Department of Social Political and Historical Studies (SPHS).

Mr. Amosah is a PhD candidate and as part of his programme he is gathering data for the PhD programme.

The University would therefore appreciate it if you could offer him the necessary assistance he might need.

Counting on your cooperation.

Yours faithfully,

Job Asante
Senior Assistant Registrar

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