UNIVERSITY OF CAPE COAST

CLIMATE CHANGE, WATER CONFLICT, AND HUMAN SECURITY IN THE BAWKU AREA OF GHANA

YAW ASAMOAH

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BY

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DECLARATION

Candidate's Declaration

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

Candidate's Signature……………………………….... Date……………………..

Name: Yaw Asamoah

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature ……………………… Date ……………………

Name: Prof. Kwabena Barima Antwi

Co-Supervisor's Signature …………………………… Date ……………………

Name: Dr. Simon Mariwah

ABSTRACT

The publication of the Fourth Assessment Report by the Intergovernmental Panel on Climate Change ignited several debates, including the security implications of climate change. While some authors have pointed out some forms of relationship between climate change and conflict, others have had contradicting views. This current study sought to unravel this nexus and to contribute our understanding of the supposed association in the Bawku Area of Ghana. Guided by the Hydro-Climatic Change, Conflict and Human Security framework, and the Political Ecology theory, case study design was employed to conduct this qualitatively-led mixed method study. In all, a total of 187 respondents participated in both in-depth interviews and focus group discussions. This primary data was complemented by a 40-year temperature and rainfall data from Ghana Meteorological Agency, a point and line data taken with a GPS device, and some digital pictures. It was found from the secondary data that rainfall in the regions have not decreased significantly. Yet according to respondents, availability of water to meet their demands is low. This scarcity compelled residents to rely largely on dams and underground water sources for their farming purposes, especially during dry season. In their attempts to adapt to the scarcity situations, some minor conflicts ensued in all the eight communities studied. These minor conflicts which involved communities and individuals – women and children, vegetable and livestock farmers, as found, could trigger major violent conflicts if they are not resolved. It is therefore recommended that dams and irrigation facilities be constructed by the Ghana Irrigation Development Authority in order for residents to have regular supply of water for their activities.

KEY WORDS

Adaptation

Climate change

Ghana

Human security

Water conflict

Water scarcity

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DEDICATION

To the people of the Bawku Area of Ghana

Table of Contents

	Page
DECLARATION	ii
ABSTRACT	iii
KEY WORDS	iv
ACKNOWLEDGEMENTS	v
DEDICATION	vi
LIST OF FIGURES	xvi
LIST OF TABLES	xix
LIST OF ACRONYMS	xx
CHAPTER ONE: INTRODUCTION	
Background to the Study	2
Statement of the Problem	16
Objectives	18
Research Questions	19
Significance of the study	19
Delimitation	21
Limitations	22
Definition of Terms	24
Adaptation	24
Bawku Area	24

Climate Change 24

Human security 25

Water conflict 25

Water stressed communities 25

Organisation of the study 26

CHAPTER TWO: WATER, CLIMATE CHANGE, CONFLICT AND COOPERATION

Introduction 29

Global Water Resources 31

Global water yield 31

Global water use and demand 32

Some Impacts of Climate Change on Water Resources: Water Scarcity, Drought, Flooding 39

Drought 40

Flood 44

Water scarcity 49

Adaptation as a Response to Climate Change 54

Types and forms of adaptation 56

Existing climate change coping and adaptation strategies 57

Maladaptation, Conflict and Cooperation 59

Linking climate change impacts to conflict and cooperation 60

The Water Conflict Debate 64

Evidence supporting the water conflict debate 71

Critiquing the water conflict debate 74

Water and Cooperation 78

Climate Change and Human Security 82

Implications of climate change on human security 84

Summary 90

CHAPTER THREE: THEORETICAL AND CONCEPTUAL ISSUES

Introduction 92

Conflict – what it is, and what it is not 93

Types of conflict 94

Stages of conflict development 97

Theories of Conflict 99

The human needs theory 100

Vasquez's territoriality thesis (the concept of space) 103

The theory of political ecology 106

Conceptual Framework 111

Safeworld's framework for climate change and conflict analysis 111

Conceptual framework of hydro-climatic change, conflict and human security 114

Summary 118

CHAPTER FOUR: METHODOLOGY

Introduction 120

Epistemology and Research Design 120

Study Area 124

Location 124

Climate 127

Drainage 128

Vegetation 129

Population 130

Target Population 132

Sample size and sampling procedure 133

Data collection instruments 137

Pre-test of research instruments 139

Ethical considerations 140

Data Collection/fieldwork Procedures 142

In-depth interviews (IDI's) 142

Focus group discussions (FGD) 143

Water source data 143

Temperature and rainfall data 143

Data Trustworthiness 144

Credibility 144

Transferability 145

Dependability 146

Confirmability 147

Fieldwork challenges 147

Data processing and analysis 148

Mann-Kendall Trend test 150

Summary 151

CHAPTER FIVE: METEOROLOGICAL EVIDENCE AND RESIDENTS' PERCEPTION OF HYDRO-CLIMATIC EVENTS

Introduction 154

Background Characteristics of Respondents 154

Climate Pattern in the Bawku Area of Ghana from 1976 to 2015: Time-Series Analysis of Rainfall and Temperature in the 40-Year Period 156

Trend in mean monthly, annual and seasonal changes in rainfall and temperature at the Binduri Meteorological Station 157

Trend in mean monthly, annual and seasonal changes in rainfall and temperature at the Garu meteorological station 166

Trend in mean monthly, annual and seasonal changes in rainfall and temperature at the Manga meteorological station 174

Statistical analysis of trends at three meteorological stations in the bawku area 183

One-Way ANOVA Post Hoc Analysis 191

Time-series analysis of rainfall and temperature discussed 195

Residents' perception of climate change 197

Summary 199

CHAPTER SIX: WATER SOURCES AND USE, AND RESIDENTS' ADAPTATION MECHANISMS TO WATER SCARCITY ISSUES IN THE BAWKU AREA

Introduction 201

Water Sources and Use 201

Rain water 203

Boreholes and hand-dug wells 206

Dam water 210

Dug-outs 215

Respondents' Perception of Water Availability and Scarcity Situation 217

Implications of Erratic Rainfall and Water Scarcity on Food and Animal Production 224

Food crop production 224

Livestock rearing 226

Respondents' Adaptation Mechanisms to Water Scarcity Condition 228

Expanding irrigation agriculture/Dry season vegetable farming 230

Changing planting periods and mixed-cropping 234

Cultivating drought-resistant crops 236

Raising livestock with underground water sources and dried grass 237

Community "Rationing" of domestic water sources 240

Other supplementary practices: picking and sales, food storage 243

Migration 246

Summary 247

CHAPTER SEVEN: EVIDENCE OF WATER CONFLICT AND COOPERATION

Introduction 249

Residents' perception and awareness of conflict 249

Some Identified Conflicts 254

Conflict between Kuka and Lansa 254

Conflicts among irrigation farmers within communities 258

Conflict over domestic water sources 258

Conflict between livestock and irrigation farmers 261

The Climate Change-Conflict Pathways: Political Ecology and CLICO's Explanations 263

Political ecology theory's explanation 264

CLICO's explanation 267

Water Scarcity and Potentials of Violent Conflict 269

Residents' Awareness of the Other Causes of Conflict 273

Water and Cooperation 280

Traditional authorities and conflict arbitration 282

Summary 286

CHAPTER EIGHT: HYDRO-CLIMATE EVENTS, SOCIO-POLOITCAL ENVIRONMENT AND HUMAN SECUROTY

Introduction 289

Residents' perception of human security 290

Hydro-climatic events and human security 294

Socio-political dynamics and human security 296

Summary 300

CHAPTER NINE:SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction 303

Summary of main findings 303

Conclusions 308

Recommendations 309

Contribution to knowledge 312

Areas of further studies 313

REFERENCES 314

APPENDIX

APPENDIX A: Focus Group Discussion Guild For Water User Group 379

APPENDIX B: In-Depth Interview Guide For Key Informants 388

APPENDIX C: In-Depth Interview Guide For Public And/Or Private Agency 397

APPENDIX D: Informed Concent Form 406

APPENDIX E: Permission Letter To The Bawku Police District Commander 408

APPENDIX F: Introductory Letter 411

APPENDIX G: Ethical Clearance Letter From UCCIRB 413

LIST OF FIGURES

Figure		Page
1	Water uses for main income groups of countries	36
2	Average per capita water withdrawal for domestic use from some countries.	38
3	Flood map of Central and West African sub-regions as of October 2017	47
4	Renewable water resources per capita as at 2010.	52
5	Freshwater scarcity and stress in Africa by 2025.	53
6	Number of reported water conflict events per year, 1931-2012.	68
7	Incidence of reported water-related conflicts for transnational events (solid line) and subnational events (dashed line) since 1931.	70
8	Stages of conflict development	97
9	Safeworld's framework for climate and conflict analysis.	112
10	Conceptual framework of Hydro-climate Change, Conflict and Human Security.	115
11	Study areas in regional and national context.	126
12	Mean Monthly Rainfall for Binduri (1976-2015)	158
13	Annual and Seasonal Rainfall for Binduri (1976-2015)	160
14	Mean Rainfall Change for Binduri (1976-2015)	161
15	Mean Monthly Temperature for Binduri (1976-2015)	162
16	Mean Annual Temperature for Binduri (1976-2015)	163
17	Mean Annual Temperature Change at Binduri	165

18	Mean Monthly Rainfall for Garu (1976-2015)	167
19	Mean Annual and Seasonal Rainfall for Garu (1976-2015)	168
20	Mean Annual Rainfall Change for Garu (1976-2015)	169
21	Mean Monthly Temperature for Garu (1976-2015)	170
22	Mean Annual and Seasonal Temperature for Garu (1976-2015)	173
23	Annual Temperature Change at Garu (1976-2015)	174
24	Mean Monthly Rainfall for Manga (1976-2015)	175
25	Mean Annual and Seasonal Rainfall for Manga (1976-2015)	178
26	Mean Annual Rainfall Change for Manga (1976-2015)	179
27	Mean Monthly Temperature for Manga (1976-2015)	180
28	Annual Mean Temperature for Manga (1976-2015)	181
29	Mean Annual Temperature Change for Manga (1976-2015)	183
30a	Homogeneity Test in Annual Rainfall and Temperature	185
30b	Homogeneity Test in Annual Rainfall and Temperature	186
31	Women and children fetching water at a borehole at Kuka	207
32	Map of Kuka community, showing water sources and dry season farms.	211
33	The community dam at Kuka. [In the picture is the researcher standing at the bank of the dam].	212
34	(A&B)Tube and canals to source water from dam to farms at Kuka; (C) – Irrigation channels at an onion farm at Kuka.	213
35	Map of Gabuliga community showing water sources and dry season farms.	214

36	(A) Dam under construction at Zabugo; (B) – Researcher at the dried community 'dam' at Yirigungu.	215
37	An image showing the rocky nature of Yirigungu landscape.	216
38	A dug-out in a vegetable farm at Zabugo in the Bawku Municipality	217
39	(A) – A stick pointing to the level of Kuka dam at full capacity; (B) – Receding water of the Kuka community dam; (C) – Some dried portion of the Kuka dam.	218
40	(A)Gullies at Yaanatinga where water is collected during rainy season; (B) – A dried 'dam' at Yirigungu; (C & D) – Dried farms/environments at Anisi and Apotdabogo II respectively.	220
41	A Researcher holding a perforated plastic watering (A) can used by farmers in irrigating crop.	231
42	A Woman and children working on harvested onions while researcher looks on at Kuka.	234
43	A Livestock loitering around a well for water at Yirigungu	238
44	Collected dried groundnut stalk (fodder) used as a feed for livestock	240
45	Cow dung collected for sale	244
46	Barn/silo (Baare/Boore) for the storage of food, particularly cereals at Apotdabogo II.	245
47	Mud fence built around farms at Gabuliga	261

LIST OF TABLES

Table		Page
1	Global water stock and their distribution	32
2	Water availability over time by continents	34
3	Falkenmark's Water Stress Index	51
4	Discriptive statistics of rainfall and temperature and percentage distribution of mean monthly rainfall for Binduri	164
5	Discriptive statistics of rainfall and temperature, and percentage distribution of mean monthly rainfall for Garu	172
6	Percentage distribution of mean monthly rainfall	176
7	Discriptive statistics of rainfall and temperature, and percentage distribution of mean monthly rainfall for Manga	182
8	Homogeneity Test Statistics	187
9a	Annual Rainfall MK Trend Test	188
9b	Annual Temperature MK Trend Test	190
10a	ANOVA Test Statistics, Binduri	192
10b	ANOVA Test Statistics, Garu	193
10c	ANOVA Test Statistics, Manga	194
11	Water sources in the study communities in dry season	202

LIST OF ACRONYMS

AMS	American Meteorological Society
AWDR	African Water Development Report
CWSA	Community Water and Sanitation Agency
CCAPS	Strauss Center for Climate Change and African Political Stability
CLICO	Climate Change, Hydro Conflicts and Human Security
FAO	Food and Agricultural Organisation
GENI	Global Energy Network Institute
GHG	Greenhouse gases
GSS	Ghana Statistical Service
GWCL	Ghana Water Company Limited
HDR	Human Developemnt Regport
ICA	Intellegence Community Assessment
IDWC	International Dialogue on Water and Climate
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
LDCs	Less Developed Countries
MEA	Millennium Ecosystem Assessment,
MENA	Middle East and North Africa
MEST	Ministry of Environment, Science and Technology
MoFA	Ministry of Food and Agriculture
NCCP	National Climate Change Policy

NDC	National Democratic Congress
NIC	National Intelligence Council
NPP	New Patriotic Party
OECD	Organisation for Economic Co-operation and Development
UER	Upper East Region
UNDP	United Nations Development Programme
UNDESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children Emergency Fund
UNU-EHS	United Nations University's Institute for Environment and Human Security
UKCIP	United Kingdom Climate Impact Programme
USAID	United States Agency for International Development
US-DIA	United States-Direct Investment Abroad
WARICC	Water-Related Intrastate Conflict and Cooperation
WBCSD	World Business Council for Sustainable Development
WBGU	German Advisory Council on Global Change
WDR	World Development Report
WEO	World Economic Outlook
WFP-CFSVA	World Food Programme's Comprehensive Food Security and Vulnerability Analysis
WHO	World Health Organisation

WUA	Water User Associations
WWAP	World Water Assessment Programme
WWDR	World Water Development Report
WWF	World Water Forum

CHAPTER ONE

INTRODUCTION

Climate change has infamously been tipped by writers and institutions such as Burke, Miguel, Satyanath, Dykema, and Lobell (2009), Hsiang, Meng, and Cane (2011) and United Nations Environmental Programme [UNEP] (2011) to cause greater *conflict* especially in communities where poverty thrives, with weak governance, and where insecurity is endemic. This linkage has gained much attention evident in remarks by world leaders, media reportage and book-titles such as *Global Warring* and *Climate Conflict*. The topic has not escaped the agenda of the United Nations, hence, making its way into several international fora such as the Rio Declaration on Environment and Development, the European Security Strategy, and the UN High Level Panel on Threats, Challenges, and Change. In all the discussions of the matter, climate change is touted to have, and will continue to influence weather-related hazards including the increase of risk associated with extreme events caused either by variability in rainfall or temperature. Drought and/or floods are the likely outcomes.

This debate has called for a number of research works within the past few decades, with varied findings. Among some of the initial findings is the fact that climate change is seen to have fueled conflict and undesirably affected the security of many societies. Others have also revealed that though climate change can play a role in fomenting conflict, such conclusions must be reached with care because conflicts are not just caused by a factor, rather, it is most often a result of a complex web of interactions in which socio-economic and political factors often outweigh the contributions by environmental factors (Benjaminsen, Alinon, Bugaug, & Buseth, 2012).

Despite these revelations, further in-depth research with different approaches will be essential to advance one's understanding of the Climate-Water-Security-Nexus and to appreciate the exact influences that climate change will have on *human security* and peoples' livelihoods. The outcomes of such studies will serve as essential prescription for policy makers at local, national and international levels to enact policies that will respond to climate change, and at the same time address conflict where it is deemed fit.

Background to the Study

Both the fourth and fifth assessment report (AR4 and AR5) of the Intergovernmental Panel on Climate Change's (IPCC) agree to the unequivocal severe warming of the earth's atmosphere. The reports made these conclusions based on observations of increases in global air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (IPCC, 2007, 2014). The report attributes these changes of the climate system, largely to anthropogenic origin – human's production and consumption patterns, which in the end, emit gaseous substances that are inimical to biotic existence. For instance, the AR5 clearly states that "It is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in GHG concentrations and other anthropogenic forcings together" (IPCC, 2014, p. 48). Similarly, the body of independent scientists' 2007 report had mentioned that huge human impact on the earth since the 1750s have increased the atmospheric concentration of greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (IPCC, 2007). In recent time, Hulme (2016) minsed no word when he reported in his book, *Should Rich Nations Help the Poor?* that "contemporary economic growth is besed on strategies that raise CO2 concentration in the atmosphere" (IPCC, p. 93). This move, he emphasised, is characterised by "energy-intensive industrialisation, transportation and agriculture; deforestation; cattle rearing; and energy-profligate lifestyle and consumption pattern". In fact, this increase in the concentration of GHGs is said to "far exceed pre-industrial values determined from ice cores spanning many thousands of years" (IPCC, p. 32 & 37).

Both the fouth and fifth assessment reports of IPCC anticipate rising global mean surface temperature. For instance, while the AR4 asserts that if the current rate of CO_2 emissions continues, the global temperature will increase from 2 to 6 centigrade in the next century, the AR5 presumes that by the end of the 21st century (2081–2100), global mean temperature may have risen to between 0.3°C to 1.7°C. The obvious consequences of this supposed increased in global temperature are varied but not limited to drought, desertification, floods, diseases and sea level rise (Brown & Crawford, 2009; Hulme, 2016; IPCC, 2014, 2007). According to Brown and Crawford, and Salehyan (2008), such climate change-induced problems will worsen already existing environmental problems, and will have serious environmental consequences for humans and nature. The International Institute for

Strategic Studies (2011) and Werz and Conley (2012) give an example that climate change could cause mass migrations out of severely affected areas and (violent) conflicts since they compromise some basic needs of humans, and as well, could reduce governments' ability to provide human welfare.

Among the debates and controversies generated by the publication of the AR4 by IPCC was the security implications of climate change. Progress, though controversial, have been made in this area of research including those done by Bernauer, Böhmelt and Koubi (2012), Gleditsch (2012) and Scheffran, Brzoska, Kominek, Link, and Schilling (2012). While one bloc within the quantitative sphere of research has some empirical evidence to support a link between climate change and violent conflict, others entirely or find only but weak evidence (Gleditsch, Nordås, & Salehyan, 2007; Maxwell & Reuveny, 2000). In several of these studies either linear or indirect models are largely used to make assumptions or arrive at conclusions implicating climate change respectively as being the direct or indirect driver of conflict (Forsyth & Schomerus, 2013).

In the case of the former, environmental change is purpoted to leads directly to conflict as carried in the Malthusian and/or Neo-Malthusian writers. Evidences in support of this connection has been borne out of some established notion that some disastrous environmental events have to some extent, subsequent socio-ecological repercussions. For instance, Davis (2001) has established some association between El Nino events and famines in the late 19th century that killed millions of people across the tropics, and concluded that the event brought about famine as a result of drought. This has been corroborated by Diamond (2005) when he argued that several incidences of catastrophic social change and traces them to some environmental change, and in particular, climate change as a cause of many.

The indirect model on the hand postulate that though climate change can be associated with conflict, yet emphasise that social practices or institutions, as well as social vulnerability (or adaptive capacity) act as mediating factors (Forsyth & Schomerus, 2013). Thus, the model speculates that climate change, coupled with existing weak institutions presiding over already threathened natural resources, and anability of users of these reasons to adapt appropriately act as a “threat multiplier” (Brown & Crawford, 2009; Scheffran, 2011). For example, Blackwell (2010) concedes that climate change is the ‘underlying link’ between poverty and conflict among pastoralists in the Greater Horn of Africa. Similarly, Temestgen (2010) observed that environmental deterioration together with other social, political, and economic factors ‘tremendously increase’ the likelihood of conflict in the Horn of Africa. It therefore not out of place for these studies to recommend that limiting the potential physical impacts of climate change will not be enough, rather, building local adaptive capacity and firming up policies by institutions will aid in mitigating future conflicts.

However, in any of these instances, the association between climate change and conflict directly or indirectly impact on any aspect of human security (Kloos, Gebert & Rosenfeld, 2013), as it has always been the case in the views of Barnett and Adger (2007). In the authors’ view, the impacts of climate change are worrisome in view of the fact that for several years, climatic variations have caused large-scale social disruptions.

Burke et al. (2009), Hsiang et al. (2011), Klare (2001) and UNEP (2011) have revealed some connections between factors associated with global climate and climate change such as higher temperatures and/or less rainfall and conflict. Thus, climate change (any change in climate over time, whether due to natural variability or as a result of human activity) is projected to affect security of several countries through changes in the hydrological cycle and the quantity, quality and variability of water resources (National Intelligence Council, 2008). For instance, Gehrig and Rogers (2009) on one hand asserts that the most obvious underpinning cause of water-related conflict or violence is the inability of communities to access freshwater resources for any use. Again, extreme hydrological events such as droughts or floods have been mentioned to have been responsible for some violent conflicts across the globe (Carius, Dabelko, & Wolf, 2004; Swatuk & Wirkus, 2009; Swedish Water House, 2005; Thomasson, 2006; Turton, 2015; Ravenborg, 2004).

According to these authors, most of these *water conflicts* exist between nations, with very few ones occurring within states (intra-states) which are often considered as low-intensity domestic conflict. Water conflict here, is explained to mean any situation where water is considered as a cause of any range of negative interactions between individuals or groups. Usually, the interaction includes mild verbally-expressed discord and cold interstate relationships, as well as hostile military acts or declarations of war. (Goulden, Conway, & Persechino, 2009). The situation is referred to as conflict simply because there exixts a state of incompatibility between actors over interests or values (Gleditsch, 2011).

Several theoretical models have explained the possible pathways of linking climate change to intrastate armed conflict. Example, in Gleditsch's (2011, p.5) conference presentation paper *Regional Conflict and Climate Change*, the author combined insights from case studies and other statistical studies of conflict to explain that the effects of climate change (natural disasters, sea-level rise, and increasing resource scarcity) most possibly could lead to loss of livelihood, economic decline, and increased insecurity either directly or even through forced migration. However, this outcome is reached when poor governance, societal inequalities, and a bad neighbourhood interact with the effects of climate change to promote political and economic instability, social fragmentation, migration, and inappropriate responses from governments. "Eventually this produces increased motivation for instigating violence as well as improved opportunities for organizing it". While such possibility may persist, Bernauer et al. (2012) argues that little is known and recorded about low-intensity domestic water conflicts because of limited data availability.

Though majority of these studies fail to establish any clear relationship between climatic drivers and violent conflict, maybe due to the difficulty in providing accurate isolated examples where climate change is driving conflict (Barnett & Adger, 2007; Buhaug, 2010; Ciccone, 2011; Nordas & Gleditsch, 2007; Theisen, Holtermann, & Buhaug, 2011; Werz & Conley, 2012), they are able to establish an explicit causal relationship between political systems (Koubi, Bernauer, Kalbhenn, & Spilker, 2012) or economic factors (Buhaug, 2010; Buhaug, Gleditsch, Theisen, 2010) and violent conflict. For instance, in their report on

Climate change, water conflicts and human security: regional assessment and policy guidelines for The Mediterranean, Middle East and Sahel, Kloos et al. (2013) observed that climate, together with hydrological factors, socio-economic, institutional and political conditions are the major drivers of human (in)security. Again, even though the report found a stronger association between political, economic and social factors and water-related conflict than between climate-related variables and water conflict, future relationships, according to Kloos et al., might change**.**

The Middle East section of the Mediterranean region has a distinct structure pertaining to climate change, water conflict and human security. Conflict at this zone is either historical or due to extreme hydrological events of either water scarcity or drought (Kloos et al., 2013). The Jordan River Basin comprising part of Israel and part of the Palestinian territory of the West Bank, parts of Lebanon, Syria and Jordan makes it one of the most unstable and conflict-laden parts of the world (Global Energy Network Institute [GENI], 2011), yet water (extremely in limited supply due to arid climatic condition and low variable precipitation) is regarded as one of the main causes of conflict in a region (Kloos et al.). On the other hand, Cyprus is ranked with the top 20 water scarce countries in the world with average renewable water resources of about 440 m^3/year per capita (Cyprus Meteorological Service [CMS], 2012). According to CMS, the country has to rely on imported water shipped from Greece during the 2007/2008 drought season. In spite of this, conflict over water is rare. Accession of Cyprus to European Union membership, coupled with heeding to implementation of European institutions and policy directives such as Water Framework Directive, Groundwater Directive, Flood Directive and the Common Agricultural Policy have buffered the country from any form of water conflict (Kloos et al.).

Climate change collaborate with North Africa's already existing problems of high population growth, extreme reliance on agriculture, and weak governance (Link, Piontek, Scheffran, & Schilling, 2010) to result in conflict rather than cooperation. Mason (2004) had spelt doom of potential conflict for the countries of the Nile river basin over reduced water supply over an extended period. According to Brauch (2006) and Piontek (2010) Egypt's reliance on the Nile (95%) for most domestic and industrial activities is a conflict-in-waiting situation if the water source is depleted upstream. Situation in the northern African countries of the Mediterranean region resonates in other parts of the continent. For instance, Sachs (2007) and UNEP (2007) have strongly linked the 2003 Darfur conflict to climate change, with both asserting that the phenomenon (of climate change) brought about some harsh realities of desertification, drastic reduction in rainfall, and water stress conditions. UNEP's report actually showed average rainfall in some part of Darfur had decreased by 16 to 34 percent, if the periods 1946–75 and 1976–2005 are compared.

In their view, Hendrix and Glaser (2007) and Raleigh and Urdal (2007) report from their study that climate change outcomes including freshwater availability or water scarcity contribute to civil conflict in Africa. Hendrix and Glaser further postulates that the likelihood of civil conflict in Sub-Saharan Africa even over short term climatic changes of inter-annual variability in rainfall. Also, Burke et al. (2009, p. 20670) found a "strong historical linkages between civil war and temperature in Africa, with warmer years leading to significant increases in the likelihood of war". The authors further claimed that "when combined with climate model projections of future temperature trends, this historical response to temperature suggests a roughly 54% increase in armed conflict incidence by 2030".

In fact, drought may not be the only consequence of climate change, frequent flooding may as well result. The potential impact of climate change on the likelihood of the occurrence of floods in Bangladesh and its implications (in terms of characteristics of floods and crop damage), for the basin areas of the Ganges, Brahmaputra and the Meghna River have been adequately studied (Mirza, 2002). All these case studies address the question of how climate change affects human security directly in terms of protection from floods, food security, or access to safe drinking water.

According to the Strauss Center for Climate Change and African Political Stability (CCAPS) (2011), between 1990 and 2009, Africa experienced nearly 6,300 social conflicts including strikes, coups, riots and protests, which were more common during "extremely wet and dry years than in years of normal rainfall." This suggests that climate change-induced drought and floods can lead to violent conflicts, and African countries and other developing countries will be greatly affected because of their limited capacity to adapt. For instance, during a three years of relentless drought in parts of East Africa, Wax and Thomason (2006) carried in a report, *"Dying for water in Somalia's drought"* that wells (water) in Somalia's town of Rabdore and other communities became a priceless commodity which were worth fighting and dying over, and for that matter were controlled by warlords and guarded with weapons. By the end of the drought, conflict over wells, termed "War of the well" had claimed 250 lives. Burke *et al.* (2009, p.1) hence conclude that:

> *We find strong historical linkages between civil war and temperature in Africa, with warmer years leading to significant increases in the likelihood of war. When combined with climate model projections of future temperature trends, this historical response to temperature suggests a roughly 54 percent increase in armed conflict incidence by 2030, or an additional 393,000 battle deaths if future wars are as deadly as recent wars.*

Though extreme hydrological events have caused some devastation to Ghana, these have not resulted in any conflict. For instance, intensive rainfalls events resulted in the floods of 23rd April, 2008 and 24th June, 2009 in parts of Accra that destroyed lives and properties. The flood of 2007 also affected about 332,600 people while killing about 56 people in the Upper East, Upper West, Northern regions and some parts of Western region of Ghana (Kankam-Yeboah, Amisigo, & Obuobi, 2010). As such, violent conflict over scarcity or abundance of water within the country is rare as there is no such record. However, water-related mild conflicts regarding pollution of water sources are not uncommon in mining communities in the Tarkwa-Nsuaem (or Wassa West) Municipality and Kibi since there have been issues of reported conflicts between mining communities and mining companies and/or illegal mining operators (Asamoah, Akyeampong, Antwi, & Dauda, 2013; Asamoah, Antwi, Akyeampong, Baidoo, & Owusu-Koranteng, 2014; Kendie, Osei-Kuffour, & Boakye, 2014; Osei-Kufuor, Kendie & Boakye, 2016; Singh, Koku, & Balfors, 2007).

Again, inter-state clashes or conflict is quite a common phenomenon between some border towns of Ghana and Burkina Faso. The latent conflict of 1998 between the two countries where Burkina Faso was accused of being the cause of the fallen water level of Ghana’s Akosombo Dam readily comes to mind. Another is the seasonal flooding of the northern parts of Ghana caused by the opening of Burkina Faso’s Bagre dam. While the two nations have made a number of steps to resolve the seasonal conflicts which they engage in, potential of water conflict is very high in the wake of extreme hydrological events such as drought and flooding resulting from climate change, as well as the increase in the energy needs of nations seeking to grow their economies (van Edig, van de Giesen, Andreini, & Laube, 2001).

Conflict is just one of the chains of end products of climate change. The nature and extent of climatic changes will as well deprive humanity of development and environmental conservation, and present a huge threat to human security at both national and individual levels (Dankelman, 2008). In the view of John Ashton, UK Foreign Secretary’s Special Representative for Climate Change at the January 2007 *Conference on Climate Change: The Global Security Impact* commented that “there is every reason to believe that as the 21st century unfolds, the security story will be bound together by climate change…Climate change is a security issue because if we don’t deal with it, people will die and states will fail” (Vogel, 2007, p. 1). Then in April of the same year, the then UN Security Council, for the first time in history, took up the issue of climate change as an important human security challenge (Dankelman).

According to Dankelman (2008, p.6), "human security is threatened and conflicts arise where climate change impacts on food, health and water availability". Thus, human security in the context of climate change, is the situation where people and communities have the capacity to manage stresses to their needs, rights, and values (Alkire, 2003). Humanity have every reason to worry about the impacts of climate change on human security because the changes associated with the climate may weaken human security by means of reducing access to, and the quality of natural resources that are of relevance to sustaining livelihoods, and that climate change may undermine state's capacity to act in ways that promote human security and peace. There is even a threat of increase in violent conflict which will result from climate change (Barnett & Adger, 2007).

However, the authors continue that vulnerability to climate change hinges on the degree to which people are dependent on natural resources and ecosystem services in their possession, the degree of sensitivity of these resources to climate change, and the capacity of the people to adapt to changes in these resources and services. Thus, vulnerability is greater when people are more reliant on climate sensitive resources than they are to economic and other forms of social capital (Barnet & Adger, 2007).

This suggests climate change's influence of undermining human security will vary across the globe since entitlements to natural resources and services, as well as economic and social capacities to adapt to the changes brought about by the climate vary across space. For example, in most developed countries such as the United States, 1 to 2 percent of the country's workforce are in the agricultural sector (Dimitri, Effland, & Conklin, 2005). Aside this, well established social welfare, health and security agencies (Robinson & Acemoglu, 2012) are enough to buffer vulnerability from climate change to a greater extent. On the contrary, developed countries' agriculture are nature dependent, with majority (50 to 90 percent) of the population engaged in subsistence agriculture (Kwa, 2001; www.worldbank.org). Coupled with this, the World Bank reports that about 17 percent of developing countries' population living below the poverty line (www.worldbank.org). This situation is also accompanied by poor health, weak educational establishment, poor social welfare schemes, and unrealiable security services (Robinson & Acemoglu, 2012). All these have implications for whether a country's human security will be resistant or not, to the pressures of climate change.

For instance, East Timor has 85 percent of her population dependent on agriculture as the country's main source of income (United Nations Development Programme [UNDP], 2002). Therefore, in times of low rainfall, and in the absence of any irrigation facilities, supply of maize which is the most important food source is cut by up to one-third, resulting in widespread hunger and malnutrition (Barnett, Dessai, & Jones, 2007). Though the situation is worsened in the dry season when less of rainfall is experienced, Barnet and Adger (2007) have noted that social anomalies such as weak public education and a very basic health system, among other things, are the deeper causes of the hunger and malnutrition they experience.

Clearly, it can be said that most of the problems that undermine or strengthen human security resulting from climate change, be it environmental or socio-economic or political, are often external to the localities where the individual reside. They are normally situations people may have little or no influence over. For instance, environmentally, community members may not have any control over upstream users of water resources or even any distant atmospheric pollution; and also, local people may have little to large scale "architecture of entitlements" (Adger & Kelly, 1999) such as warfare issues, corruption, trade dependency, or macroeconomic policies.

Another perspective to the climate change-water conflict-human security nexus should the appreciated. While scarcities brought about by climate change may demean human security, conversely, Gerstetter, McGlade, Vidaurre, Tedsen, & Bar-On (2012) reports that any dip in human security, may indirectly result in conflict. The authors found in Ethiopia that "the loss of livelihoods, socio-economic conditions, poor health and food insecurity all reduce stability, which can in turn give rise to conflict tensions" (p. 14). While this may be true, Barnett and Adger (2007) are still convinced that vulnerable livelihoods, poverty, weak state and migration intensified by the consequences of climate change are some of the array of factors responsible for either conflict or human (in) security.

These multiple factors make it challenging when conducting studies relating to climate change and human security because one will have to find out whether there really exists a linkage between a prevailing changes in the environment that are attributable to climate change (Allen & Lord, 2004). Nevertheless, this study will rely greatly on strategies used by different authors in studying the relationship between climate change and human security. These studies focused on the local dynamics that limit residents' access to environmental, financial, and social resources necessary to either mitigate or adapt to *climate change* and/or variability (Adger, 1999; Bohle, Downing, & Watts, 1994; Leichenko & O'Brien, 2002).

Statement of the Problem

Ghana's Upper East Region is mainly drained by rivers the White Volta (which contributes on an annual basis, an average of 20 percent of the inflow to the Volta Lake) and the Red Volta, as well as their tributaries including Atankwidi (270 km^2), Anayere (200 km^2), Yarig-tanga, Abuokulaga, Tamne, and Yalebele (Namara, Horowitz, Nyamadi, & Barry, 2011). Aside these rivers, there are also groundwater which is usually abstracted from boreholes or protected wells for most rural settlements, as well as urban areas to supplement urban water supplies. This makes the region one of the poorly drained locations in Ghana, and for that matter, the driest place (hydro-climatic stressed region) in the country. According to Antwi-Agyei, Dougill, and Stringer (2013), and Owusu and Weylen (2009), the UER which falls within the Sudan Savannah, has been experiencing frequent droughts due to the region's high variability in rainfall and temperature, and the Food and Agricultural Organisation [FAO] (2007) indexing suggests that the area's aridity index of 0.44 is on the high side. Available data suggest that the region recorded the highest frequency (37%) of the occurrence of drought (Dovie, 2010), and that Bawku and its environs is considered as the driest part of the country (Dietz, Millar, Dittoh, Obeng, & Ofori-Sarpong, 2004).

The resultant effect is that the region, including the *Bawku Area*, have witnessed a decline in the level of groundwater where over hundreds of boreholes have been drilled since the mid-1970s to provide potable water to communities (Frenken, 2005). It is expected that a significant reduction of groundwater between 5 and 22 percent by the year 2020 and between 30 and 40 percent for the year 2050 could be experienced in the events of climate change (Ghana Statistical Service [GSS], 2012). Future rainfall in this ecological zone will witness further decline as has been predicted by Minia (2008) and Stanturf et al. (2011). For instance, Minia has predicted percentage reductions in rainfall between -1.1 in 2020, -6.7 in 2050, and -12.8 in 2080. These will affect the availability of water for domestic and agricultural purposes, compelling residents in to adopting any means possible to adapt.

Apart from the aforementioned hydro-climatic stressor (increased climatic variability, as well as extreme events) experienced in this locality, the Bawku Area is also considered as one of the hotspot of violent conflict in the country (Kendie et al., 2014; Osei-Kufuor, et al., 2016). Specifically, Osei-Kufuor et al reported in their *Conflict, peace and development: A spatio-thematic analysis of violent conflicts in Northern Ghana between 2007 and 2013* that in terms of frequency of conflict between 2007 and 2012, Bawku had recorded up to 25 violent conflict, a figure which is far more than any of the hotspots in the eastern corridors of northern Ghana. Again, the area is tagged as "the most prominent hotspots in northern

Ghana, together accounting for approximately 30 conflicts", yet Bawku's figure is said to be "disproportionately larger" (Osei-Kufuor et al.).

It is on record that the violent conflict in Bawku has been waged between the Kusaasi and Mamprusi ethnic groups for decades. There are also some political underpinning factors to the conflict (Kendie, 2010; Kendie et al, 2014; Noagah, 2013). Aside the identified ethnic-political nature of the conflict, it is hard to rule out role played by natural resources in fomenting such conflicts. Thus, these two opposing actors seeks to wield their authority over the control of resources in the area. Kendie et al. predict that the domination of access to scarce resources such as water by one group or community to the exclusion of others could generate violent conflicts among users of the resource. It will therefore be interesting to investigate how, when, and under what conditions will climate-related stress phenomenon and adaptation to them by residents bring about conflict in the area. It is to unravel this nexus and to contribute our understanding of the supposed association that motivated this study.

Objectives

The main objective of the study was to investigate the relationship between climate change, water conflict and human security ("Climate-Water-Security nexus") in the Bawku Area of Ghana. The specific objectives were to:

i. Map water sources used by residents in the study area;
ii. Explore residents' adaptive and/or mitigation mechanisms towards hydro-climatic events.

iii. Evaluate how water and climate-related hazards, exacerbate or mitigate conflict;

iv. Examine the social, economic and political factors that either exacerbate or mitigate conflict;

v. Assess how human security is affected by risks that are associated with hydro-climatic hazards, social, economic and political factors.

Research Questions

Following from the above, a number of questions have been posed to direct this study. These include:

i. Where do residents of the study communities get their water from?

ii. What adaptive and/or mitigation mechanisms are employed by residents in events of hydro-climatic hazards?

iii. How do water and climate-related hazards exacerbate or mitigate conflict?

iv. How do social, economic and political factors exacerbate or mitigate conflict

v. How is human security affected by risks that are associated with hydro-climatic hazards, social, economic and political factors?

Significance of the study

It is significant to undertake a study such as this because, in spite of Ghana's recognition that climate change poses a threat to her progress, no specific mention was made in response to, or tackle the conflict potentials of the phenomenon in the country's National Climate Change Policy (NCCP) document (Ministry of Environment, Science and Technology [MEST], 2012). Thus, though social development is a key concern of the NCCP, all the systemic pillars of the policy, including governance and coordination; capacity building; science, technology and innovation; finance; international cooperation; information, communication and education; monitoring and reporting (MEST), failed to make any explicit effort to discuss issues of potential conflict associated with climate change. Hence, this study will provide a policy direction for policy makers and other stakeholders in future policy formulation or revision of existing one on climate change to include issues relating to conflict. The recognition of this fact will help avert any potential conflicts and rather ensure corporation in any part of the country where water resources abound.

While it will be imperative for a policy direction on this issue, a research of this nature is worth it particularly because of the relevance of the region concerned – the Upper East Region, both water stressed and conflict hotspot of Ghana (Kendie, et al., 2014; Antwi-Agyei et al., 2013; Owusu & Weylen, 2009). This is explained by the fact that this study will expose either the conflict or cooperation potentials of climate change to policy makers, which will provide evidence as to 1) the appropriate mitigation or *adaptation* strategies to adopt in extreme hydro-climatic events, and 2) to look into ensuring and sustaining peace and cooperation in the study areas, from the spectacles of water resource management, instead of fixating on the so-called traditional causes conflict (social and/or ethnic, political, economic) in the study areas.

Again, the use of both qualitative and quantitative research design sought to give insight to policy makers as to how climate change, combined with other socio-economic factors from the point of view of respondents could trigger conflict or induce cooperation. Such understanding will aid the policy makers in formulating policies. Furthermore, other sectors of the economy can draw inspiration from this study in stakeholders' socio-economic activities since the study will expose how climate change can interact with global political and economic forces to undermine local developmental efforts. Lastly, as a major research on climate change, water conflict and human security, gaps identified in this study will serve as pointer for future studies in the areas of climate change and conflict management and/or resolution.

Delimitation

This study was conducted using empirical data sourced from the Bawku Area of Ghana. By this, the researcher was limited to four administrative districts within the Upper East Region, which covers the north-eastern part of the country. In all, eight communities within the districts were selected for this study. Even though the conceptual framework depicts external events (especially those outside of Ghana) that influence conflict or cooperation in an area, the micro perspective nature of this study means that such external influences are more or less excluded (or no data were collected on them), hence, this study was incapable of making assumptions of conflict and cooperation beyond the study communities and national levels. The study however acknowledged that the narrow focus of the thesis was more profitable for adequate analysis than spreading over too much.

Another issue of concern is the fact that the study could not cover all water stressed communities or district within the enclave. For instance, in spite of the fact that Pusiga District falls within the Bawku Area with similar climatic features and social set-up or demographic characteristics as those of the selected districts, it was omitted in this study. Nevertheless, the researcher anticipated that no different data would be sourced from the communities in Pusiga District due to similarities in climatic conditions, common social ancestry and societal set-up.

Limitations

This study's major limitation was the language barrier between the researcher and the study participants, especially those in the selected communities. The researcher was deficient on the field of data collection in terms of communicating effectively with indigenes as I was unable to speak the predominant language spoken in the Bawku Area, Kusale. This realization became clear when I went to Zontrokuom (a community in the Garu-Tempane District) to pre-test my tools for data collection. In order not for the communication gap to have any toll on the study, I recruited two researcher assistants, with at least bachelor's degree to assist with the data collection and transcription. The assistants were trained over a period of one week to abreast themselves with the data collection instruments. Apart from their academic qualification, the assistants had mastery over the predominant local languages – Kusale, Mamprule and Hausa. Where it was necessary, a research assistant aided me to communicate with community elders for protocols, and with respondent on matters of clarification. This action allowed a fruitful communication and data collection exercise.

Another challenge that this study had to grapple with during the data collection exercise was commuting from one community to another. Getting easy means of transportation (for instance a car) for the research team as well as other materials, were virtually unavailable. This was not an unexpected situation since the major means of transportation at that part of the country is rather motor bikes. Hence, the researcher had to hire/rent two motor bikes to move from one community to another; and one district to the other. As challenging as it was, this never negatively affected the data collection exercise since the team was always ahead of time to make it to our destinations, and for that reason, never missed any schedule or appointment with any community or group of respondents. It must however be made clear that the research assistants recruited already knew how to ride motor bikes.

Again on the field of data collection, there was a huge bureaucratic procedure that the researcher had to go through to get permit from the Ghana Police Service for their perspectives on the subject under study. Though successful eventually, officers were not permitted to be interviewed using audio recorder due to the sensitive nature of the subject under investigation. For that reason, the interview with the only officer of the service who granted us the attention was hand written, and subsequently transcribed.

Definition of Terms

This section defines terms as used in this study. They are either adopted or adapted within the context of this study.

Adaptation

The adjustment in individual, group and institutional behaviour in order to reduce society's vulnerabilities to climate". This includes all the the process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits associated with climate variability and climate change.

Bawku Area

This includes all the five administrative districts of the Upper East Region which are located in the north-eastern corner or tip of the country where the Kusaasis and the Mamprusis ethnic groups are dominant. They include Bawku Municipality, Garu-Tempane, Binduri District, Pusiga District and Bawku West. However, in this study, all but the Pusiga District was considered. With the exception of Bawku West, which was established by Legislative Instrument in 1988, Garu-Tempane and Binduri districts were part of the Bawku Municipality until 2004 and 2012 respectively, when they became different administrative entities.

Climate Change

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. Thus, any change in climate over time, whether due to natural variability or as a result of human activity.

Human security

It is the situation where people and communities have the capacity to manage stresses to their needs, rights, and values. The likelihood of this ideal situation in the wake of climate change is weakened by means of reducing human's access to, and the quality of, natural resources that are of relevance to sustaining livelihoods, and even in some respect, increase the risk of violent conflict (Alkire, 2003; Barnett & Adger, 2007).

Water conflict

It is any situation where water becomes the *casus belli* of any range of negative interactions that encompass mild verbally-expressed discord and cold interstate relationships, as well as hostile military acts or declarations of war. It includes conflicts associated with ineffective or illegitimate governance or water resources, but disregards any violent conflict between individuals over other issues in which water infrastructure was damaged (Goulden, Conway, & Persechino, 2009).

Water stressed communities

The ability or lack thereof, [of a community] to meet [it's] human and ecological demand for water. Thus, it is a condition whereby a community's demand for water exceeds the available amount during a certain period and/or when poor quality restricts its use (Schulte, 2014).

Organisation of the study

This study is organised in nine chapters. Chapter One is the introductory part of the study which comprises the background of the study, statement of the problem, objective of the study, research questions, significance of the study, delimitation, limitation, definition of terms and organisation of the study. The second chapter was dedicated to the review of literature and/or empirical evidence related to climate change, water conflict and human security. Thus, particular emphasis was laid on issues of climate change and water – impacts of climate change, water scarcity, adaptation as a response strategy to climate change. Focus was as well placed on how the failure to adapt appropriately could result in conflict. Cooperative tendencies arising from adaptation to water-related vulnerabilities were also looked at. The chapter ended with the implications of climate change on human security. In Chapter Three, the concept of conflict was reviewed. Some types and the various stages of conflict development will offer the reader an understanding that conflicts do not just occur; rather, it picks up from one point (mostly mild) to a point of escalation when it reaches a crescendo. Aside this, some theories of conflict analysis such as human needs theory, political ecology theory and Vasquez's territoriality thesis (the concept of space) are discussed to explain why individuals and societies engage in conflict. The study's conceptual framework was discussed here by first looking at Safeworld's framework for climate change and conflict analysis, and later, CLICO's hydro-climatic change, conflict and human security framework are also reviewed.

Chapter Four focused on the methods employed for the study. Issues in this chapter include research design, description of the study area and the target population, sampling procedure, size of the target population to participate in the study, sources of data, data collection instruments, ethical consideration and tools and/or data analysis techniques, etc. In Chapter Five, the evidences of climate change in the study areas, with 40 years' rainfall and temperature data from the Ghana Meteorological Agency has been presented. Specifically, the chapter presents some trends in mean monthly, annual and seasonal changes in rainfall and temperature at three weather stations in the study districts. With this aside, some statistical analysis of the various trends was carried out. The chapter ended with some views of residents in the studied communities in relation to the changing climate in the area.

In Chapter Six, the various water sources available the studied communities are explored. In connection to this, residents' views on water availability and/or scarcity situation in the study communities, as well as the implication of the scarcity situation they experience are discussed in this chapter. Lastly, residents's adaptation strategies in living with the erractic rainfall patterns, high temperature and water scarcity examined to end this chapter. Next, is the seventh chapter which deals with residents' perception and awareness of conflict in their communities were sought and discussed. Here, some identified conflicts are presented with much emphasis on conflicts found between communities, and those among women and children, and crop or vegetable farmers and livestock rearers. The various conflicts found have also been explained using the political ecology theory and CLICO's framework on climate change, water conflict and human security. In conclusion, how the identified conflicts were resolved are also discussed in this seventh chapter.

Chapter Eight tackles residents' perception of conflict and cooperation in their communities, but from social, economic and political points of view. Risks posed by hydro-climatic hazards, social, economic and political events on the human security of the study communities are assessed to end the chapter. The final chapter summarises the entire study, draws conclusions based on evidence and then make recommendation for policy.

CHAPTER TWO

WATER, CLIMATE CHANGE, CONFLICT AND COOPERATION

"Fierce competition for fresh water may well become a source of conflict and wars in the future."

(Kofi Annan, March 2001)

"But the water problems of our world need not be only a cause of tension; they can also be a catalyst for cooperation…If we work together, a secure and sustainable water future can be ours."

(Kofi Annan, February 2002)

Introduction

One essential ingredient that humans cannot do without for their security and sustainable development is water. Water is a fundamental and irreplaceable resource in all societies. It is needed to grow food and support economic growth, and even ensure that diseases are kept at bay. Given its centrality to human life, it is not surprising that management of the resource has been considered in various international platforms including Agenda 21, World Water Fora, the Millennium Ecosystem Assessment, World Water Development Report, etc. (Bates, Kundzewicz, Wu, & Palutikof, 2008). One other characteristic of water is that management of it is often multifaceted and that water-related interests are often contested. Access to water in sufficient quantity and quality can drive competition, especially where its usage by one deprives the other. The logical flow is that, when humans use water, they affect the quantity, timing, or quality of water available for other users. For instance, when water is dammed and used for irrigation purpose in one area, water is made unavailable for other users (downstream) within the basin because of the consumptive nature of the crops.

This is not always the case because the use of water to generate electricity is non-consumptive since water is still shared with those downstream but not necessarily on the appropriate time. Irrespective of the contentious nature of water, it still can also stimulate cooperation with good management principles. The need to better understand water is therefore very paramount as it relates to all levels of conflict and/or cooperation. Even when water is not directly involved as the proximate cause of a conflict, it is still appropriate to consider the various avenues by which water insecurity could possibly be relating with the social and institutional dynamics in fragile or conflict-affected situations.

Hence, this chapter looks into the various dynamic as to how water has been at the centre of arguments in various conflicts globally; and where it has also fomented cooperation in other respects. Specifically, the chapter focuses on global water yield in terms of the demand and supply side of the resource, how climate change impacted the availability of water for various uses, water related conflicts and cooperation, as well as the human security linkage to the water conflict and cooperation dynamics.

Global Water Resources

Global water yield

While there is roughly 70.8 percent (1.39 billion km^3) of water covering the Earth's surface (Shiklomanov, 1993), fresh water which is depended upon by humans constitutes only about 2.53 percent (total volume of fresh water of about 35 million km^3). Majority (70%) of these fresh water resources are stored in glaciers and icecaps of the Antarctica, Greenland and high mountains (Table 1) (Shiklomanov), a location which is arguably far from reach for human use (Braeden-MacGuire, 2013). Aside those stored in the form of ice, groundwater and soil moisture harbours about 30.8 percent of fresh water resources, and but 90 percent of this resource, especially ground water, is readily available for human consumption (UNEP, 2002; World Bank, 1998). On the other hand, soil moisture, though plays a major role in storing fresh water for agricultural activities (mainly crop use), it does not make water available for direct human consumption. The remaining amount of groundwater is replenished annually through infiltration percolation, and fossil deposits that do not receive substantial recharge (Postel, 1992). It should be noted that fresh water of underground deposit that are closer to coastal areas are under continual pressure of salt-water intrusion (Braeden-MacGuire).

Table 1: Global water stock and their distribution

Type	Volume (10^3 km^3)	% of fresh water
Glaciers, permanent snow cover, ground ice & permafrost	24,364	69.56
Ground water & soil moisture	10546.5	30.15
Lakes, rivers, shallow underground basins	93.12	0.266
Others	25.49	0.024
Total	**35,029**	**100**

Source: Shiklomanov's (1993) global water stock

Surface water from streams or rivers, lakes and shallow underground basins are also important sources of fresh water for human use. It constitutes about 0.266 percent (200 000 km^3) of global fresh water (Table 1) and 0.007 percent of all water on Earth (Braeden-MacGuire, 2013; Postel, 1992; Shiklomanov, 1993). Though this source is quite located far from human populations, and the fact that majority of it is lost to annual floods through run offs, it still remains as the most reliable and easy-to-access source of fresh water supply throughout human history for both rural and urban populations (Braeden-MacGuire; Postel; Wolf, 1998).

Global water use and demand

There is a clear association between population growth, migration and changing consumption patterns on one hand, and fresh water demand on the other. Increasing population growth has posed an availability challenge of fresh water to some users; an indication that fresh water is not always available for human use in terms of quantity, quality, and even at the time and places they are needed (International Energy Agency [IEA], 2012a). Water, though renewable naturally, is simply not equally distributed the world over, especially in the three major areas of the resource use – agriculture, industry, and domestic.

When the world's population reached 7 billion in 2011, it resulted in a reduction of 76.4 percent per capita fresh water across the globe, with some few countries including Brazil, Russia, China, Canada, Indonesia, U.S., India, Columbia and the Democratic Republic of Congo possessing about 60 percent of this natural stock (World Business Council for Sustainable Development [WBCSD], 2005). The stock of water available to Brazil is attributed to the high rainfall in the region, and by contrast, many countries in Middle East and North Africa (MENA), since the 1970s, have been largely in chronic condition for water due to the minimal rainfall (Allan, 2001; IEA, 2012a).

With continuous increase in population and affluence, especially in Africa, South America and Asia, the situation is estimates to be dire since water resources, considered relatively constant, cannot match the increase in human numbers (Intellegence Community Assessment [ICA], 2012; Braeden-MacGuire, 2013). These continents with the growth in their population, have always affected the per capita availability of water since the second half of the 20^{th} century as shown in Table 2.

Table 2: Water availability over time by continents

Continent	Water availability (103 m3 per capita					Percentage change 1950 – 2000 (%)
	1950	1960	1970	1980	2000	
Africa	20.6	16.5	12.7	09.4	05.1	-75
Asia	09.6	07.9	06.1	05.1	03.3	-66
Australia & Oceania	112	91.3	74.6	64	50	-55
Europe	05.9	05.4	04.9	04.6	04.1	-31
North America	37.2	30.2	25.2	21.3	17.5	-33
South America	105	80.2	61.7	48.8	28.3	-73

Source: (Braeden-MacGuire, 2013).

Table 2 presents a disproportionate high decrease of fresh water in Africa (-75%), South America (-73) and Asia (-66), compared to North America (-53) and Europe (-31). Similarly, VeldKamp et al. (2015) made an observation that between 1960 and 2000 that the share of the global population living under some sort of water scarcity increased from 19.8 percent to 49.9 percent in the respective years under transient conditions. The authors specifically mentioned Asia, some African regions, and a few areas within Northern America as those areas which were affected by these water scarcity conditions throughout the period 1960–2000. It should be noted that the decrease in global per capita fresh water supply over the period does not in itself show proof of water scarcity, but it is a clear indication of the link between population growth and water scarcity (Braeden-MacGuire, 2013).

However, the projected increase in global population to about 9.3 billion in 2050 (United Nations Department of Economic and Social Affairs [UNDESA], 2011) will increased water demand, primarily from agriculture, manufacturing, and domestic use, which will lead to further stress on water resources.

Agriculture consumes the majority of water resources available for human use and that about 70 percent of the Earth's water resources are channelled into the production of food, fibre and pharmaceutical to sustain the growing human numbers (United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2003), and over 90 percent of this usage is in the Least Developed Countries (LDCs) (FAO, 2011a). While some countries are in fresh water deficit scenario, others, especially most developed countries do have fresh water in excess, to the point of exporting water in the forms of water-intensive agricultural goods. This happens even though the developed countries use just about 30 percent of water for agricultural activities, as compared to the developing countries (both low and middle-income economies) who use 82 percent of the commodity for the same purpose (Figure 1). For instance, irrigation, which is considered as a major component of the green revolution in many developing countries, is believed to account for 90 percent of agricultural water withdrawal; 1 percent in England; and more than 70 percent in Spain, Portugal and Greece (WBCSD, 2005). Note must however be made that about 38 percent of irrigated areas around the world depend on groundwater (Siebert et al., 2013). This means that groundwater abstraction for agricultural irrigation alone have increased to about ten-folds over the last 50 years (WWAP, 2016).

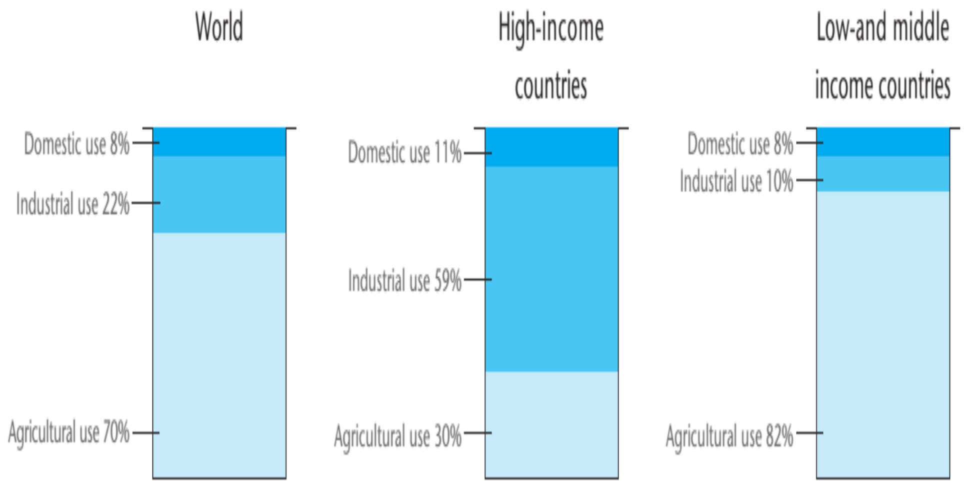

Figure 1: Water uses for main income groups of countries

Source: UNESCO (2003).

From different organisations and agencies, different projections have been made regarding future water use in the agricultural, as well as the industrial and domestic sectors. For instance, ICA (2012) has shared the view that water withdrawal in the sector is expected to increase from the current 3,100 billion cubic metres (bcm) to 4,500 bcm in 2030. In fact, earlier in 2012, the UN's WWAP reported that barring any improved efficiency measures, the agricultural sector's consumption of water on a global scale is projected to increase by about 20 percent by 2050. Irrigation alone is projected to witness 6 percent growth from 2760 km^3/yr to 2926 km^3/yr in 2050 (Alexandratos & Bruinsma, 2012).

The industrial or manufacturing sector is reported to be using about 19 percent of the world's total water withdrawal (FAO, 2014f). But a higher percentage of this withdrawal is in the high-income countries who are known to be the net exporters of fresh water in the form of manufactured goods. This they do, through their investment of 59 percent of water for industrial use (Hoekstra &

Hung, 2002; UNESCO, 2003). This development is associated with economic growth of countries, affluent lifestyle and the drift of populations to urban areas. The various demands of populations to making life comfortable require some amounts of water. However, the amount of water used is dependent on the type of industry. Water for cooling in thermal power generation is the single largest use of the commodity by industries. For example, IEA (2012b) carries that energy alone uses about 15 percent of the total water withdrawal for the industrial sector. The other use is for the production of foods, beverages, pharmaceutical, etc. that are delivered in liquid forms or otherwise (WBCSD, 2005). Should development and lifestyle continue in this manner, future stress on water resources is expected to increase by 400 percent by the year 2050 (Organisation for Economic Co-operation and Development [OECD], 2012c).

Water for domestic use constitutes the minimum of all the withdrawals, yet seem to be the most inaccessible, especially in physical and quality terms, and as and when needed (IEA, 2012a). Where it is available from aquifer or shallow rivers in developing countries, the quality is commonly compromised via activities including salt-water intrusion, biofuel, industrial, agricultural and sanitation processes (ICA, 2012). Though the world is on the verge of realizing that each individual gets at least 2 liters of drinking water per day (less than a cubic meter per year) to survive, countries of Sub-Sahara Africa lag behind (WHO/UNICEF, 2004) (Figure 2). Apart from the physical inaccessibility of water in these countries of SSA, the problem of access to water is largely due to local mal-distribution issues. Thus, whereas the urban rich have access to water (mostly piped water supplies in their homes, protected well/boreholes or public standpipes) in most cases, the reverse is true with the closest neighbour, the urban slum and those in the rural communities (WBCSD, 2005).

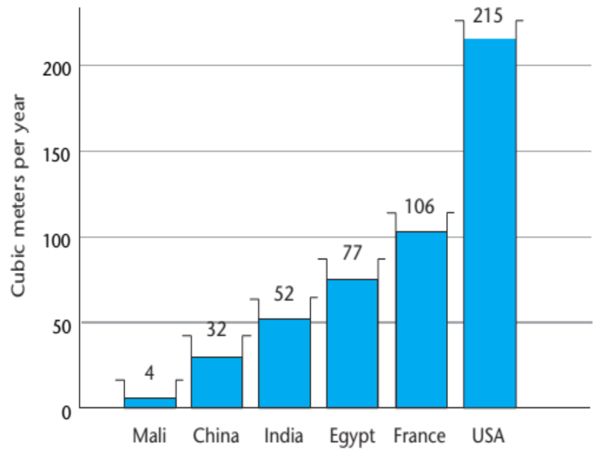

Figure 2: Average per capita water withdrawal for domestic use from some countries.

Source: AQUASTAT-FAO (2003).

With the world's population projected to grow from the current 7.2 billion to near 8.1 billion people in 2025, coupled with increasing urbanisation and affluence especially in OECD and developing countries, demand for water is sure to increase (ICA, 2012). For instance, in the OECD countries, dietary shift from plants to a more water-intensive meat (e.g. beef which requires roughly 1,900 gallons of water per pound for growing the cattle feeds and water the animals drink), means a sharp rise in demand for water (Creelman, 2014; WWAP, 2012). It is therefore appropriate to deduce that every continent will face some form of water scarcity or vulnerability in the future. According to the World Economic Outlook [WEO] (2012), even countries that seemingly are considered 'water-rich' such as southwest United States and non-coastal Australia, are most likely to face this water vulnerability threat. Apart from these aforementioned, poor management of water resources reflected in deforestation, poor infrastructure in cities (for instance leakages), limited understanding of ground and surface water, etc., will deepen the water vulnerability challenge. Even more intriguing in the future water challenge for human population across the globe is the climate change phenomenon – a "new sector for water consumption" (Anderson et al., 2006). ICA (2012, p.3) also admit that scarcity of water in the future is likely to erupt into social disruption, though the agency was quick to add that the disruption is most like when citizenry realize the scarcity is as a result of "poor governance, hoarding, or control of water by elites and other destabilizing factors".

Some Impacts of Climate Change on Water Resources: Water Scarcity, Drought, Flooding

Climate, freshwater, biophysical and socio-economic systems are often interrelated in a complex web, such that any observed change in any one component will have an implication on the other (Bates et al. 2008). This is to say that the already unsustainable freshwater issues confronting nations (having too much water, having too little water, and having too much pollution) are likely to be exacerbated due to the changing of the Earth's climate largely from anthropogenic origin. Arnell (2004) opines that climate change is expected to affect the volume and timing of river flows and groundwater recharge, with a major impact on the numbers and distribution of people affected by water scarcity. The availability and quality challenge of freshwater in the midst of climate change, is to be the main pressure and issues for nations and the environment (Bates et al.). While the use of freshwater for industrial purposes will ignite economic growth, the competing demands for it for domestic and agriculture use can be a major bone of contention over the resource (Kabat, Van Schaik, & Appleton, 2003). With such an important complexity of water resource use at hand, it is imperative to improve human's knowledge of the complex phenomenon (Bates et al.).

This section therefore delves into some of the impacts of climate change including drought and flooding, and their implication for water resources in terms of availability and accessibility.

Drought

Drought condition can occur in almost parts of the world – in wet and humid regions, yet this recurring and global phenomenon with spatial and temporal characteristics vary significantly from one location to another. The tropical regions of the Earth, however, have been associated with drought conditions, especially since the 1970s (Tallaksen & van Lanen, 2004; van Lanen, Tallaksen, & Rees, 2007). Normally, drought is used to describe a period of dry spell of a location as opposed to its normal condition. It is often used to describe a "below-normal" precipitation condition of an area over a period of months to years (Dai, 2011). Thus, drought could be explained as a "sustained and regionally extensive occurrence of below average natural water availability", with low precipitation and high evaporation rates as the major causal factors in tropical regions. In temperate areas, drought (winter) occurs when the temperature falls below zero degrees (van Lanen et al.). Care must however be taken not to confuse drought with aridity (a long-term average feature of a dry climate or permanent dryness in arid regions), or with water scarcity (a deficit conditions in relation to available water resources (supply) and the demand of the same) (Tallaksen & van Lanen; Working Group on Water Scarcity and Drought, 2006).

Drought is often classified into meteorological, agricultural, hydrological, and (sometimes) environmental drought (American Meteorological Society [AMS], 1997; Wilhite, 2000). Meteorological drought occurs when a below-normal precipitation and above-normal temperature is experienced in a region over a period of months to years; a condition which normally heralds the entry of any of the other types of drought. In the case of agricultural drought, a long period of dry soils resulting from below-average precipitation, intense but less frequent rain events, or above-normal evaporation, lead to reduced crop production and plant growth. Hydrological drought on the other hand occurs when river stream-flow and water storages in aquifers, lakes, or reservoirs fall below long-term mean levels. The major causative factor here is lack of precipitation which gradually depletes water stock in natural aquifers without it being replenished. In the views of Bates et al. (2008), all the three forms of drought could be summerised as environmental drought. Although all these forms of drought are largely caused by natural forces, yet human influences including poor adherence to environmental principles or policies, bad water resource management, and excessive water withdrawal, can be major motivation for drought conditions (Dai, 2011; Urama & Ozor, 2010).

The relationship between climate change and future trends of drought, though complex and undoubted, yet the scientific understanding seems to be evolving (Folger & Cody, 2014). Very contradictory reports have emerged on the subject matter, though sometimes from same sources or institutions. For instance, the IPCC's AR4 earlier mentioned in 2007 that on a global scale, very dry areas had more than doubled since the 1970s due to El Nino Southern Oscillation (ENSO) events and global surface warming (Solomon et al., 2007). The report added that global wet areas also decreased by 5 percent. This report has been corroborated by van Lanen et al. (2007) who assert that climate change, with its associated impact on precipitation, temperature and potential evapotranspiration (is likely to) affect the occurrence and severity of meteorological droughts, especially in the mid-continental area.

Furthermore, findings from a single-model study of global drought frequency revealed that the proportion of the land surface experiencing extreme drought at any one time, the frequency of extreme drought events, and the mean drought duration are projected to increase by 10- to 30-fold, two-fold, and six-fold, respectively, by the 2090s (Burke, Brown, & Christidis, 2006). For instance, while precipitation in southern and central Europe is expected to decrease on one hand, temperature is also supposed to increase (which would enhance evaporative demand) on the other hand. In the opinions of Christensen, Hewitson and Busuioc (2007) and Douville et al. (2002), such occurrences would certainly result in the reduction of summer soil moisture and more frequent and intense droughts. In the case of Africa, the continent which currently is experiencing endemic drought especially in both southern Africa and the Sahel region of western and northern

Africa, is projected to experience this phenomenon even more towards the end of the twenty-first century (Urama & Ozor, 2010).

Contrariwise, a report released in 2012 by the same body, IPCC, submitted that "there are still large uncertainties regarding observed global-scale trends in droughts" (IPCC, 2012). This new report is an indictment on the earlier one which mentioned that "very dry areas of the Earth had more than doubled since the 1970s" (IPCC, 2007). According to IPCC (2012), this claim was flawed because the conclusion was reached based on only one study, which made use of a measurement largely related to temperature, and not moisture. IPCC (2012) again reported that other studies which focused on soil moisture simulations, revealed that global trends in drought duration, intensity, and severity predominantly were rather decreasing, but with strong regional variation. The conclusion therefore, according to IPCC in their 2012 report was that in spite of the new and many studies that are trying to broaden the understanding of the causative factors of drought there is still limited evidence to attribute any observed changes in drought patterns towards the end of the 20th century to any anthropogenic influence.

The ongoing debate about this nexus nonetheless, cannot freeze the discussion on the impact of the phenomenon on humanity and the environment. The impacts of droughts on human livelihood could directly and indirectly be felt (Kabat, 2003), and these impacts affect millions of people each year (Wilhite, 2000). Directly, drought has caused a number of crop losses and subsequently, starvation especially in the absence of alternative food sources. In an endemic scenario, nomads lose hundreds of their cattle. Drought indirectly causes water shortages which subsequently lead to the spread of disease, which also stem from people's lack of water for basic hygiene (Urama & Ozor, 2010). For instance, the death of over half a million people in Africa in the 1980s was linked to drought (Kallis, 2008). Again, drought is considered economically disruptive since millions of dollars are spent on the impacts and response to the phenomenon. In 1988, the United States spent about $40 billion on drought, whiles in 2012, the country spent estimated $30 billion in damages (Center for Climate and Energy Solutions, 2016; Smith, Lott, Houston, Shein, & Crouch, 2015).

It is important to note that the impacts of drought vary from one region to the other. It however is largely dependent on the status of an economy on the development trajectories and partly on a region's geographical location. For example, farmers from developed countries with advanced irrigation systems can cope better with the impacts of drought than their counterparts in Africa and other developing countries. These farmers in most cases lack the capacity to combat the consequences that are associated with droughts and natural disasters in general. Moreover, the impacts of drought are felt greatly in arid or semi-arid regions where water availability is already low under normal conditions, and so forth (Dai, 2011; Urama & Ozor, 2010).

Flood

Floodplains have throughout history offered opportunity for humans in terms of access to fertile soils, flat terrain for settlements, and easy and safe access to water (Kabat, 2003). This natural opportunity provided by riverine floods has been so for millions of years. For example, in ancient Egypt the natural annual flooding of the Nile brought much needed nutrients to irrigated soils. However, in recent times, floods, either natural or under humans' influence have posed greater risk to populations who have encroached floodplains for settlements (Urama & Ozor, 2010, p. 4). Some of the floods which have posed threat to humans include river floods, flash floods, urban floods, sewer floods, glacial lake outburst floods (GLOF) and coastal floods. These are however, often dependent on intensity, volume, and the timing of precipitation (rain or snow). Also, antecedent conditions of rivers and their drainage basins such as presence of snow and ice, soil character and status – frozen or not, saturated or unsaturated, wetness, rate and timing of snow/ice melt, urbanisation, existence of dykes, dams and reservoirs are contributing factors (www.ipcc.ch/pdf/technical-papers/ccw/chapter3.pdf).

Climate change might already have had an impact on the intensity and frequency of floods because of the observed increase in precipitation intensity together with other observed climate changes, such as an increase in westerly weather patterns during winter in Europe, hence leading to very rainy low-pressure systems that often trigger flood (Kron & Berz, 2007). The summary report of the Working Group I of the Fourth Assessment Report (AR4) of IPCC submitted that the frequency of heavy precipitation events within the 20th century increased in most areas across the globe, and that human contribution in this trend could not underestimated. Future scenario of the impact of climate change on flood has been determined. According to the AR4, future precipitation is projected to become more frequent over most regions throughout the 21st century, with the potential of increasing the risk of urban flooding in most parts of the world.

Palmer and Räisänen (2002) had earlier predicted a substantial surge in the risk of a very wet winter due to an increase in extreme precipitation associated with mid-latitude storms in much of central and northern Europe. The authors made a similar projection for the Asia region where they predicted that there will be a very wet monsoon season in the 21st century. Specifically, based on some climate models, Mirza (2003) submitted that flooding in the area flooded in Bangladesh in 1998 is expected to increase by at least 23-29 percent with a global temperature rise of 2°C. Flood is seen as the most common natural disaster in North Africa, the second most common in East, South and Central Africa, and third most common in West Africa (Africa Water Development Report [AWDR], 2006). Many cities in the continent have suffered the devastations caused by flood since 1995 (Douglas et al., 2008). About fourteen (14) countries, namely Burkina Faso, Chad, Ethiopia, Ghana, Kenya, Liberia, Mali, Niger, Nigeria, Senegal, Sudan, Togo, Uganda, and Rwanda, are considered to be the worst hit by flood in the African continent ("Rains threaten flood-hit Africa," 2007). Figure 3 shows how devastating flood was in 2017. Thus in the said year, flood cause some significant material and human casualties in the West and Central Africa sub-regions. According to Mason and Joubert (1997), the pattern of erratic large floods will change, more than long-term average river flows, while extended heavy rains will likely increase in volume and frequency.

Floods are considered to be one of the most destructive natural disasters which affect about 140 million people per year on average (World Development Report [WDR], 2003; 2004). Berz (2001) disclosed that the number of flood disasters which required both international and inter-regional assistance (great flood disasters) in nine-year period (1990-1998) was higher than in the earlier three-and-a-half decades (1950-1985) together. Floods have caused the destruction of major infrastructure such as roads, rail lines, airports, electricity supply systems, water supplies and sewage disposal systems.

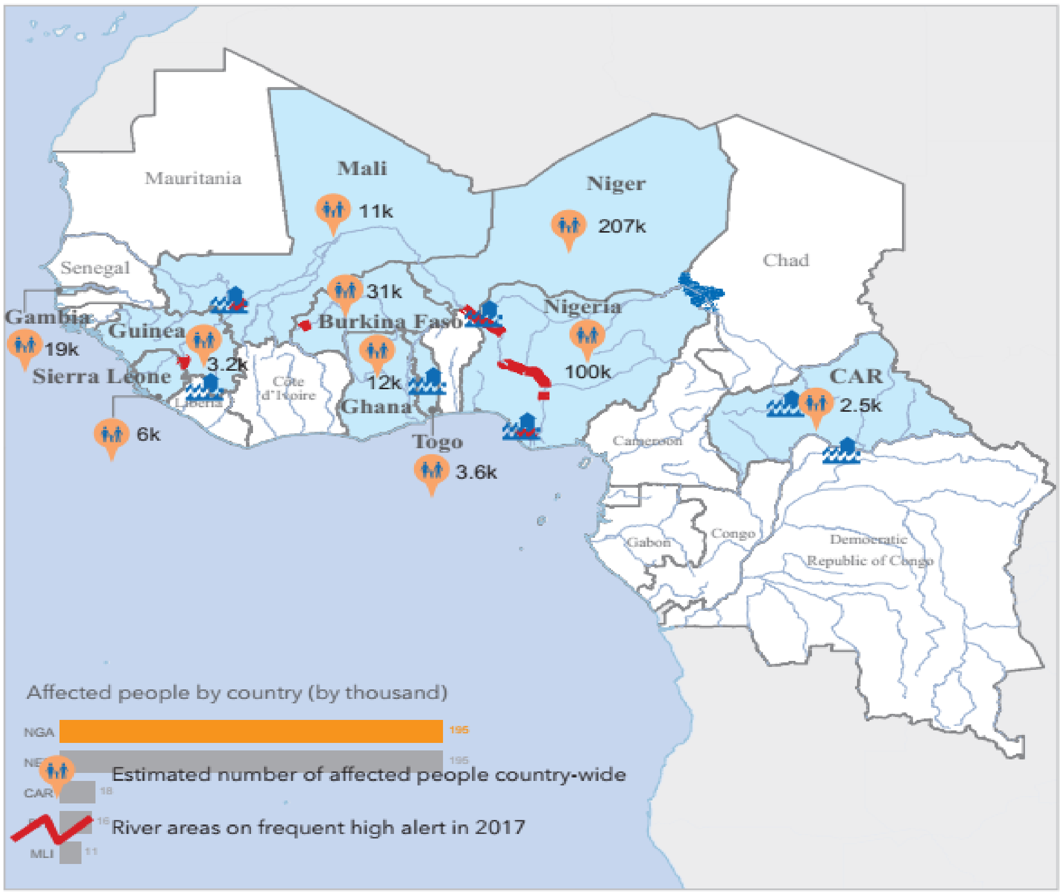

Figure 3: Flood map of Central and West African sub-regions as of October 2017.

Source: United Nations Office for the Coordination of Humanitarian Affairs (2017).

These have consequently increased the costs of flood disasters over the years substantially (Re, 2005). The cost or the economic effects of flood disaster could be direct or indirect. The direct economic effects of floods are in most cases are "greater than indicated by the physical effects of floodwater coming into contact with buildings and their contents" (World Health Organisation [WHO], 2002, p. 4). In much the same way, the indirect economic impacts largely spread well beyond the flooded area and may last much longer than the flood itself. Britain alone spent close to £6bn on devastation cause by the 2015 floods that hit the country. The cost resulted from closed businesses, people unable to go shopping or travel, damaged infrastructure and loss of agricultural output (Independent, 2015; SKY News, 2015).

Floods with devastating consequences, according to Vordzorgbe (2003), accounted for 26 percent of total disaster incidences in Africa from 1971-2001. Apart from infrastructural damages, millions of people have died and been displaced by floods that have inundated much of the continent of Africa, including their most productive farmlands (Urama & Ozor, 2010). For example, about 800 died in the 2001 floods in the northern part of Algeria. Economically, the country lost about $400 million in that flood event. A year earlier, 2000, floods (worsened by two cyclones) killed 800 people, dipped Mozambique's growth rate from 10 percent to 4 percent, rendered 329,000 people homeless, and almost 2 million people needing food because of destructions that was caused to agricultural lands. Respectively, floods cost about $1.8 billion to Kenya's economy and killed 2, 311 people in Somalia in 1997/98, and about 1.8 million deaths were also recorded in Sudan in 1999 (AWDR, 2006).

Water scarcity

Several countries in the world are already faced with water stressed conditions that are associated with use factors such as demands from households, agriculture and industries (Cabot, 2007). The pressure on water resources will be exacerbated by climate change through changing rainfall patterns, river flows, lake levels, and groundwater recharge (Simms, Reid, & Magrath, 2005). This will result in water stress conditions for several countries. Blue water scarcity (often referred to as water scarcity, is experienced in a region there is an "imbalance between water availability (natural runoff) and the needs for water over a specific time period" (Veldkamp et al., 2015, p. 20). Again, the term, which is sometimes used synonymously with water stressed conditions, according to German Advisory Council on Global Change [WBGU] (2003), affects a region when the location uses more than 20 percent of its renewable water resources. Pittock (2005) on the other hand puts it that any withdrawal that exceeds 40 percent of a regions' renewable water resource means the area is seriously water stressed. It is also defined as "the ability or lack thereof, to meet human and ecological demand for water" (Schulte, 2014). Furthermore, the condition occurs when a region's demand for water exceeds the available amount during a certain period and/or when poor quality restricts its use. Caution must however be made that those areas that are seen as experiencing 'water scarce' situations, especially based on hydro-climatic mean conditions, do not in reality experience water scarcity every year (Kummu, Gerten, Heinke, Konzmann, & Varis, 2014; Mason & Calow, 2012).

It should however be noted that the condition of water scarce depends on how the people of a particular locality water needs are; the proportion of water made available, or could be made available, to satisfy these needs; and the temporal and spatial use of water (Rijsberman, 2006). Put differently, Falkenmark (2013a) have indicated that water scarcity can either be population-driven (water available per person per year) or demand-driven (actual consumed water by all sectors and people relative to the water available). The measure of water scarcity using the water availability vis-à-vis the population logic as which was earlier propounded by Falkenmark in 1989 has been long standing, in spite of the numerous criticisms it has received. Using the annual and national averages do not take into consideration scarcity at smaller scales. The index again, fails to recognize the availability of infrastructure that modifies the availability of water to users, and the simple thresholds do not reflect important variations in demand among countries due to, for instance, lifestyle, climate, environmental demands, etc. (Braeden-MacGuire, 2013; Rijsberman).

In spite of these backlashes, Falkenmark's Water Stress Index (WSI) (Table 3) has dominated the discussions on water scarcity (Rijsberman, 2006) for two main reasons: a) there is always data readily available for analysis; and b) one is spontaneously and easily to understand it's meaning. The Falkenmark's Water Stress Index proposes 1700m^3 of renewable water resources per capita per year as the threshold of water required depending on a country's estimates of water requirements in the household, agricultural, industrial and energy sectors, and the needs of the environment. Therefore, any country whose supply of renewable water falls short of the threshold figure is said to be in *water stress* condition; a supply below 1,000m^3 *water scarcity*, while any figure below 500m^3 represent an *absolute scarcity* situation (Falkenmark, 2013a; Falkenmark, 1989).

Table 3: Falkenmark's Water Stress Index

Mean annual runoff per capita (m3)	Classification
> 1700	No stress
1000 – 1700	Stress
500 – 1000	Scarcity
< 500	Absolute scarcity

Source: Falkenmark, 1989; Braeden-MacGuire, 2013.

Based on Ghana's 2008 population estimate (22, 900,972), the total actual renewable water resources per inhabitant is 2,375. Compared to the so called Falkenmark indicator or "water stress index", it can be concluded that Ghana is currently not water stressed. But, available estimates have revealed that by the year 2025, the country will go into water stress condition as a result of increasing population (UNEP, 2002).

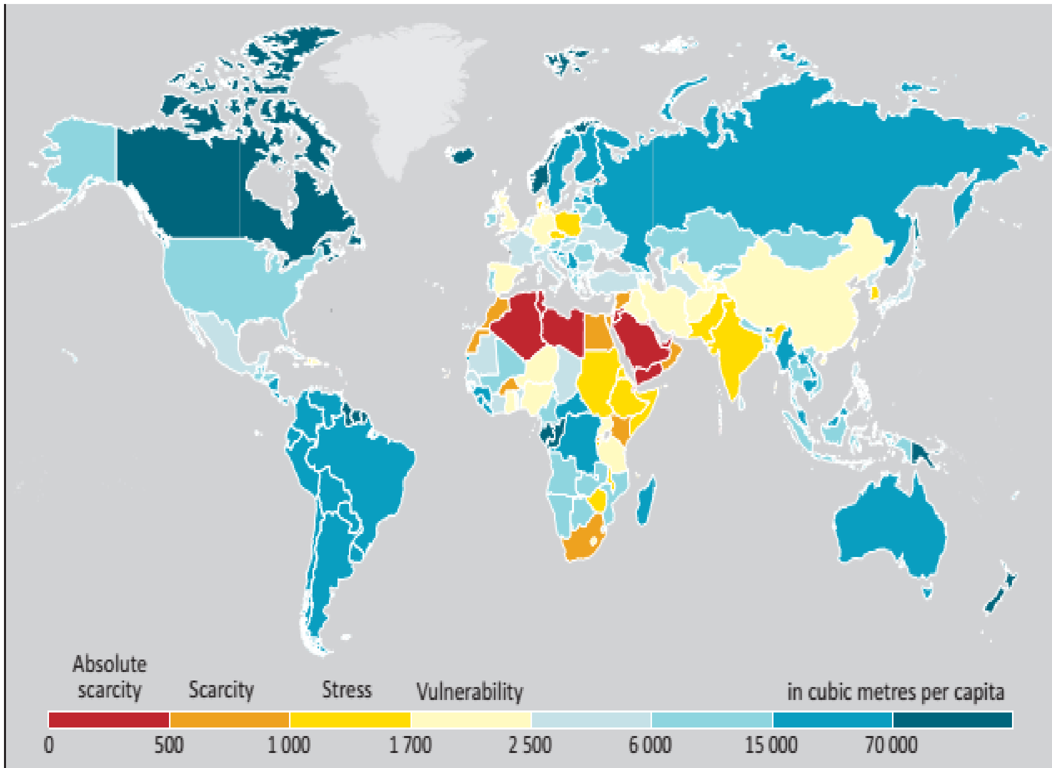

Figure 4: Renewable water resources per capita as at 2010.

Source: UN FAO Aquastat Database

Going by this criterion, and as shown in Figure 4, several countries, especially those in the African are to be inescapable from the fact that there will be less availability of freshwater, and will be severely stressed in future dates (The International Dialogue on Water and Climate, 2004). Climate change will increase the pressure on nations, particularly in Africa, that are already threatened with issue of sustainable water resource use (Urama & Ozor, 2010). For instance, estimates by the Stockholm Environment Institute (Simms, Reid, & Magrath, 2005) reveals that even with a moderate climate change, percentage of populations living in water stress countries will double from the 1995 figure of 34 percent to 63 percent by 2025 (Figure 5). Cabot (2007) supported this claim by lamenting that climate change will have a disturbing outcome on African water resources especially within the basins of River Niger, Lake Chad and Senegal where the available freshwater has already declined from 40 to 60 percent.

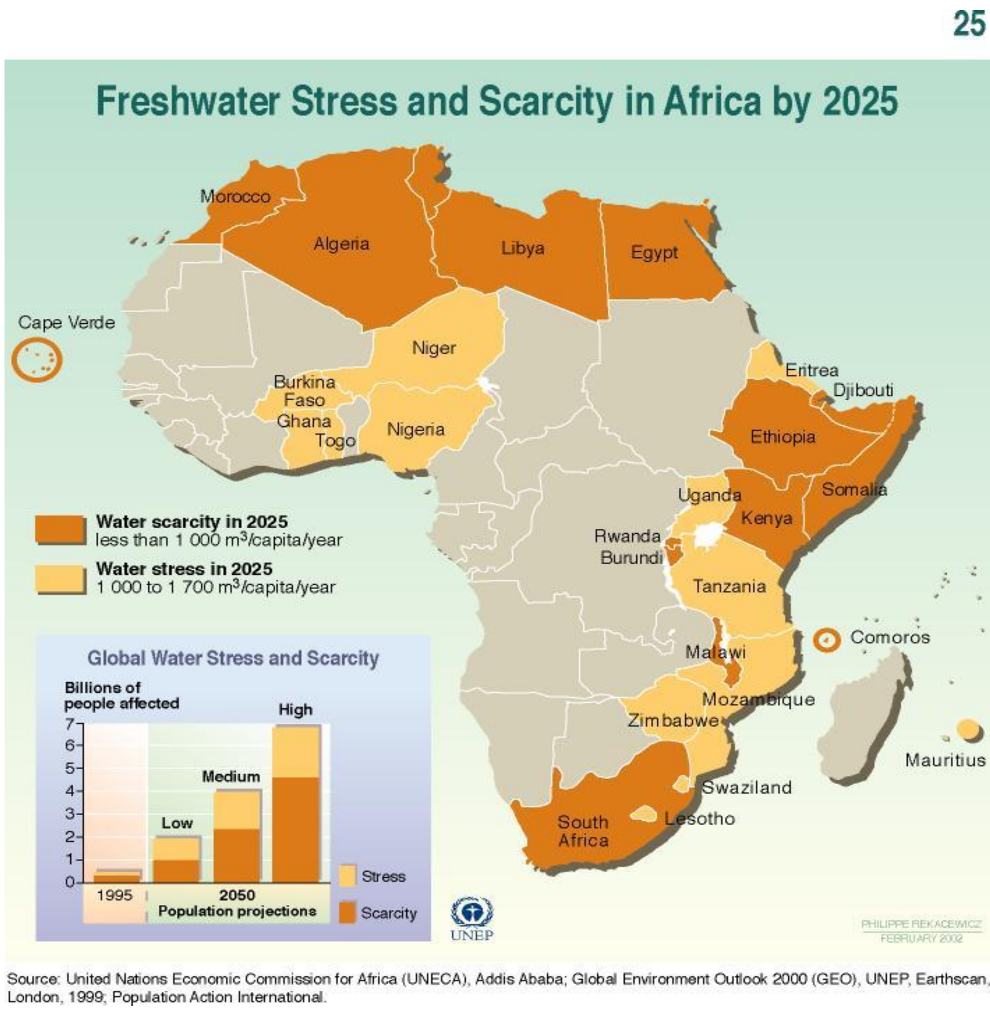

Figure 5: Freshwater scarcity and stress in Africa by 2025.

Source: United Nations Economic Community for Africa, Global Environment Outlook 2000

The susceptibility of Africa to Climate change's impact on water resources may not come as a surprise due to the region's geographical location, poverty, and low technological and institutional capacity to adapt to rapid changes in the environment. The impacts cut across almost every aspect of the African's livelihood because of the continent's greater reliance on climate-sensitive renewable natural resource sectors such as water and agriculture (Eboh, 2009). According to Spore (2008), understanding and responding to the impacts of climate change in Africa is a matter of life and death.

Caution must however be taken on the over reliance of the assumption that water scarcity should be taken to mean that there is insufficient water for domestic use since that may be erroneous (Urama & Ozor, 2010). The total amount of water required for domestic purposes is small, and for that reason, cannot be affected by water scarcity (Rijsberman 2006). For instance, "at a minimum water requirement per capita of 50 litres per person per day, the domestic requirement is less than 20 m^3/capita/year". It should be noted that Falkenmark WSI's thresholds of 1700 m^3 did not mean that water is becoming scarce for domestic purposes; rather, the resource is becoming scarce for food production (Rijsberman, 2006, p. 4). Again, the physical absence of water may not necessarily connote water scarcity as purported by Falkenmark index (Falkenmark, 1989). It also means that water service delivery is ill-done, and that people are financially status (poverty) do not afford them the luxury of accessing the water services available (Rijsberman).

Adaptation as a Response to Climate Change

Adaptation is not a new concept. It has its root in evolutionary biology and Darwin's concept of natural selection (Smith, 1993). Adaptation appears in several disciplines of study to connote adjustment to changes in circumstances (Schipper, 2004). Yet, it has become one of the most important issue of discussion in both domestic and international circles when mention is made of climate change. The concept has fast become one of the policy options to reduce the adverse impacts of climate change and variability, especially in developing countries (Babatolu & Akinnubi, 2016; Levina & Tirpak, 2006). Its popularity over the years has birthed a number of definitions attempting to clarify what the concept truly is. In the literature, IPCC or UNFCCC's definition is often cited, even though several others are also quoted to meet specific fields.

According to the IPCC (2001a, p.6) adaptation refers to the "adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects, which moderates harm or exploits beneficial opportunities". Imbedded in this definition is a specification made to climate change and variability (Schipper, 2004), making it suitable for this study. Other definition, also suitable for this study is Pielker's (1998), which defines it as "adjustment in individual, group and institutional behaviour in order to reduce society's vulnerabilities to climate". It also seen as the process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits associated with climate variability and climate change. Although there are other, be it general or specifically defined, adaptation is simply changes the individuals or groups needs to make in order to ameliorate unfortunate impacts, or even to "make or become suitable for a new use or situation" (Oxford Reference Dictionary, 1986, p. 7).

Types and forms of adaptation

Based on purposefulness, timing, duration and location/spatial scope, and several others, some distinctions have been made about adaptation (Gilbert, LaGro Jr, Nowak, & Sullivan, 2010; Huq, et al. 2004; IPCC, 2001a; Schipper, 2004). Based on purpose, adaptation can be autonomous or spontaneous and planned or purposeful. Autonomous adaptation is triggered by ecological changes in natural systems and by markets or welfare changes in human system. This occurs naturally as a reactive response to climatic stimuli, without a conscious intervention of a public agency. Simply put, this adaptation means that a system is able to adapt without interventions of laws or policies. This therefore does not mean that individuals or groups concerned do not put conscious measures in place to adapt. Farmers, based on their experiences acquired over years are able to adapt in this manner. On the other hand, when deliberate policies are put in place by governments on behalf of societies in reaction to conditions that have changed or about to change, it is termed as planned or intentional adaptation (Huq, et al.; Bates et al., 2008; Schipper).

The next type of adaptation is determined by when (time) an action is taken in response to changing conditions. While reactive adaptation takes place in response to observed impact, though there is no guarantee that actions taken would prevent impacts from occuring (Klein, 1998; Smit, Burton, Klein, & Street, 1999). Anticipatory adaptation on the other hand is carried out before the impacts of the phenomenon is observed (Smithers & Smit, 1997). Though these two forms of adaptation commonly take place in human systems, yet only the reactive adaptation is predominant in natural systems (Klein, 2003).

On the level of time-scale or duration, there could either be tactical or strategic adaptation (Burton, 2000; Huq et al., 2004; Smit et al., 1999). Tactical adaptation is a short-term management decisions taken to respond to immediate stimuli, such as selling off livestock during drought or intense dry season (Smit, 1993; Smit & Skinner, 2002). According to Burton, tactical or instantaneous adaptations are often taken by individuals or small communities or enterprises in the private sector, without any government intervention. Strategic, long-term or cumulative adaptation (Smit et al.) on the other hand is a large-scale or long-term actions often taken by governments to respond to severe climatic events. This, according to Smit and Skinner, include adjustments made by farmers in their operations, often with subsequent seasons in mind.

Lastly, based on spatial scale, another category of adaptation is determined. Thus, there is either localised/national or widespread/international adaptation (Frankhauser, 1998; Huq et al., 2004; Smith, 1993; Smit et al., 1999). Of course, these are adaptation mechanisms that are either taken by a group in a specific localised location or those that are implemented to affect a wider population. Often, the widespread once are as a result of national or international policy implementation.

Existing climate change coping and adaptation strategies

The Intergovernmental Panel on Climate Change (2001a, p. 6-8) has indicated that human and natural systems will, to some extent, adapt autonomously and that planned adaptation can supplement autonomous adaptation. However, "options and incentives are greater for adaptation of human systems than for adaptation to protect natural systems". The IPCC's report further indicated that societies have, for a long time in history, adapting to the impacts of weather and climate through several means including crop diversification, irrigation, water management, disaster risk management, and insurance. But where expertise is quite lacking, adaptation measures that consider climate change are being implemented by public and private bodies in both developed and developing countries.

In most developing countries, with Africa inclusive, the farming sector of the economy, especially, have had to struggle to adapt. In fact, the farmer in these regions of the world have a long history of proving capable of responding to changing influences and of implementing adaptations and innovations as circumstances change (Mengistu, 2011). Various studies have shown that there are wide range of actions that are taken by individual farmers to adapt, sometimes depending on particular enterprises or land types, and others general application (De Loë, Kreutzwiser, & Moraru, 2001; Maddison, 2007; Nhemachena & Hassan, 2007). Among the options that have been adopted by farmers in the sub-region to minimising the climate change risks include adjusting time of planting to coincide with the onset of rains, changing crop varieties, adapting practices to a shorter growing season, mixed cropping, destocking, dry season irrigation farming, expansion of farm size, crop diversification, Fadama (planting at wetlands found along rivers/streams or low lying/swampy areas), granaries (farmers keep their excess harvest in granaries/silos for the off-season time when food is always scarce and costly), picking and processing of some traditional fruits and vegetables, petty businesses, reduction of daily meal in amount and frequency to eat, migration, etc. (Babatolu & Akinnubi, 2016; Dumenu & Obeng, 2016; Fosu-Mensah, Vlek, & Manschadi, 2010; Mabe, Sienso, & Donkoh, 2014; Mengistu, 2011; Stanturf et al., 2011; Yaro, 2010).

Maladaptation, Conflict and Cooperation

Apart from adaptation capacity itself, one other concepts that is often used when assessing and discussion adaptation process is *maladaptation* (Schipper, 2004). As defined by the Working Group II of the IPCC (2001, p.80), maladaptation is "any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increase it instead. While Schipper shares the view of increase in vulnerability, the author further asserts that maladaptation can generate new risk for an individual or society whenever adaptation strategies are poorly planned. The risk becomes even more sensitive when the adaptation has to do with groups struggling live on scarce shared resources.

For example, maladaptation could result in conflict when two or more states share the waters of a transboundary river, especially if adaptation policies reduce water supply in the downstreame regions, while upstream communities enjoy the benefits of water supply (Wolf, 2007). While this notion of maladaptation as a cause of conflict exist, on the other hand, adaptation measures have been noticed to be a potential cause of cooperation. For instance, Tänzler, Carius, and Maas (2013, p.7) emphasise that it is possible that a "successful climate change adaptation could empower countries to better withstand various social and economic stressors, while at the same time avoiding the destabilization of their governing institutions and societal structures".

Understanding the possible pathways for maladaptation to aggravate conflict and ensure cooperation have been explained differently, and sometimestion criticised sharply. Whereas direct association have been established between individuals and societal adaptation strategies and conflict, others claim indirect linkage, explaining that conflicts are only possible with some intervening variable. These arguments have been explained as follows:

Linking climate change impacts to conflict and cooperation

Different studies present different evidence about how climate change and conflict are linked based upon assumptions about the causes of conflict. In their paper which aims to analyse the evidence for the connections between climate change and violent conflict, Forsyth and Schomerus (2013) found, after a comprehensive search of academic literature, books, newspaper articles and blogs, that three main avenues exist for climate change and conflict to relate. First, is the category of knowledge which admits a linear, causal connections between environmental change (triggered by climate change), scarcity, and violent conflict. This ideology, regarded as the "continuation or revised version of the Malthusian concept" (Benjaminsen et al., 2012), is based on the assumptions that population growth fuels struggles and competition over resources which have been made scarce as a result of environmental change (Homer-Dixon,1994). Often, the Darfur Conflict is cited as an evidence. The second category, which is so critical of the first, focuses on the politics of how climate change and conflict are portrayed, arguing that such a linear and simplistic presentation is the reasons why people engage in conflict are "misleading and unhelpful for countries affected". Rather, these category of writer maintain that a more complex understanding of what constitute violent conflict is required for one to draw a conclusion, and that such evidence could be politically useful (Forsyth & Schomerus).

The third and last category of the linkage between climate change and conflict carries that conflicts have several causative factors, and for that reason, has dwelt greatly on the role played by local institutions and behaviour of individuals which contributes to conflicts. In effect, this school of thought also throws out a mere direct or linear causal relationship between the two variables, emphasising that if institutions and behaviours are well laid, attempts to adapt to any severe climatic event rather will lessen or avoid conflict and ensure cooperation (Forsyth & Schomerus, 2013). To them, conflict will most probably result when the harsh impact of climate change interacte with poor governance, societal inequalities, and a bad neighbourliness lead to political and economic instability, social fragmentation, migration, and inappropriate responses from governments. These occurrences, according to Gleditsch (2011), are enough incentive for people to initiate violence. This popular notion has been corroborated by the Future Directions International [FDI] (2012), German Advisory Council on Global Change (2007) and Kloos et al. (2013).

From these backgrounds, some conflicts have been identified. While some directly linked climate impacts such as drought, flood and water scarcity to some conflicts, others have presented cases where the impacts of climate change interacted with poor or weak institutional setups to bring about conflict. For example, studies by Adano, Dietz, Witsenburg, and Zaal (2012), Guyo et al. (2005), Kimani (2008), Mkutu (2007), Moru (2010), Opiyo, Wasonga, Schilling and Mureithi's (2012), and Oxfam (2017) portrayed some associations between drought and violent conflicts among pastoralist communities inhabiting the drylands of East Africa. In all of these studies, climate change, manifesting itself through drastic reduction in rainfall and increasing temperature resulted in drought and scarcity of water, and then invariably forced pastoralists to migrate areas that are less hit with the drought conditions. The eventual outcome of these movements have mostly been violence or conflict.

Furthermore, violence or local conflict could thrive in Somalia for about thirteen years (Maystadt & Ecker, 2014; United Nations Resident & Humanitarian Coordinator for Somalia, 2011) when the nation was declared by the United Nations to be experiencing famine in June 2011 after the East African region was hit with drought one of the worst drought in 60 years. Here, poor coping and adaptation strategies, coupled with weak institutional arrangements got people to migrate to other parts of the country to "compete" for the little resources available there (Achour & Lacan, 2011). Opiyo, Wasonga, Schilling and Mureithi's (2012, p.442) work which studied the Turkana and Pokot pastoralists in Kenya found that competition for scarce natural resources (water and grass) "triggered by frequent droughts" and exacerbated by weak local institutions, proliferation of small firearms, political incitements, unclear property right regimes and cattle-raiding, was considered central to the violent conflicts observed in the area".

Conflict over water has mostly been associated with scarcity of the resource. It is also clear that there are sometimes conflicting situations over the resource in times of abundance, thus, during flooding. Bangladesh, India and Africa are the worst culprits in this scenario where especially water users downstream will engage in conflict with those upstream when the latter open their dams. In other cases, people are forced to move out of their homes to other host communities to struggle over space – jobs, houses, and other resources. Especially where the host communities are of different ethnic background, distrust and ethnic tensions result (Ashton, 2002; Forsyth & Schomerus, 2013; Ghimire & Ferreira, 2015; Ghimire, Ferreira, & Dorfman, 2015; Prasad, Joy, Paranjape, & Vispute, 2012). After compiling data on civil conflicts, large floods, and a set of socioeconomic, political, and geophysical country characteristics and temporal-spatial controls for 125 countries between 1985 and 2009, Ghimire and Ferreira (2013) found floods as negative shocks to GDP growth, implying that any one additional flood lowered GDP growth in the next period by about 2 percent. According to the authors, the reduction in GDP was a recipe for civil conflict through worsen socioeconomic conditions since the lower economic situation can bring about frustration and grievances.

The Water Conflict Debate

Although it may seem sketchy, yet the relationship between water and conflict is dated back to antiquity. The relationship has to some extent, been traced to the Christian Bible; the book of *Genesis Chapter 26* "where the herdsmen of Gerar strove with the herdsmen of Isaac over control of water wells". Again, the writings of Herodotus give another *exposé* as to the association between water and conflict (Yoffe & Wolf, 1999). For example, Hillel (1994) reports of how Herodotus describes the Persians surrendered, after they were cut off from their wells and water tunnels. Lastly, it cannot be taken for coincidence that the word "rival", from the Latin word "rivali" which means "those living on the same stream" has an association with water – "stream".

Management of water is one of the most complex issues with comprehensive and often contentious effects. This is perhaps due to the interplay of these tensions with a number of political, socio-economic, environmental, and cultural factors that have determine violent conflict in different geographical locations of the world. These, apparently make it difficult to explain any water-related tension across the globe, a phenomenon which is not uncommon (USAID, 2014). There is popular public opinion that it will not be an unusual thing to see in the twenty-first century that people or nations are fighting over available freshwater resources. Kofi Annan, former UN Secretary General shared his opinion on the subject in 2001 that "*Fierce competition for fresh water may well become a source of conflict and wars in the future".* Such views have long been expressed by authors such as Cooley (1984), Gleick (1993) and Starr (1991) that considering the total volume of global potable freshwater resource vis-à-vis the rate of human population growth, struggle over water will likely lead to war. Clearly, these authors and several others have reached these conclusions based on evidences gathered from past water-related conflicts and other statistical analysis that reports evidences of water scarcity as having a strong association with the outbreak of either domestic or international conflicts.

It will be worthy to note that proponents of water conflict have hypothesized that there reasons for any water-related conflict or tensions at any scale (intra or inter nations) could be categorized into three – quantity, quality, and timing. According to the authors, competition over limited scarce quantity of water resources is the most likely cause of water-related conflict. Again, low water quality, either as a result of pollution from wastewater and pesticides or excessive levels of salt, nutrients, or suspended solids, have ever caused tension between South Africa and Mozambique over their use of the Incomati River (Wolf et al.).

Thus, when shared water resource is made inappropriate for drinking, industry, and sometimes even agriculture by users at one end (mainly those upstream), conflict is most likely to occur since it (polluted water) may pose serious health threats to both humans and ecosystem at the downstream. Furthermore, low water quality which affects the livelihoods and the environment of a group of people can be an incentive enough for public protests. Lastly, the timing of the flow of water, especially dams, is an important trigger of conflict. For instance, the likelihood of conflict will be high when upstream users open dams/water at a time downstream users are not in need of the overflow, and vice versa.

Similarly, Dabelko and Wolf (2004) share that water is related to conflict when viewed from three main angles. These are a) access to adequate water supply, b) water and a group's livelihood, and c) water and its management. Thus, there is the likelihood of conflict over the adequacy of water (quantity and quality) for various user groups. While water scarcity could be a major threat to the security of an area, there is also an equal danger when the quality of water resources meant for a group is compromised by especially external source(s). In the long run, any of the access challenges – quantity and quality could force people to migrate to other areas where their presence could spark conflict or destabilise the political environment of their destinations. Additionally, whenever the livelihoods of agricultural-dependent societies are threatened through water scarcity, drought, flood, and pollution, conflict could be the eventual outcome in receiving communities where water-threatened migrants have travelled to. Lastly, while it is common to cite scarcity of water as the *casus belli*, inappropriate management of water resources have been alleged to have caused numerous conflicts. The improper management have stemmed from lack of adequate water institutions, inadequate administrative capacity, lack of transparency, ambiguous jurisdictions, overlapping functions, fragmented institutional structures, and lack of necessary infrastructure (Dabelko & Wolf).

Studies on water scarcity (aggravated by climate change) and its association with water conflicts, as well as reported cases of water-related disputes of conflict is on the increase (Gleick & Heberger, 2014) as shown in Figure 6. Thus, the increase in the incidence and reporting especially could be attributed, on one hand, to the growing tensions and disputes over limited freshwater resources and the unresolved political challenges associated with "peak water" (Gleick & Palaniappan, 2010). Another reason is the improvements in reporting conflicts, new internet tools that allow more comprehensive collection and dissemination of news, data, and information; and more widespread awareness of the subject matter (Gleick & Heberger, 2014). On the parts of Leurig (2012) and United States-Direct Investment Abroad (2012), estimates of growing absolute and per capita scarcity of water, water contamination, and the overreliance of agriculture and some urban uses of non-renewable water sources could account for this increase in water-related conflicts.

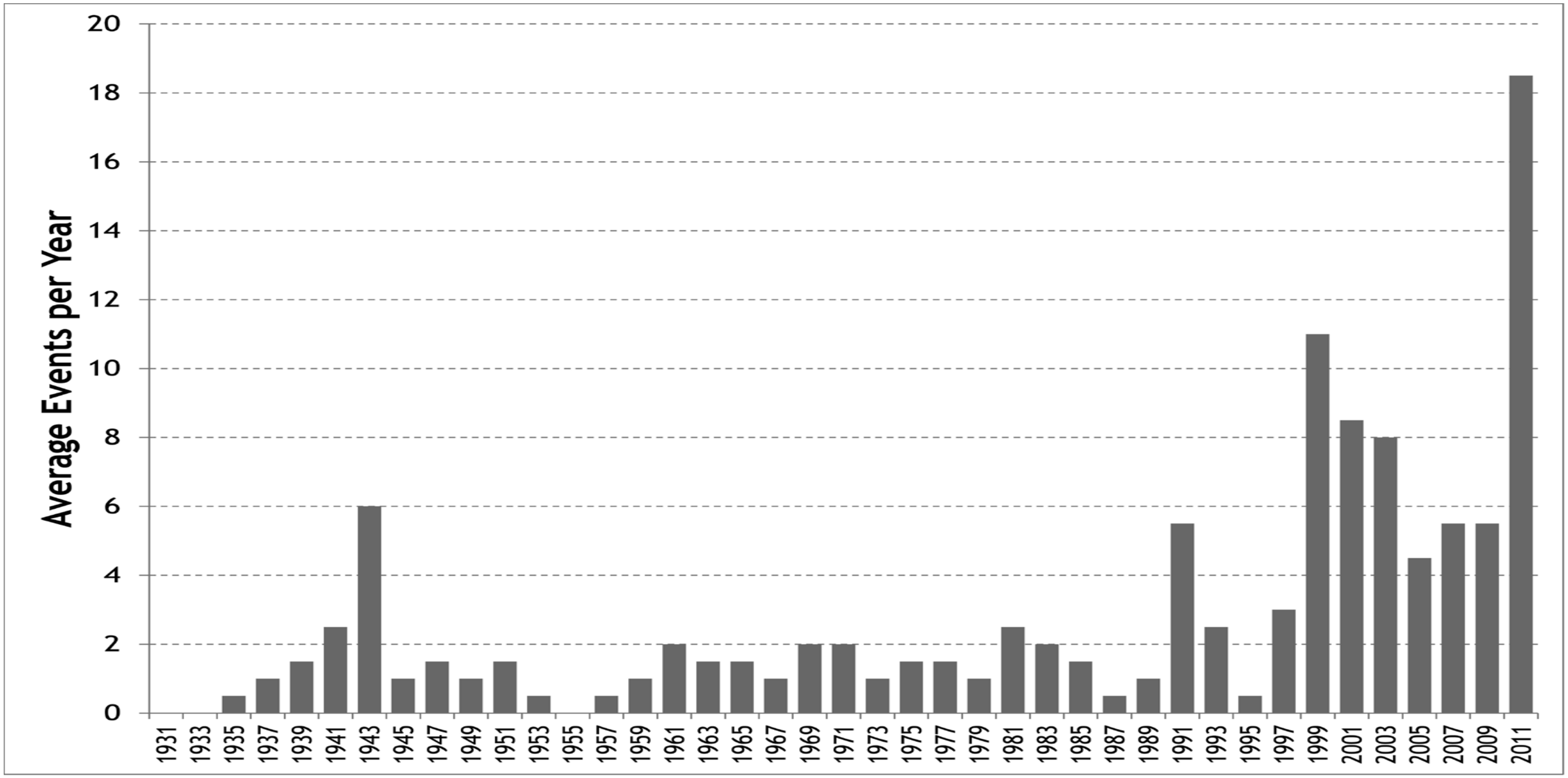

Figure 6: Number of reported water conflict events per year, 1931-2012.

Source: Gleick and Heberger (2014).

It is noteworthy that while much discussion and analysis of water wars has focused on transnational or interstate conflicts, there is rather an increase in the incidence of water conflict within nations or state (subnational or intra-state) (Figure 7), an observation that was made as far back as 1998 in The World's Water (Gleick 1998, p. 105). Again, reasons may abound for this observation: thus, the prevalence and availability of international mechanisms to mediate the risks of interstate water conflicts does little or no help to influence conflicts within states. Thus, the international diplomatic and political tools allow nations to move toward cooperation rather than conflict, while such tools are almost unavailable within states where especially political institutions may be considered weak (Gleick & Heberger, 2014).

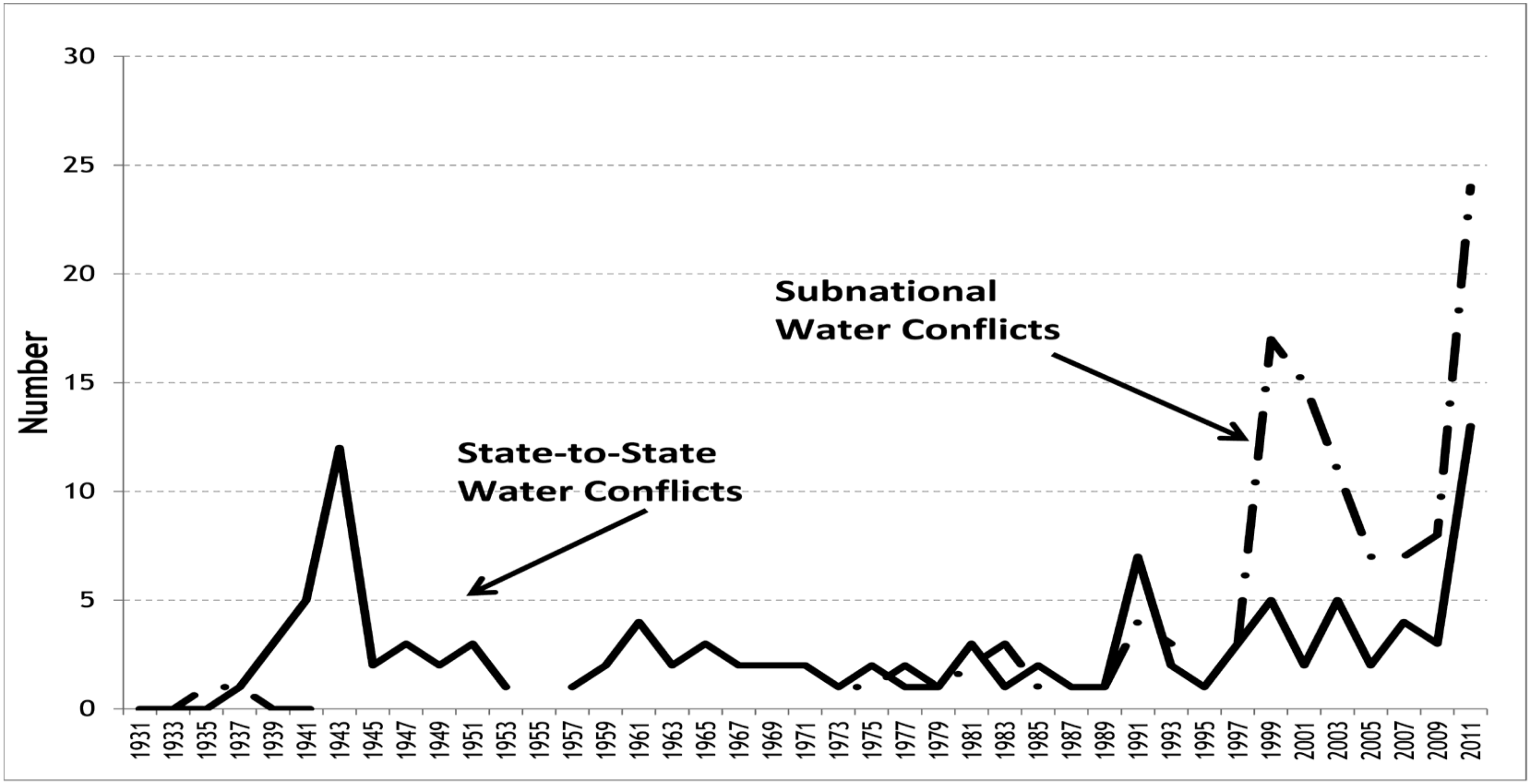

Figure 7: Incidence of reported water-related conflicts for transnational events (solid line) and subnational events (dashed line) since 1931.

Source: Gleick and Heberger (2014)

Evidence of such observations can be seen in a study of the Mediterranean region of southern Europe, North Africa, and the Middle East. The study produced slightly different results for different locations within the region due to substantial dissimilarities across space regarding vulnerability and problem solving capacity (Barnet & Adger, 2007). The Southern Europe section of the region is characterized by relatively high economic and social capabilities and further support from the European Union to mitigate the phenomenon of climate change, and its associated conflicts, than those in North Africa and the Middle East (Brauch, 2006).

Evidence supporting the water conflict debate

While it is almost impossible to lay a finger on a convincing proof in a literature that a particular conflict was as a result of issues surrounding water, declarations by public officials, theoretical models, and sometimes "empirical evidences" are levelled by proponents of the hypothesis to support their claims. The late President Anwar Sadat of Egypt in 1979 mentioned that "The only matter that can take Egypt to war again is water" (Starr, 1991, p. 19). Former Prime Minister of Israel, Ariel Sharon also stated in his autobiography that the 1967's Six Day War was in fact "started two and a half years earlier," when Israel bombed Syria while they (Syria) was trying to divert the headwaters of the Jordan River (Sharon & Chanoff, 1989, p. 167). Another aggressive statement was released years later by Sharon again that the use of the Jordan River in Lebanon (the river's upstream) could again lead to war (Amery, 2002).

Theoretically, several authors including U.S. Senator Paul Simon (1998), Starr (1991), Homer-Dixon (1994, 1999) etc. have hypothesized that it wouldn't be anything difficult for countries to wage war over their water resources they perceive threatened by other users. This will especially be the case for countries with scarce water resources. The end result will be obvious. With what has been described as "hydrological imperative", such countries will employ any means possible, including violent conflict, to get access to additional water supply from any close source (Cooley, 1984; Stauffer, 1982; Stork, 1983). Homer-Dixon (1999) found five categories of violent conflict associated with water scarcity – interstate conflict, local disputes, ethnic clashes, civil strife and North-South war; but pointed out ethnic clashes and civil strife as the most likely to occur. No matter how this hypothesis may be challenge, Giordano, Giordano, and Wolf (2002) have argued that the water scarcity and conflict phenomenon is deeply rooted in history, as the authors defended that while it may seem too naïve to conclude, it cannot be denied either that water was an irritant exacerbating factor in the already fragile situation in the first Palestinian intifada in 1987 through to 1991.

Consideration must also be given to the fact that even within the same theoretical path, other dissenting views that seem to slightly tilt from the path exist. Thus, whiles those arguments support water scarcity as a casus belli, it may not alone cause conflict. In Gleick (1991) view, water scarcity may only worsen an already existing conflict situation, be it international or domestic set ups. This is such a contentious suggestion because in as much as conflict has resulted with water taking either active or passive role, one is left with a very slim or no choice at all, to place the cause of the conflict at the doorstep of this so-called active or passive agent.

Although the water conflict has been lambasted over a period of time from numerous authors, there are a number of empirical evidences from relatively recent case studies and anecdotal references suggest a positive correlation between water and (violent) conflict (Katz, 2008). Israel's bombing of Syrian bulldozers which attempted to divert the headwaters of the Jordan River and the Palestinian Liberation Organization's (PLO) attempt to blow up Israel's National Water Carrier are often cited as most convincing evidences of water conflict or war (Gleick, 1993; Lowi, 1993; Starr, 1991). The Middle East and the northern part of Africa are the areas of the world with most of these conflicts, perhaps, because of the high degree of drought experienced in these areas (Katz, 2008). On the hand, the Jordan River has been pinpointed to be the cause of, and potential cause of any future conflict within the vicinity (Homer-Dixon, 1994; Myers, 1993; Westing, 1986). A study by the United Nations University's Institute for Environment and Human Security (UNU-EHS) conducted in the Mediterranean, Middle East and the Sahel regions confirmed the linkages that exist among climate change, water conflict and human security (Kloos et al., 2013). Notwithstanding these, other areas of the world, such as Sri Lanka, have recently been cited by many, including Bajpaee (2006), Bohle and Fünfgeld (2007), Reddy (2006) and The Economist (2006) to have been experiencing violent conflict over water. The 1998 skirmishes between Ghana and Burkina Faso had the White Volta (one of the three principal tributaries of the Volta Basin) as the main casus belli (Niasse, 2005; Owusu, Waylen, & Qiu, 2008).

Other statistical studies on the subject have been conducted to and published to draw concrete evidence for the hypothesis. Hauge and Ellingsen (1998) concluded on the basis of a multivariate analysis of all countries studied in the period 1980-92 that water scarcity is statistically correlated with the outbreak of civil wars. It was also found in the same study that water was a major cause of armed conflict within nations between 1989 and 1992. Also, according to Gleditsch, Furlong, Hegre, Lacina, and Owen (2006), extremely dry countries are more likely to experience conflict than those in humid environments. Similarly, Levy, Thorkelson, Vörösmarty, Douglas, & Humphreys (2005) opined that areas with high levels of rainfall variability were statistically more likely record high intensity domestic conflict than the opposite condition. In much the same way, Miguel, Satyanath and Sergenti (2004) also found a similar result where rainfall was found to have an association with violent conflict in Africa. Seen differently, other authors have also found a link that exist between countries that share common water resources, and their likelihood of conflict. For instance, Furlong, Gleditsch and Hegre (2006) and Toset, Gleditsch and Hegre (2000) found that countries that share water resources are more likely to engage in violent conflict over water they share than neighbouring countries that do not, and that the higher the number of rivers available to be shared, the higher the likelihood of conflict. The authors were however careful to add that such an association is most likely to be the case when all other variables (esp. economic and political situations) are held constant.

Critiquing the water conflict debate

Apart from the vividly proven documented interstate dispute between the Sumerian city-states of Lagash and Umma over whose right it was to exploit boundary channels along the Tigris in 2500 BCE (over 4500 years ago) (Cooper, 1983), there are even greater amount of evidence in the literature to disprove the arguments advanced by the proponents of the water conflict debate as outlandish. The linkage between water scarcity and conflict within and among nations are purported to be narrowly focused because there seem not to be any convincing proof that suggest a solid causal relationship between the two entities. Where any relationship is drawn, Wolf (1998, p. 254) is of the view that it "only describes the relationship between interstate armed conflict and water resources as a scarce resource", but not as water scarcity leading to conflict. For instance, there is complete misrepresentation of any causal relationship between water and conflict in the Middle East (Wolf). The author continues that most articles cited about water conflict or war in the Middle East are rather about political tensions and not wars, or even water as a tool, target, or victim of armed conflict. This, according to (Katz, 2008), is one of the methodological flaws in most case studies of this hypothesis.

Largely, pronouncements by public officials, which are sometimes relied upon as impetus for concluding on the debate has been refuted, as lacking credibility (Katz, 2008). For instance, a common statement from the '80s, '90s and the beginning of the 21st century by public officials that "the next war in the Middle East will be fought over water, and not politics", only speculate potential for water related conflict, rather than actual conflict. It therefore becomes extremely difficult for one to conclude based on such assumptions, since according to Leng (1980), the frequency of the threats of war and the onset of it has no association. Wolf, Yoffe, and Giordano (2003) findings from a study on conflict and cooperation over water resources between 1948 and 1992 attested to Leng's (1980) assertion. The former in their finding revealed that out of the over 400 incidents of verbal exchanges by public officials which were conflictive in nature, only 37 of them (mostly from the Middle East – 30) ended in some degrees of war or violence.

Furthermore, it should be noted that theoretical justification for water conflict is not just simplistic and deterministic as proponents of the hypothesis try to make readers to believe. War and/or conflict are not mono-causal phenomenon. It incorporates a number of variables including level of democracy, relative power parity, economic development, etc., yet "many popular models (including the proponents of the water war hypothesis) reduce war to single deterministic causes" (Vasquez, 2000, p.17). Goldstone's (2001) assertion that even where environmental factors are statistically significantly correlated with the outbreak of violent conflict, such are in most instances less significant as compared with other explanatory variables. In the case of the water conflict hypothesis, proponents in their analysis of the causes of conflict often ignore other relevant variables such as historical relationships between parties, riparian position, relative military balance of power, governance and decision-making structures, trade relationships, and others.

Another strong critique of the hypothesis however lies in its inability to provide systematic and empirical statistical evidence of correlation between the variables. In spite of his conflict chronology published over several years, Gleick's (2006) findings of several water conflicts are only filled with incidences of water and water-related infrastructures being used as tools or targets of conflicts, rather than water as a trigger of those conflicts. A similar finding was made by Yoffe et al. (2004) and Wolf et al. (2003) which submitted that cooperation is more likely than conflict among countries that share water resources. In their findings, only 28 percent (which were largely verbal exchange) of 1,831 events in the Middle East North Africa (MENA) regions between 1948 and 1999 were considered as conflictive, while 67 percent were cooperative. For instance, there has been more cooperation between Israel and Palestine Liberation Organization (PLO) and Israel and Jordan over their shared water resources since 1993 and 1994 respectively, against the popular claims that population growth in those aforementioned countries would be a catalyst for future war over water. It was therefore not out of context for Hensel, Mitchell, and Sowers (2006) to assert that even though there could be a possibility of conflict (without evidence though), water scarcity and cooperation are more plausible between states.

Last but not the least, the fears of the proponent of the water conflict and/or war hypothesis is premised on the future scarcity of freshwater resources. Such fears have been allayed by the “cornucopians” or “optimists” who are of the view that the tendency of improvement in the use and management of water resources, especially for agricultural purposes (irrigation technologies), efficient water pricing policies, and reductions in delivery loss rates and costs for desalination and reclaimed sewage, etc., will nib such fears in the bud (Lomborg, 2001; Myers & Simon, 1994; Simon, 1996). Therefore, it could be concluded, according to Katz (2008) that if the water conflict hypothesis is based on future scarcity of freshwater resources with rising population increase, then the potential for any future war conflict over these resources are to be eliminated or reduced with rising technological and managerial improvements.

Perhaps, the tons of rebuttals again the water conflict hypothesis has yielded fruits eventually, hence compelling some leading scholars for the argument to soften their stance on the debate. One of such pundits is Homer-Dixon. The author earlier declared that 'the renewable resource most likely to stimulate interstate resource war is river water" (Homer-Dixon, 1994, p. 19). The author's recent comment on the same subject is less weighty as compared to the former: "wars over river water between upstream and downstream neighbors are likely only in a narrow set of circumstances…[and] there are, in fact, very few river basins around the world where all these conditions hold" (p. 208). While this may be the case, plans for the management and prevention of water conflicts should not be shunned because potential for future water conflict cannot be wholly written off especially in those regions of the earth that are considered as water stressed and conflict hotspot.

Water and Cooperation

While Neo-Malthusians have maintained their stance that water scarcity rightly has an association with conflict, Cornucopians on the other hand argue that the adaptive capacities of societies are well able to avert any such conflict (Water -Related Intrastate Conflict and Cooperation (WARICC) (n.d.). Some relevant adaptive capacity that could be employed by societies to forestalling any conflict associated with water includes technological innovation, the use of the market mechanism, cooperation, and effective and functioning social institutions. Effective management of water, synonymously referred to as conflict management (Wolf,

2007) has ensured cooperation within and among several nations, especially those sharing water. Several experts, including geographers have always relied on the resource (i.e. international river basin) as a conduit of peace and cooperation within the catchments Jordan, Indus, and Mekong river basins (Wescoat Jr, 1992).

Perhaps geographers' craving for using water for ensuring cooperation is borne from George Cressey's 1957 presidential address to the Association of American Geographers that suggested that "no drop of rain should run off to the sea without having done something useful for man; preferably it should serve multiple functions. These services may represent consumption by man, provision for navigation, or the use of water to carry away sewage or to generate power" (Cressey, 1957, p. 109). Of course, doing something useful includes ensuring peaceful co-existence among the users of the resource, an opinion epitomized in the latter view of the use of water resource and cooperation by Gilbert White in the late 20th century. According to White (1998), there exists a linkage between the effective use of water resources and the economic development, and international cooperation, which countries should endeavor to utilize.

In a way, this path has been followed. Cooperation in some sense of the word, – "the fact of doing something together or of working together towards a shared aim" (Wehmeier, 2000, p. 276), has empirically been found. Though the definition seems broad, yet according to Facius (2008), the definition "matches the reality that many types of cooperation may be found" (p. 24), as was the case in the author's study sites in Tanzania where the "villagers" cooperated by dividing water resources for irrigation among the Water User Associations (visible cooperation), and when the same users develop rules and regulations for water use (invisible cooperation). However, care must be taken in the definition of the term since cooperation in the use of a common resource does not connote the absence of conflict, neither does it symbolizes having an equal (equal power relationship) access to the shared resource (Facius).

Though some empirical studies have been done on water and cooperation at the domestic level, several have however been done at the international level. For instance, while a study by Böhmelt et al., (2014) admitted domestic water related conflict in 35 Mediterranean, Middle Eastern, and Sahel countries between 1997 to 2009 among different tribes and water-use sectors, they further confirmed greater amount of cooperation among diverse water user groups. The chunk of the empirical evidences supporting cooperation has existed at the international level (between nations). Globally, over 3,600 treaties had been signed over different aspects of international waters, with about 150 of them dealing with water quality alone (Yoffe, Wolf, & Giordano, 2003).

Instead of war, there has been a number of cooperative treaties among a number of countries in the Middle East – Israel, Jordan and Egypt, as well as states of the Arabian Peninsula (Chapagain & Hoekstra, 2004). For example, Egypt is a party to the Nile Basin Initiative; Israel and Jordan have signed a treaty to share the River Jordan; and in the Olso II agreement Palestinian and Turkey, together with some other downstream riparian countries agreed on the minimum flow of the Euphrates River (Zeitoun, Mirumachi, & Warner, 2011). Again, studies Wolf et al. (2003) and Yoffe et al. (2004) have provided some proofs of water as a tool for cooperation. The Basins at Risk I and II studies involved interactions over the use of water as a scarce and/or consumable resource or as a quantity to be managed between two or more countries, whether conflictive or cooperative. The results found 67.1 percent and 27.7 percent of cooperative and conflictive interactions respectively, with 5.2 percent being neutral or insignificant. Among the cooperative issues found were those over water quantity, quality, infrastructure, flood control, water management, and technical cooperation.

Water as a tool or avenue for cooperation has also been critiqued sharply. Breaden-MacGuire (2013) has noted that for one to conclude that states have cooperated, means that person has ignored the condition(s) under which such a cooperative treaty was signed. In some instances, Selby describes such cooperation as “domination dressed up as cooperation”, as in the case of the Water Joint Committees for licensing water project in Palestine (2005). There hardly will be a cooperative interaction because of the dynamic nature of political struggles. Furthermore, the findings of the BAR I and II are faulted on the basis of subjectivity – simply inconsistent, since reviewers’ decisions on the ratings of the study ranged from “fair” to “excellent” (Bernauer et al., 2011). Last but not the least, it is very argumentative to accept any cooperation “where water is the driver of all event” as water cooperation. While such an agreement fails to hold for water conflict and/or war, it similar becomes impossible to hold for water cooperation (Wolf et al., 2003).

It will only be fair to admonish that while water conflict has or is failing to be accepted as the really on the simple grounds of lack of empirical evidence, the conclusion drawn for water cooperation is not without flaws. This has and will be the case despite the number of dataset of evidences channeled in explaining each of the divide. The end to this is not in view, as it has always swung in the academic literature on water and conflict (Zeitoun et al., 2011).

Climate Change and Human Security

Even though human security was often mentioned before 1994 (Kurusu, 1998), the concept became a matter of serious public discourse as a post-Cold War attempt to re-examine the "traditional" concept of security, where the state was seen as the provider of protection from invading armies (Shinoda, 2004; Owen, 2004). Put differently, it meant the protection of the state from external threats (Tsuchiyama, 1998). Thus, the wellbeing of the individuals within the state were believed to be in the inherent military build-up of the state and the sovereignty she wielded.

However, despite the macro-level stability brought about by the East-West military balance of the Cold War resulting from the fall of the Berlin Wall, there were still some evidence of insecurity among citizens who "were being killed by the remnants of proxy wars, environmental disaster, poverty, disease, hunger, violence and human rights abuses" (Owen, 2004, p. 17). These occurrences led to the challenging of the view of traditional concept of security (Baylis, 1997). It was therefore not out of place for the Former Secretary General of the UN to proclaim in 2000 that: "Security can no longer be narrowly defined as the absence of armed conflict, be it between or within states. Gross abuses of human rights, the large-scale displacement of civilian populations, international terrorism, the AIDS pandemic, drug and arms trafficking and environmental disasters present a direct threat to human security…" (United Nations General Assembly, 2000).

Human security (and/or insecurity) have become a universal issue (Adger, et al, 2014), probably because every country on earth have some vulnerable individuals and groups who are in one way or the other insecure (Mahoney & Pinedo, 2007; Pietsch & McAllister, 2010), especially those from developing countries (Berrang-Ford, Ford, & Paterson, 2011; Leichenko & O'Brien, 2008; Naess, Norland, Lafferty, & Aall, 2006). Especially within the controversial discussion of the subject of climate change, the concept of human security has gained fame in recent times after efforts were made to link the two themes. According to Adger et al., "the framing of climate change as a security issue has been controversial" (p. 760). Others have claimed that the attempts made to link the two extreme subjects only downplays the discussions of national security, while at the same time, shifting the attention on the discourse of climate change response strategies for the most vulnerable human populations to the state (Barnett 2007, 2009; Floyd, 2008; Brauch, 2009; Dalby, 2009; Verhoeven, 2009; Trombetta, 2012; Oels, 2013).

Although attributing changes in climate directly to human security is difficult, some evidence to link climate change as mainly posing threat to food security, water stress and scarcity, as well as destruction of property are well identified (Battisti & Naylor, 2009; Bohle, 2009; Carter, Little, Mogues, & Negatu, 2007; Deligiannis, 2012; Hertel, Burke, & Lobell, 2010; Leary, Conde, Kulkarni, Nyong, & Pulhin, 2008; Paavola, 2008; Peras, Pulhin, Lasco, Cruz, & Pulhin, 2009; Schlenker & Lobell, 2010; Tang, Petrie, & Rao, 2009). In most instances, climate change will threaten livelihoods, compromises culture and individual, identity, increases migration by undermining the individuals' and the states' ability of providing the necessary conditions for their human security. It should however be noted that several authors engaged in this argument agree that the climatic events which produce these unfavourable outcomes as mentioned, work in close collaboration with multiple factors in one's economy and society.

Implications of climate change on human security

Conflict

Among the numerous impacts of climate change on human security, the most widely-discussed are the possibilities of violent conflicts, food insecurity, and/or (mass) migration resulting from biophysical or ecological disruptions brought about by climate change (Brown & Funk, 2008; O'Brien et al., 2008; Schmidhuber & Tubiello, 2007). For instance, after using rainfall variation as a proxy for economic growth in some 41 African countries, Miguel et al. (2004) concluded that decrease in rainfall strongly increase the likelihood of conflict in the following year. Similar findings have been made found by Hendrix and Glaser (2007), Meier, Bond, and Bond (2007), and Nel and Ringharts (2008) who have clearly shown some associations between rainfall variability and violent conflict, especially in low and middle income countries. On the other hand, others have challenged these assertions, on grounds that no or limited concrete evidence to substantiate the argument that climate change will increase violent conflict (Barnett, 2003; Barnett & Adger, 2007; Salehyan, 2008; Scheffran, 2008; etc.). In fact, Wolf, Kramer, Carius, and Dabelko's (2006) work on international river basins reveals that water access and water scarcity in most cases have led to cooperation among nations, instead of conflict as speculated. In spite of the inconclusive nature of this argument on water conflict and/or cooperation stemming from the fact no statistical data have produced robust findings (Buhaug et al., 2010), there is enough evidence to suggest that human insecurity emanating from lack of food, water, shelter, and several others have had adverse impact on human development (Sen, 1999).

Food insecurity

"We live in a highly food insecure world" (Devereux & Edwards, 2004, p. 22). This assertion and conclusion by these authors and several other have been made on the grounds of climate change. This is because several author have concluded that climate change have, and will continue to impact agricultural production, and by extension, food supplies in several part of the world, particularly, in developing countries (Brown & Funk, 2008; FAO, 2016, 2008b; Schmidhuber & Tubiello, 2007). Thomas and Rosegrant (2015) of the International Food Policy Research Institute (IFPRI) on their part have stated that climate change impact on crop production in Africa have been adverse.

These report conclusive state that one greatest and awful implication of changing climate that humanity face is food security, which is defined by the FAO (1996) a situation "when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." Availability, access, utilization and stability have been identified as the four main pillars of food security (High Level Panel of Experts [HLPE], 2012; Schmidhuber & Tubiello, 2007).

Though humanity is at risk with respect to all these pillar, food availability seems to stand tall. For instance, Lobell et al. (2008), after using crop models to calculate changes in agricultural production to 2030, concluded that that climate change will most likely lead to reduction in agricultural production, and eventually, reducing food availability, especially in region with low technology in agricultural practices. The authors further reports that 30 percent of farmers in developing countries are food-insecure due to the massive reduction in their yields of corn, wheat, and rice. Other evidence within the larger global perspective also have shown climate change has already negatively affected wheat and maize yields in many of the world (Lobell, Schlenker, & Costa-Roberts, 2011).

The possible effects of climate change on agriculture are not limited to food production alone, but also livestock. Climate change affects the livestock sub-sector of agriculture. This indeed is a matter if concern due to important role livestock play in the livelihoods of families in dry lands regions of SSA. Livestock are a major asset which provides a number of critical services such as saving, credit, income for educational and health needs, and a buffer against extreme climatic events among rural communities of arid and semi-arid regions of SSA (FAO, 2016). Under climate change, all these provisions are threatened since the extreme temperature and decline rainfall adversely affects the feeds, forage or grassland,

and water which are mainly ingredient for raising livestock. Some studies by some authors and organisations have shown that several countries in SSA lost 20 percent to 60 percent of livestock during serious drought events in the past two or three decades. While South Africa is expected to have their dairy yield decreased by 10 percent to 25 percent under certain climate change scenarios, Botswana is also estimated have a 23 percent rise in the cost of supplying water to animals from boreholes (FAO, 2016; Niang et al., 2014; Rota, 2009).

In spite of these and several findings made about food security, especially for populations in developing countries, solutions abound for farmers to mainly adapt to climate change. This is borne out of the notion that food insecurity, "is not solely a product of 'climatic determinism' and can be addressed by improvements in economic, political, and agricultural policies at local and global scales" (Brown & Funk, 2008, p. 581). The authors specifically suggested and encouraged farmers to resort to improved seed, fertilizer, proper land-use practices. According to Lobell et al. (2008), switching from the production of corn (and similar grains) to sorghum which is noted for its lower water and higher temperature requirements for warmer and drier climates, will be appropriate. Darwin (2001) similarly opines that farmer adapt the cultivation of varieties of crops, and to shift from crops to the rearing of livestock, mainly because of the higher vulnerability of crops production to the impacts of climate change. Specifically, livestock producers are advised engaged in production adjustment strategies – diversification, intensification and/or integration of pasture management, livestock and crop production; changing land use and irrigation; altering the timing of operations; conservation of nature and ecosystems; modifying stock routings and distances; introducing mixed livestock farming systems, such as stall-fed systems and pasture grazing, etc. (Rota, p. 6; (FAO, 2008b; Sidahmed, Nefzaoui, & El-Mourid, 2008; Thornton, et al., 2007).

Governments and policy makers are encouraged to provide reliable 6 to 8-month weather projections (early warning) or information about suitable crop and livestock alternatives to help farmers increase their production efficiency. Again, governments are to provide irrigation facilities, develop flood control programmes, and sponsor research for the development of new varieties of crops or livestock that are better able to withstand the effects of climate change (Brown, Funk, Galu, & Choularton, 2007; Darwin, 2001). As well, since adaptation is not a guarantee that farmer will be able to continue with their cultivation in an area, it is prudent for "policies that facilitate the migration of people from one location to another or the transition from one profession to another", to be enacted (Darwin, p. 2).

Migration

Even though migration, whether permanent or temporary, internal or international, has always a possible coping option for people facing environmental changes (Warner et al, 2008), recent discussion on the subject of environmental or climate induced migration has assumed some prominence among think tanks, governments, NGOs, and several others (Elliott, 2012; Kolmannskog, 2008), particularly due to the security implications of such movements (Werz & Conley, 2012). The prominence of this discussion prompted the term "environmentally induced migrants", which is defined by the International Organisation for Migration [IOM] (2007) as "persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad". The general notion among concerned authors and groups is that climate change has the power to 'push' people from their homes to other favourable locations for better living conditions, trigger conflict, and disturb national security (Elliott, 2012). This bit, conflict and insecurity, is often referred to as the "third layer" of the climate-migration nexus by Werz and Conley.

According to Werz and Conley (2012), such concerns should be taken serious since climate change is inevitable, that the world could witness significant numbers of 'climate migrants' in the 21st century. In spite of the fact that statistics on current environment-related population movements are difficult to come by many, including the IPCC, rely on those provided by British ecologist, Norman Myers (Adger et al., 2007). In Myers' (2002) estimation, there will be about 200 million environmental refugees across the globe by mid- to late century. The movements and/or displacements, according to the author, are to be particularly caused by the impacts of climate change and related sea level rise. Similar conclusions have been arrived by Christian Aid (2007) and McGranahan, Balk, and Anderson (2007).

While the statistics may portray migration in an international dimension, it is important to understand that considerable number of internal migration, which particularly affect the poorest people (Warner et al., 2008), exacerbated by climate change persist. The internal movements could lead to instability, especially when the migrants have to compete with host communities for their scarce natural resources. Hence, Warner et al, warns that if such vulnerabilities associated with climate change are not dealt with, environmentally induced migration will continue to be a human security issues.

Indeed, this nexus have received a number of criticism. Some studies have sharply condemned the association as nothing but a mere exaggeration, thereby creating danger of inappropriate policy responses, especially for those who are mostly at risk of the climate change phenomenon (Adger & Barnett, 2005). Some have even raised questions about Myers and Christian Aid's "alarmist predictions", with questions such as these being raised: "how many migrants there may be; where will they move from and to; and over what time scale?" These and several uncertainty surrounding these claims of climate change as exacerbating migration, are suggested to be ignored, and should not be used as a basis for policy (O'Brien et al, 2008).

Summary

Climate change is underway, and it appears that it has come to stay with humankind due the colossal amount of carbon dioxide and greenhouse gases already in the earth's atmosphere (IPCC, 2007). The impacts associated with the phenomenon has been observed in several parts of the world, and are manifested through extreme climatic events such as drought, flood, water and food scarcities, and several others. In fact, some of the implications are said to have some multiplier effects. For instance, some have argued that some conflicts and cooperation experienced in some part of the world have been as a result of those areas suffering from lack of water resources (Böhmelt et al., 2014; Cooley, 1984; Gleick, 1993; Starr, 1991; Wolf et al., 2003; Yoffe et al., 2004). Adaptation, in connection with several adverse impact of climate change, have become a means of survival for many, particularly among regions where agriculture, as a main means of survival, is nature-dependent.

Adaptation techniques, when not properly or apppropraitely carried out, become a recipe for conflict. Yet, this may not be a straight forward likelihood because several some writers opine that for conflict to be possible in the face of scarcity, there should be some favourable socio-cultural or political environment. Indeed, this enabling environment will interact with the climatic condition to forment conflict. However, in a situation where the social environment is right in terms of clear and sustainable institutional setup, cooperation, rather than conflict will result.

Adaptation to climate change in diverse ways are relevant for public discourse due to its association with the human security of millions of people (O'Brien et al., 2008). Human security in this sense is not just about freedom from conflict or prevention of population displacement, but the means available to someone to secure basic rights, needs, and livelihoods, and to pursue opportunities for human development (O'Brien & Leichenko, 2007). In as much as communities are encouraged to employ various strategies to avert insecurities associated with the changing climate, governments' and allied agencies' enactment of favourable and effective policies will minimise looming threats.

CHAPTER THREE

THEORETICAL AND CONCEPTUAL ISSUES

Introduction

As already mentioned, there is not single cause of conflicts. This situation makes it difficult to unravel the actual causes or sources of the conflict. Hence, many existing studies have relied on a number of theories to study conflict in many human settings. Largely, most of these studies relied on these theories as conflict analysis tools to explain the causes or sources of conflict, and to address the root of the problem, while avoiding or even resolving existing conflicts. Several of these studies have explored the link between natural resources and violent conflict in many parts of the world, and more specifically, others have looked at the relationships between climate, water and conflict or cooperation using theories such as the human needs theory, the theory of political ecology, and the concept of bounded rationality (the concept of space). These theories will be discussed in this chapter, as well as the conceptual framework of hydro-climatic change, conflict and human security that will be used to guide this study. Yet before delving into the theories, the chapter reviews that the concept of conflict is, and what it is not. It also looks at the types of conflict as well as the stages of conflict development.

Conflict – what it is, and what it is not

As a starting point, it is important to understand what conflict on one hand, and water conflict on the other really mean, before delving into the arguments of the reality or otherwise of it. Conflict exist when there is a pursuit for a real or perceived set of incompatible goals and interest between two or more people or groups, and as such, these opposing actors operate on different parallels on the same issue (Folarin, 2015; Kloos et al., 2013). Put differently, any existing state of disagreement or hostility between two or more people, according to Nicholson (1992), is tantamount to conflict. Within these definitions, two things are common – conflict may either be hostile or not, and that, so far as different worldviews are expressed by two or more groups on an issue or situation, conflict has taken place (Barash & Webel, 2002). The phenomenon only becomes hostile or gets physical when different interpretation of a motive reaches a crescendo (Jeong, 2000), and that the intents of the opposing forces are to maim, cause a physical destruction leading to mass mobilization, destabilization, violence, or even death (Kloos et al., 2013; USAID, 2014, p. 4-5).

When a hostility or aggression between two or more parties is expressed by "conventional (uniformed and armed) soldiers, with the knowledge and observation of a third (neutral) party who sees to it that acts are within the rules of engagement (Waltz, 2007)", then war, rather than conflict is declared. It therefore becomes common to refer to all wars as being a conflict, while on the contrary, all conflict situations may not necessarily be a war situation. For example, since M23 rebels in the Democratic Republic of Congo (DRC) is not a conventional army, their attack on state installations will be classified as conflict. Meanwhile, the conflict in Mali is a state of war (Folarin, 2015).

This clear distinction makes it possible to classify what conflict is, and what it is not. It is clearly noted that anything less or short of the description of war connotes conflict. Hence, words that are often used interchangeably with conflict are all considered as such. These words or synomyns include disharmony, discord, struggle, contest, strife, antagonism, controversy, clash, rivalry, contest, contention, brawl, fisticuff, fight, battle, feud, combat, tension, disagreement, polarization, etc. (Folarin, 2015; Kohlrieser, 2007). For the purpose of this study, Goulden et al's. (2009, p. 806) definition of the term is adopted. The authors' definition did not just consider armed violent conflict between nations, but also "any range of negative interactions that encompass mild verbally-expressed discord and cold interstate relationships, as well as hostile military acts or declarations of war". While the latter part of the definition may not suffice in the current study, the observance or notice of any will not be ruled-out.

Types of conflict

From several study fields, such as Psychology, Political Science, Sociology, and History, different types of conflicts are realized. There are, from Psychology, intra-personal conflict; Sociology, inter-personal, intra-group or intra-unit, and inter-group conflict; Political Science and History, inter-ethnic or intra-state conflict, and international conflict. Intra-personal conflict, also referred to as "man-against-self" by (Lamb, 2008), is a state of implosion in an individual often shaped by one's state of mind, and the circumstances that he/she finds around him/herself. The resultant outcome of such situations are anger, depression, confusion, frustration, etc., and could eventually lead to aggression, erratic behavior, addiction, and in extreme cases, suicide (Ross, 1993).

In the case of inter-personal conflict, there is either a direct opposition or a subtler conflict between the desires of two or more persons (Nikolajeva, 2005). There could be direct exchange of blow where there is direct opposition, or implicit hostility where the conflict "may not be obvious to the third party, but the disagreeing or unfriendly parties already understand that there is a state of discontent between them" (Folarin, 2015, p.5). The 'man against society or nature' type of conflict is where an individuals stand to fight against a man-made institution or practices such as slavery, human trafficking, child prostitution, human rights abuses, bullying, corruption, bad governance, etc. or against his natural environmental phenomenon including global warming, climate change, rainstorm, hurricane, desertification, etc. to overcome and master it (Lamb, 2008; Morell, 2009).

Again, Sociologists describe as intra-unit conflict, when for instance, there is a battle within a family unit, and are often triggered by familial roles, expectations and role conflict. On the other hand, an inter-group conflict exist when there is a disagreement or feud between two or more sectarian or religious groups, ethnic groups, communities, or interest groups. A vivid example is the onslaught against Christians and the Nigerian State by the Boko Haram Islamist terrorist since 2009 (Folarin, 2015), and the recent spate of attacks by the Islamic States (ISIS). Furthermore, value differences in terms of uneven development, resource control and revenue-sharing formula have led to conflicts in several societies including old Sudan. This type of socio-economic or intra-state conflict are restricted to the borders of a sovereign state (Folarin).

There is inter-state conflict or international conflict when there is a territorial encroachment by another state, breakdown of diplomatic ties, exportation of toxic or contrabands to another country, etc. which in most cases degenerates to a state of war. Example of such conflicts include the Nigeria-Italy conflict resulting from the dumping of toxic substance in the Koko, a sedate village in Delta (Bendel) State (Nigeria) by the Italians in the 1980s. This scuffle remained a conflict. However, the conflict between Iraq and Iran degenerated to war between 1980 and 1988. It is worthy to note that such conflicts between two or more states could lead to a full-blown global conflict. For instance, the First World War was started by Serbia and Austrialia in 1914, whereas the World War II was as a result of the German-British conflict of 1939. There are also cases of global conflict not directly caused by states. On the other hand, not all global conflicts are started by states. Example is the on-going global conflict between states across the globe and terrorism (Folarin, 2015).

While several reasons might be mentioned as the cause of conflict in all these types of conflict, access to or control over objects – ideology, power, information, territory, and resources (be it natural or man-made) dominate in most conflict literature or studies as the reasons why actors engage in conflict. In the case of conflict over natural resources have been fought over the scarcity, rather than the abundance of them.

Stages of conflict development

Conflicts the world over, have their own dynamics; it barely burst out of nowhere. Rather, the act of conflict is known to develop from one point to the other – thus, it travels through different stages of escalation until it recedes over time (Frère & Wilen, 2015). According to Wehrmann (2008), each stage of conflict reflects the changes in activity, intensity, tension and violence of the act over time until resolution is reached. In spite of their dynamics, every conflict is purpoted to go through at least three phases: pre-conflict, in-conflict or crisis, and post-conflict (Wehrmann) (Figure 8), but for the purpose of conflict management, Fisher et al's. (2000) five phases of conflict are considered. The phases include the pre-conflict, confrontation, crisis, outcome, and post-conflict. Knowing the stage of a conflict aids one to choose the appropriate antidote or intervention for resolving the conflict.

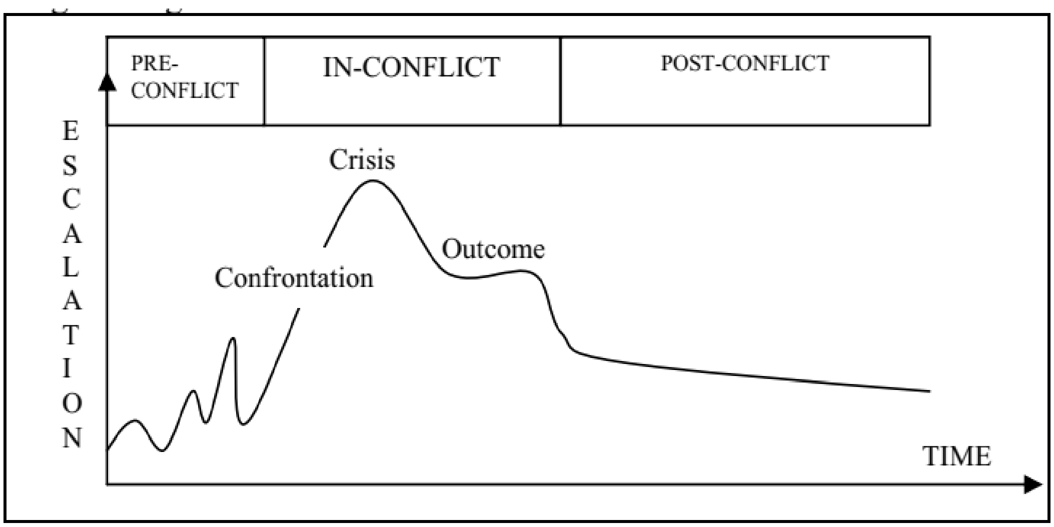

Figure 8: stages of conflict development

Source: Wehrmann (2008),

The pre-conflict phase is the birth of conflict which generally starts with a hidden incompatibility between the goals of two or more actors, which when not tackled, has the potential to lead to an open conflict. Here, conflicting parties try to avoid each other in several ways, such as avoiding any communication, with the view of carrying a message that one is not in agreement with a prevailing circumstance. At the confrontation phase, there had been increase in polarisation between the conflicting parties, and each one will be on the look out for more resources and support to fight the opposing party. At this stage where conflict begin to escalate, there are usually some low levels of open violence. Conflicts reaches crescendo at the crisis phase where tension or violence get out of control at any least confrontation. Opposing parties take advantage of their previous differences to fight with any least opportunity acting as a trigger. Here, intensions of war are openly declared, with each party accusing the other of wrong doing. As characteristic of any conflict, it surges and subsides. Conflicts subsides when parties agree to end it, or when one is defeated. There are times too when a third party comes in to impose a settlement. Since this outcome phase of conflict is still within the in-conflict stage, it will be out of place to think that conflict is totally settled or there is a truce. It will be convenient to however reason that tension has rather decrease. The last phase, the post-conflict is that point where relations between parties normalise. There are however good chances that situations could return to the pre-conflict phase again if the roots of the conflict have not been adequately addressed at the outcome phase.

Theories of Conflict

Every conflict has a theory that try to delve into what might actually be the root causes of it. These theories range from the structural to the human needs theory, political ecology theory, Vasquez's concept of space, Marxist theory, international capitalist theory, realist theory, biological theory, and psychological theory of conflict. The central truth to all these theories are that there are always the haves and have-nots, the strong and the weak, the dominant and the vulnerable, etc. in every society. These divides have always created some form of perpetual struggle. Also basic is the fact that conflict is an integral component in every society since societies are structured by whatever means to produce conflict (Folarin; Oakland, 2005).

While all these theories may be relevant, this study considered reviewing the human needs theory, political ecology theory, and Vasquez's concept of space (in the next chapter) to specifically explain the various ways through which water could be a catalyst for conflict. Also, if a water-related dispute arises out of any of the proximate contexts or causes of conflict, including ineffective or illegitimate governance of water resources, such could be considered as water conflict since any of such contexts "stoke the flames of discontent (grievance)" or even be the trigger (USAID, 2014, p. 5). Thus, both domestic (national) and international armed conflict associated with water as a trigger or bone of contention could be considered under such a definition, rather than violent conflict between individuals over other issues in which water infrastructure was damaged.

The human needs theory

Galtung (2009) held the view that conflict between two parties is as a result of existing contradictions that these two groups held against each other. Contradictions, as explained by the author, formulates unfavourable attitude between both parties of which unfavourable behaviour is eventually generated, resulting in conflict as an outcome for such disagreement. On the other hand, contradictions alone exhibit some form of deficit in explaining what might trigger conflict. A view that one's inability to have his or her needs met has strongly been expressed as a recipe or an incentive enough for conflict (Doucey, 2015). This argument of analysing the causes of conflict is termed as the human needs theory (HNT) which is explained largely as the deprivation (or lack) of individuals and communities' access to the means of satisfying their basic human needs (not necessarily "unavailability" of them) which include freedom, identity, privacy, security and protection, connectedness and affection, subsistence, understanding, participation, and many others (Burton, 1990; Doucey; SubSahara Center Ottawa, n.d.).

The HNT applied by some individuals including Abraham Maslow, John Burton, Marshall Rosenberg and Manfred Max-Neef (Danielsen, 2005) possesses some distinctive characteristic. They are physical (need for food, water or shelter), psychological, social and spiritual, and are universally expressed – everyone is aware of them. Thus, such needs are not transferred to another by a particular culture or implanted on taught by some established institutions. Again, human needs are irrepressible and non-negotiable, demanding satisfaction no matter how a society's regime may seek to suppress or manipulate them. These needs are not hierarchical as anyone of them could be sought all together, and are naturally fulfilled through the community, or through the policies, public goods, and services provided by the state (Marker, 2003). It should however be noted that their satisfactions differ from community to community.

Violence and/or conflict erupts when individuals or groups do not see any other way to meet these needs or some of them are unmet perhaps because the state fails to properly address them, or when they demand understanding, respect and consideration for their needs (Danielsen, 2005; Doucey, 2015). Rosenberg (2001) argues as well that violence is somewhat an awkward expression of unmet human needs. Similarly, the Sub-Saharan Center (n.d), shares that the inability to inadequately satisfy any of the basic human needs naturally will result in economic or political pathology which are manifested as unemployment, under-employment, hyperinflation, and poor quality of life; fear or xenophobia, crime or violence, exile and marginalization.

This catalyst of violence expression with its close association with the "relative deprivation theory", according to Burton (1990) and Danielsen (2005) should be primarily addressed or provided as a bases for averting conflict, possibly by adjusting institutions and social norms to the needs of persons or groups, be it international or political conflicts, and conflict at work place, family, school, etc. (Dronzina, Kuzutbayeva, & Zhekova, 2013).

The usefulness of this theory has been proven due to its wild applicability. Though the tool is originally meant for the prevention of conflict or post-conflict peace building, it has as well been used for violent conflicts mediation by Rosenberg and Chopra (2015) and Rosenberg (2004). It also can be applied in all levels of society, for intra- and inter-personal conflict, inter-group conflict and in an international setting. Another striking relevance of the HNT is its focus on the source of conflict, thus, looking at the most suitable means groups can have their needs met, and those of others. Finally, HNT emphasizes common humanity as it tries to unify human beings from different areas and cultural backgrounds, and ensuring a common understanding of who we are and how others need and feel the same way we do (Danielsen, 2005).

In spite of its usability, the HNT has been harshly criticized on some grounds. First, is what human needs are and are not. This comes amidst the discrepancies that between pundits of need theories including Maslow, Burton, Resenberg and Maz-Neef. If these human needs and their characteristics revealed by these authors are anything to go by, Danielsen (2005) quivers that it would be almost impossible to address human needs in times of conflict. Other drawbacks to the theory are based on a number of questions that require attention. Should certain needs be prioritized over other, as carried by Maslow? How does one know which need is most important, and who decides? How can parties at conflict sit down and talk things through in identifying the need? This question is based on the exaggerated emphasis on dialogue as it is almost impossible in times of violent conflict.

Vasquez's territoriality thesis (the concept of space)

The concept of territory and territoriality has since the first half of the twentieth century, been applied in the circles of political geography (Goemans, 2006). The relevance of it has been long recognized as one of the major concepts in explaining the causes of disputes between states. Some scholars have been able to prove the efficacy of disputes over territory as more likely cause of war than any other types of disputes (Diehl, 1999; Hensel, 1996; Huth, 1996; Senese, 1996; Vasquez, 1995), hence the assertion of Nauwelaers (2012, p.24) will not be out of place to warn against the "…myopic approaches, confined to regional boundaries and overlooking potential cross-border synergies" in conflict resolution analysis. This area of research dwells to a greater extent, on the contributions of Vasquez on his territoriality thesis which introduce some key reasons why territory could be a major trigger on conflicts (Vasquez, 1993).

In the first place, Vasquez is of the view that humans are territorial by nature, and secondly, territory is intertwined with humans' sense of self and group identities, thus, the link between territory and ethno-national identity is very much significant. Thirdly, because territory occupies an important place in humans' fundamental basic needs (identity), having this need threatened makes one very anxious and more prone to respond to these threats with aggression. It is therefore agreeable to reason that humans, according to Vasquez (1995) respond to threats of territoriality most often by the use of 'real politick strategies' or aggressive territorial display (such as marches as it is often used in Northern Ireland each summer) which lead to escalation and war. The author notes that "the existing theoretical understanding about the relationship between territory and war is that all other factors being equal, state or other sovereign groups, like tribes, will use aggressive displays to demark boundaries" (p.144). In such an attempt, any resource that fall within the domain of the group is fiercely protected against any external aggression. It is also interesting to note that conflict could arise over some historic relics of high symbolic values (particularly historic or religious significance) of territories (Hassner, 2003).

Aggressive territorial display in explaining escalation and war is not a hoax, following Diehl's (1999) view that the high value of a territory (containing extremely valuable resource such as gold, oil, fertile soil, water, etc.) must be at the root of the problem since such space would have higher economic stakes. But is it always the case that contested territories are more often than not, areas of high values? This may be a flawed assertion, as in the view of Goemans (2006) who contend that disputed territories are usually relatively worthless as they are reported. For instance, Goemans argues that Eritrea and Ethiopia fought for two years (1998-2000) over nothing but a worthless desert at the expense of more than 70,000 priceless people.

Again, Geomans (2006) draws inspirations from reports by various authors including Martin Pratt (an executive officer at the International Boundaries Research Unit in Durham, England) who purported that "Spain-Morocco rift (over tiny rock-pereji/Leila in the Mediterranean) is just one of many quarrels over tiny bits of land"). In as much as these assertions could be treated with prominence, it cannot by wholly factual as the worth of any resource is determined not by what others see it to be, rather by the views of those who use or intend to use it. It could however be said at this level that people's willingness to protecting a territory, irrespective of the inherent value – of little or no material value, must be determined by themselves, rather than an exterior judgement.

In spite of its usefulness, both the current and future role of this concept is refuted mainly due to the changing historically contingent constellations of space and power, and the transformations that comes with globalization, as well as the disturbances in the international system of states after the Cold War (Agnew, 2005; Kahler & Walter 2006; Paasi 2009). To some scholars, such as Appadurai (1996), Ohmae (1995) and Strange (1996), the world is moving towards a borderless and post-national state due to the power of globalization and the upsurge of all kinds of flows and integrated economies. Thus, states today, in reaction to changing trends in economies, and the hybridist of cultures that have resulted from immigration, displacement of people and the spread of cultural ideas have formed both international and local alliances hence decentralizing part of their powers to 'sub-state regions that are either near or far from its geographical borders or space (Brenner, 2004; Gupta & Feruson, 1997; Paasi). This, according to Brenner has made 'spatiality" a much more complex, than the traditional mechanistic distinction of spatial scales of local, national and global levels a difficult thing to study. To this end, Amin (2004) opposes that bounded space is strictly opposed to both normative and progressive politics. The same offered an explanation to this assertion in 2007 and opined that the concept of bounded space is fused with "regressive and as an 'optical illusion' associated with the power relations embedded in the cartographic legacy of measuring location on the basis of geographical distance and territorial jurisdiction" (Amin, 2007, p.103).

Does this justify the need for the concept of bounded space or territoriality to be abandoned? Pro-border and territoriality scholars disagree, but think that the relevance of the concept, as crucial and dynamic as it is, is situated in the same growing and changing trends of societal power relations. These dynamics are manifested in several ways including high scale state-level activities of the control of immigration, quotas and tariffs (Cox, 2002), as well as lower scale activities of gating communities or green belts inside cities. Again, events after September, 11th in the USA, together with subsequent issues in Iraq, Ossetia and many African states, and the decades-long contest over space in the Middle East, have given impetus to the relevance of the concept of space and territoriality. Thus, post-September 11th have resulted in an increase in surveillance of social communities and the development of new surveillance instruments for national security purpose-protecting what is within the space of state, making a mockery of the utopian images of a borderless world that have been painted by others (Paasi, 2009).

The theory of political ecology

The emergence of global environmental crisis, ozone layer depletion, changes in oceanic currents, desertification, flooding, natural resource depletion, air, water and soil pollution, biodiversity loss and climate change, coupled with the constant interaction with the current phase of globalization (expansion of the capitalist system), underscore the need for political and economic process on local environments (Cole, 2012; Robbins, 2011). It is also clearly stated by Stonich

(1998, p. 28) that political ecology helps "to understand how environmental and political forces interact to affect social and environmental changes through the actions of various social actors at different scales". In other words, political ecology has since the 1980s, been highly resorted to in research in analysing interactions between social and environmental science, especially in economic development of developing countries (Bryant, 1992; Peet & Watts, 1993).

Since the use of the word "ecology" first by the U.S. naturalist, Henry David Thoreau in 1858, to to the time it was given a proper scientific meaning by German biologist Ernst Haeckel in 1866, the word has had multiple meanings and applications in various social and academic disciplines (Little, 2007). From the foundation of "human ecology" which applies the methods of natural ecology to human societies (Hawley, 1950), the scope of its application has widened to include Julian Steward's" cultural ecology"(Steward, 1955), which has also widen in scope to include sub-fields such as ethno ecology (Conklin, 1954), neo-functionalist ecology (Rappaport, 1968) human ecology (Moran, 1990), processual ecology (Bennett, 1993), spiritual ecology (Kinsley, 1995) and political ecology, as first used by Eric Wolf in 1972 (Khan, 2013; Schmink & Wood, 1987). Little explains that this association has been perhaps due to the intensive dialogue between the disciplines of biology (natural ecology), anthropology, geography, history and political science, thus creating a distinctive trans-disciplinary space within the natural and social sciences. The increase in scope of its application on the other hand could also be interpreted to mean ecological science's intensive quick response to the new political and environmental realities encountered by modern societies.

Political ecology emerged in the 1970s when it was first used by Eric Wolf, but flourished in the 1980s or so (Schubert, 2005) as a broad based and fragmented field used as an analytical tool used across disciplines to provide explanations for association between political economy and cultural ecology (Robbins, 2011) by providing trans-discipline frameworks that apply methods of political economy to ecological contexts (Gossling, 2003). Other scholars in the field describes the approach as a masterpiece that brings together human ecology's focus on the kind of interrelations that exist between human societies and their respective biophysical environments as well as political economy's analyses of the structural power relations occurring between these societies (Little, 2007; Stonich, 1993). On the part of Bryant (2001), political ecologists have been interested in how national or global economic or legislative processes impacted local environmental practice, whilst at the same time challenging Malthusian ideas of overpopulation.

According to Robbins (2011), four main narratives in political ecology research abound including issues in degradation and marginalization, environmental conflict, conservation and control, and environmental identity and social movements. In as much as there is some degree of overlap between these central ideas (Cole, 2012), this study is interested in environmental conflict, but does not gross over in focusing on issues of marginalization and conservation and control since in the views of Paulson, Gezon, and Watts (2003), political ecology has everything to do with scramble for access to, and control of resource. This according to Cole, is exactly the case in Bali where there is a struggle over access and control of water resources. Similar studies have been conducted by Crifasi (2002), Molle (2005) and Walsh (2004) to explain this society- water interaction.

The search and use of water for various purposes at different locations, according to Swyngedouw (2009), is a conflict-ridden process and the organization of the flow of water as well, indicates how social power is distributed in a given space – issues of unequal power relations. Thus, political ecology approach is said to trace "the fundamentally socially produced character of inequitable hydro-social configurations" (Crifasi, 2002, p.58) as it focuses on how power and resources are distributed and contested to reveal the underlying interests, incentives and institutions that enable or frustrate change. Cole (2012, p.1226) further stresses that political ecology "provides a bridge from hydrological science that can tell us what is happening to water processes, to the political, social and historical social sciences that provide an understanding of how and why the present situation came about".

Analysis of the mazes of relationships in political ecology will be understood clearly if the structural and actor based approach, as used in political economy analysis is critically explained (Kütting, 2010). This is necessitated due to the fact that different groups of people are involved in these societal environmental complexities. Academics use terms such as stakeholders, interest groups, and actors to refer to these groups of people, even though their meaning largely overlap (Brown, 1998). Specifically, however, Crifasi (2002) suggests that it is rather plausible that priority is given to the use of actor-centered analysis as efficiently utilized by Bryant and Bailey (1997) in *Third World Political Ecology*.

This approach provides some benefits; 1) it reveals both state and non-state actors whose actions results in some environmental consequences, 2) it provides researchers with new insights that are non-existing through the use of traditional policy analysis, 3) the connections and relations between actors offer an opportunity to know the type of action taken by an actor, and what environmental impact the said actor can cause. This therefore suggests that political ecology provides a useful tool for modifying the underlying motivations for particular actions (Crifasi, 2002). In spite of these strengths, political ecology as a methodological guide has been critiqued strongly on the basis that it is "too vague in scope and too eclectic in theory" (Peluso & Watts, 2001, p. 24). Again, regardless of the fact the theory is very popular in explaining conflicts associated with control of resources and protest against governments' environmental policies, and so forth, it is deficient in explaining how politically motivated conflict can also induce any environmental and social change (Bohle & Fünfgeld, 2007).

Conclusively, while all the theories discussed above, namely human needs theory, political ecology theory, and Vasquez's territoriality thesis will be useful in explaining the cause of conflict in a particular milieu, it would be rather necessary to adopt a political ecology approach in the theoretical analysis of conflict and/or cooperation in such a study as this current one (Kloos et al. 2013) since according to Kallis and Zografos (2014), the approach places a much emphasis on winners and losers, as well as the distribution of costs and benefits within Socio-Ecological Systemss and society as a whole.

Conceptual Framework

Analysing the relationship between climate change and (water) conflict is difficult and complex due to the number of variables and the amount of uncertainty involved. Thus, the science of climate change is still relatively new, and analysis of the current and potential effects of climate change on the natural environment is highly politicized and contested. What makes the association further complex is the fact that analysis and predictions of conflict is another complex area of study. Hence, when these two are considered together, the rate of possibilities and uncertainties multiply (Safeworld, 2010). In order to move forward, the relationship between climate change and conflict needs to be presented in an accessible manner, without over-simplifying the issues or the interactions between them. Two frameworks, namely Safeworld's (2010) framework for climate change and conflict analysis and Goulden and Porter's (2010) revised framework (adapted by Climate change, Hydro Conflict and Human Security (CLICO) for understanding water-conflict-security nexus will therefore be reviewed for the purpose of this study.

Safeworld's framework for climate change and conflict analysis

This framework posits that the risk of insecurity or conflict is dependent on the kind of the interactions that exist between the natural consequences of climate change (e.g. drought or flooding) and the social setting of a group of people, be its political, economic and environmental characteristics. These are informed by several context variables that are key determinants of climate change induced conflict at the community level. These are environmental vulnerability, natural resource management, livelihood options, and security and justice mechanisms

(Figure 9). Thus, high levels of environmental vulnerability, combined with collections of social and institutional lapses including poor natural resource management, limited livelihood options, and weak security and justice mechanisms, will increase the risk of conflict emanating from climate change.

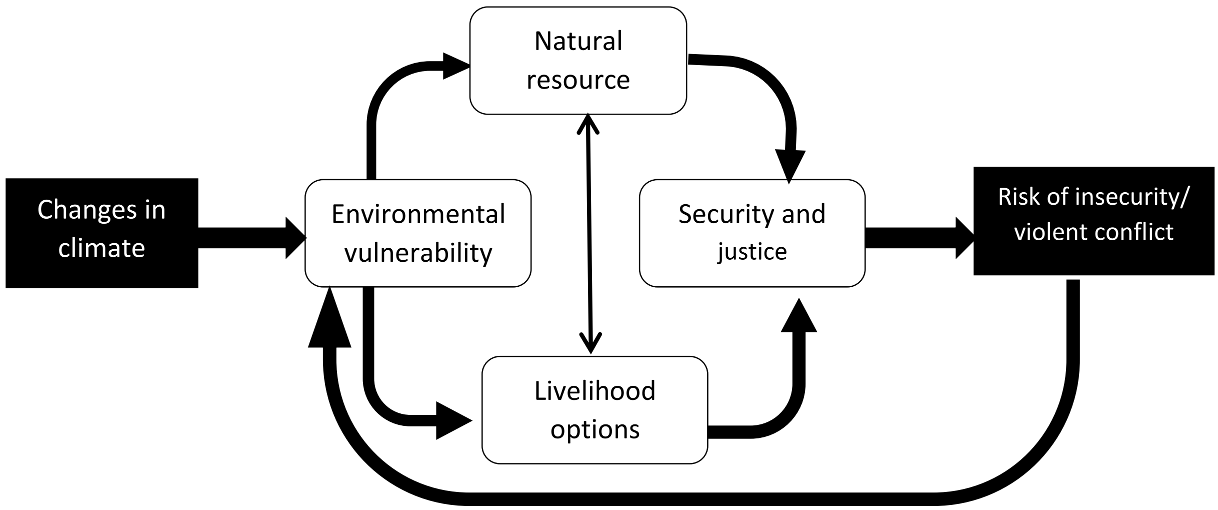

Figure 9: Safeworld's framework for climate and conflict analysis.

Source: Safeworld (2010)

Safeworld (2010) defines vulnerable environment as "the degree to which a system is susceptible to the effects of climate change, including climate variability and extremes of weather, including the extents to which an area is exposed to the effects of climate change by virtue of its geographic location as well as by its topography" (p.6). The impact of climate change upon vulnerable environments will subject such an area to have limited water resources, experience drought condition, soil degradation, etc. This will eventually result in increased pressures on natural resources, which on the other hand could be intervened by two mediation options- 1) natural resources management capacity and livelihood options, and 2) relevant security and justice mechanisms as indicated in Figure 9. Depending upon their responsiveness and effectiveness, these two mediation options may or may not prevent the additional pressures on resources from translating into insecurity or violence.

While it was revealed in northern Kenya (when the framework was applied) that there exists a negative interaction between climate change and conflict, insecurity, according to the framework may also weaken the capacities of societies to adapt strategies to sustain livelihoods, and thus making them more vulnerable to the impacts of climate change. Furthermore, increased conflict will weaken capacities to cope with future climate change at the level of the state as well as the community. Climate change can both exacerbate conflict and limit societies' ability to respond to the phenomenon in the future. This suggests a vicious circle, or downward spiral, whereby climate change increases the risk of conflict, in turn further limiting the capacity t adapt. The strength of this framework lies in the fact that it identifies the negative characteristics that increase the risk of climate change induced conflict. Moreover, it identifies the positives structures and processes that can be consolidated and built upon (Safeworld, 2010). However, in contrast to other frameworks especially the Climate Change, Hydro Conflict and Human Security Framework, human security is not so central to the Climate Change and Conflict Analysis Framework, hence the researcher's option for the former.

Conceptual framework of hydro-climatic change, conflict and human security

Climate change, hydro conflict and human security's (CLICO) framework attempts to bring out "all the relations between hydro-climatic and water-related stressors and human security as well as the determinants of human insecurity such as the economic, political and environmental conditions, to the key concepts of vulnerability and adaptive capacity as well as conflict/cooperation at multiple temporal and spatial scales" (Kloos et al., 2013, p. 35). The framework (in Figure 10) was initiated by Goulden and Porter (2010), and was adapted by Kloos et al. in their CLICO project. Out of the modified framework was derived some questions to shed light on important aspects and relationships, to better understand the water-conflict-security nexus). Comprehensive as it is, the framework is still generic enough to be applied in many cases. Thus, together with the fact that human security is seen as central element to the framework (Goulden & Graininger, 2012; Zografos, Goulden & Kallis, 2014) makes it ideal for this study.

Within the framework, human security elements within socio-ecological systems (SESs) focus on the analysis of linkages between society and the environment (Gunderson & Holling, 2002). The concept of human security of socio-ecological system is the all-encompassing frame embedding hydro insecurity (exposure and vulnerability) and adaptation/adaptive capacity, with conflict and cooperation as their main mediators.

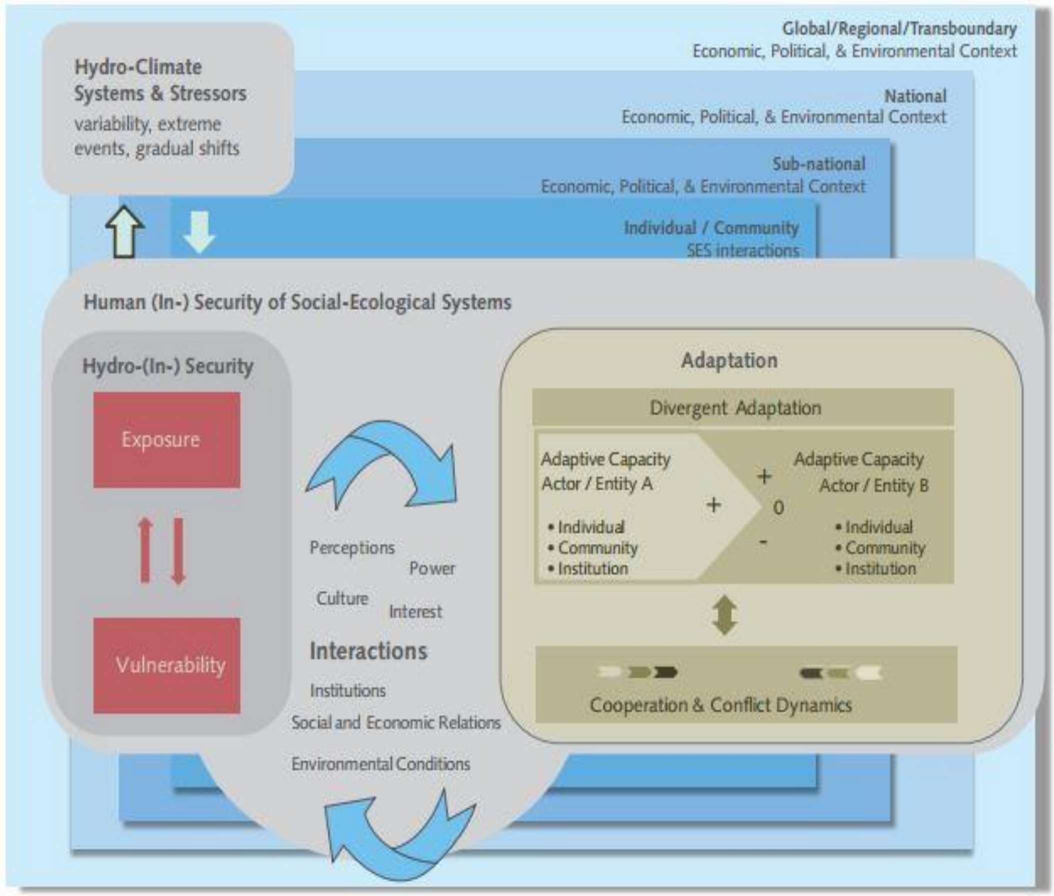

Figure 10: Conceptual framework of Hydro-climate Change, Conflict and Human Security.

Source: Kloos et al. (2013).

According to the framework, hydro-climatic systems and stressors manifest themselves in increasing climatic variability, extreme events and gradual shifts in interaction with socio-ecological dynamics on various scales. These events, over time, will also impact on exposure and vulnerability of a locality to water-related stressors, resulting in hydro-(in) security of actors or entities. The term 'hydro-insecurity' as used here stands for "not only current issues in water availability and supply", but also includes the concept of water vulnerability. This concept is also interpreted to means the extent of weakness or inability of a population to face water-related disasters occurring in combination with poverty, unemployment, human displacement, droughts, and low women's development already prevalent in the region. The concept of vulnerability extends beyond the current situation and includes the aspect of future risks (i.e. weakness in coping with water issues in the future)" (Strategic Foresight Group, 2014).

It therefore behoves on residents of such a locality to adapt to such condition of 'insecurity'. Conflict or cooperation result in actors' or entities' attempt to adapt. However, the socio-ecological systems or interactions such as environmental conditions, social and economic relations, political or institutions, perceptions, culture, power and/or interest interfere in this direct relationship to produce outcome(s) which is (are) largely dependent on the formation of adaptive capacities of various actors or entities of the locality. It is noted from this framework that an adaptation outcome of one actor/entity will have or has an impact on the other.

It is therefore worthy to note that adaptive capacities and respective adaptation outcomes of one actor/entity are often dependent on the adaptive capacities and respective adaptation outcomes of another actor/entity, resulting in a dissimilar set of multiple mutual impacts, referred to by Snorek, Renaud, and Kloos (2014) as "*divergent adaptation*". This type of adaptation is described by Barnett and O'Neill (2010) as "*mal-adaptation*". The term which originates from evolutionary biology was used to describe a situation in Tahoua, Niger, where the adaptation of one group lowers the adaptive capacity and increases the vulnerability of another. Three possible outcome could be produced as a result (sometimes influenced by the state through how its policies and institutions are designed and function) – an increase in adaptive capacities of both actors/entities ("win-win situation", +/+); a decrease in another actor's or entity's adaptive capacity ("win-lose situation", +/-); or a neutral change ("win-no change situation", +/0). The eventual outcome of such interactions is either conflict or cooperation between the actors or ongoing conflicts or cooperation can be amplified or reduced. Particularly, a conflict or an ongoing one may be aggravated if one group is negatively affected by the adaptation outcome of another – 'win-lose situation.

From the framework, the adaptive capacity of the actors or communities that are water-stressed is either going to amplify conflict or ensure cooperation through feedback loops to the communities' vulnerability and exposure to insecurities. And the interaction that will ensue between the communities and the socio-economic and political dynamics that exit will in turn, affect the status of human security in these areas.

This framework therefore becomes useful for this study due to the fact it will serve as a guide to what kind of data to be collected and analysis to be done. First of all, local climate data from the districts will be collected from the Ghana Meteorological Authority to give a clearer picture about how the impact local climate change exposes the locality to water-related stressor. Again, residents will be given the chance, through interviews and focus group discussions, to respond to how water stress condition in their environment impact on their socio-economic activities, as they will be the the most appropriate group of people to construct their own reality of any form of vulnerability they face. Aside this, data will be sought on residents' adaptation strategies put in place in responding to any stress conditions related to water.

As already noted from the framework, the socio-economic environment also is a key factor in adapation. Hence, data on the study communities' socio-economic conditions will be sought from respondents and analyse how those interact with the water-stress conditions to forment conflict or ensure cooperation. Although it will be appropriate to conclude on the human security status of the study communities based on the kind of vulnerabilities they are exposed to resulting from hydro-climatic stressors, giving freedom for residents to remark on what constitute human security to them will be worth doing.

Summary

Conflict has been identified as an inescaple act so long as humans live. It exists whenever there is incompatibility between two or more people or groups in therir attainment of their goals and interest. Individuals and groups fight for various reason, yet access to or control over objects – ideology, power, information, territory, and resources dominate in most literature. Across these reasons, conflict could either be mild, violent, latent, active, implicit, explicit, etc. Understandably, barely will conflict just explode without developing from one point to the other. According to Frère and Wilen (2015), conflicts will have to travels through different stages of escalation until it recedes over time.

Every conflict has a theory that try to explain the reason or the root cause for the act. From the point of view of the human needs theory, conflict is likely once there is the inability for an individual or a group to have some needs met either because the state fails to properly provide those needs or when people demand understanding, respect and consideration for their needs (Danielsen, 2005; Doucey, 2015). It is also established by the Vasquez's territoriality thesis that once humans are territorial by nature, and the fact that territory is intertwined with humans' sense of self and group identities, they (humans) will respond to threats (by way of aggressive display) at moments when their territory is threatened. The political ecology theory points out how national or global economic or legislative processes impacted local environmental practice to contribute to conflict.

In uunderstanding the climate-conflict nexus, two frameworks were reviewed. The first, Safeworld framework for Climate Change and Conflict Analysis states conflict in any region is dependent on the kind of the interactions that exist between the impacts of climate change (e.g. drought or flooding) and the social settings of a group of people, be its political, economic and environmental characteristics. In spite of the level of understanding that this framework brings to bare, it was prudent to resort to the use of Kloos et al.'s (2013) CLICO framework due to the fact that it rightfully showed how conflict or cooperation would result when one's exposure to vulnerabilities emanating change in climatic conditions interacts with the socio-cultural or instutional settings. Again, the fact that human security was central to this framework made it appropriate for the study.

CHAPTER FOUR

METHODOLOGY

Introduction

To gather evidence for an investigation on the effects of climate change on water conflict and human security in the four selected districts of Upper East Region of Ghana, a combination of methods was employed. This chapter presents the epistemology and research design, and the description of the study area. As well, the study population, sampling procedure, sources of data, data collection instruments, ethical considerations, and fielwork procedures are discussed. The chapter ends with a discussion on the trustworthiness of the data collected, fieldwork challenges, and well as how the qualitative and quantitative data collected were analysed.

Epistemology and Research Design

The design for this research was informed by the philosophical assumption that knowledge is generated by exploring and understanding the social environment of the people being studied, and paying in-depth attention to their meaning and interpretations of phenomenon or events around them, rather than direct observation. This philosophical paradigm, according to Crabtree and Miller (1999, p. 10) "recognizes the importance of the subjective human creation of meaning, it does not reject outright, some notion of objectivity". Furthermore, the philosophy attaches greater value to interpretation of events by those affected, without having to pay so much attention to methods used by the natural sciences (Al-Saadi, 2014). It thus carries that meanings are socially constructed by the social actors within a particular context. This method of "understanding and explaining how we know what we know" (epistemology) is termed as constructivism/constructionism or interpretivism (Bryman, 2008; Crotty, 2003, 1998; Ormston, Spencer, Barnard, & Snape, 2014).

To Searle (1995), constructivism is built on the premise of a social construction of reality. It is also "the view that all knowledge and for that matter, all meaningful reality as such is contingent upon human practices, being constructed in and out of interaction between human beings and their world and developed and transmitted within an essentially social context" (Crotty, 2003, p.42). The philosophy is not just considered as the "only legitimate stance for qualitative research" (Greene, 2007), there is also a widely accepted notion among qualitative researchers such as Denzin and Lincoln (1994) and Lincoln and Guba (2000) that "qualitative research itself is grounded in a constructivist or subjectivist epistemology" (Maxwell, 2011, p.10). Indeed, constructionism derives its strength from the close collaboration between the researcher and the participant which allows participants to tell their stories that describe their views of reality, offering the researcher a better understanding of the participants' actions (Crabtree & Miller; Lather, 1992; Robottom & Hart, 1993). Again, since it does not completely reject the notion of the positivist notion (Crabtree & Miller, 1999), it is able to work alongside with it to seek knowledge.

Going by this philosophy and it strengths, case study research design, which according to Stake (1995) and Yin (2003), is constructivist paradigm was employed for this study. Case study, according to Pring (2000), is the study of a unique case or a particular instant. Cohen, Manion and Morrison (2013) emphasises that in case study, one is presented with a unique opportunity to study real people in real situations, and for that matter would be able to appreciate and clearly understand the real situation about the people studied, rather than being presented with abstract theories about them. The design facilitates the exploration of a phenomenon within its context using a variety of data sources and methods, was employed to understand the linkage that exists between climate change and water conflict in the study areas. It is also usefull where the researcher explores a bounded system (a case) or multiples cases over time through detailed, in-depth data collection techniques involving multiple sources of information, including observations, interviews, audiovisual materials, documents and reports, and case-based themes (Creswell, Hanson, Clark-Plano, & Morales, 2007). Case study was used to ensure that issue of water-conflict is not explored through one lens, rather a variety of them to allow for multiple facets of the phenomenon to be well explored, revealed and understood (Baxter & Jack, 2008; Stake, 1995; Yin, 2006, 2003) from the point of view of local residents.

Generally, the adaptability of case study research design to different types of research questions and to different research settings is its advantage (Rose, Spinks, & Canhoto, 2015). Furthermore, case study offers the benefit of studying phenomena in detail and in context, especially in situations where there are many more variables of interest than there are observations (Rose et al.; Schell, 1992). Schell even regards the general characteristics of case study design – queried using 'how' or 'why' questions; the researcher exercising no control; and focus on contemporary, rather than historic information, as one important advantage of the approach. Another strength is borne from the use of numerous sources of evidence, hence allowing for triangulation of findings (Yin, 2009).

This "methodological pluralism" of triangulation or mixed method as applied in case study research allows the use of two or more different research strategies from both quantitative and qualitative fields to study same case so that one's finding is used to complement the other (Coast, Mondain, & Rossier, 2009; Hantrais, 2009; Lor, 2011). Thus, it helps the researcher to look at a situation of a phenomenon from several angles rather than just one direction (Neuman, 2003). This study therefore employed this qualitatively-led mixed method to source for data using multiple sources, techniques and tools such as in-depth interview and focus group discussion guides, temperature and rainfall data from the Ghana Meteorological Authority, and observations due to the advantage it has over the use of single source.

In spite of these significance, critiques of case study and qualitative research and mixed methods in general disdain the approach on several grounds. Generally, critics query that this research endeavor is an inappropriate form of inquiry, perhaps due to the concern over the lack of rigor of case study research. Thus, researchers in this field of inquiry are said to be given too much space or freedom to operate, without any systematic procedures being followed. This allows for ambiguous evidence or bias views to influence the direction of the findings and conclusions. Again, question is raised about using a single case to make any scientific generalization. This is premised from the fact that scientific facts are rarely based on single experiments; rather they are usually grounded on a multiple sets of experiments that have replicated the same phenomenon under different conditions. Where multiple methods are used to source data, the approach is criticized as having or churning out results that are incompactible (Lor, 2011). Lastly, case studies have been criticized for the wide length of time taken to conduct such studies in understanding social realities. This complaint may be justifiable given the way case studies have been done previously (e.g. Feagin, Orum, & Sjoberg, 1991).

Conclusively, in as much as the complaints from critiques do not undermine the credibility of case study as a strategy of conducting any scientific research, especially, qualitative ones. Yin (1984) advices that greater care and skills on the part of the investigator should be ensured to enter into such a difficult venture.

Study Area

Location

The Bawku Area of the Upper East Region is located in the north easternmost corner of Ghana, and share borders with two francophone countries – Burkina Faso and Togo to the north and east respectively. The inclusive districts with their capital towns are Bawku Municipality (Bawku), Bawku West (Zebilla), Binduri (Binduri) and Garu-Tempane (Garu) (Figure 11). It should be emphasized that though Pusiga District belongs to the area, it was not included in this study. Apart from the logistical constraints, it was noticed that the addition of Pusiga District would not have brought any significant difference with regard to data which would have been gathered due to similarities in climatic conditions, common social ancestry and societal set-up.

These districts were established in different time periods. The Bawku Municipality, formerly Bawku East District, was elevated to a municipality status with a Legislative Instrument (L.I) 1798 in 2004, and in 2012, a new L.I., 2144, established the municipality with a new geographical boundary when two districts (Binduri and Pusiga) were carved out from the municipality. It is currently located approximately between latitudes 11o 111 and 100 401 North and longitude 0o 181w and 0o 61 E, and shares boundaries with Pusiga District, Garu-Tempane, Binduri District and Bawku West District to the north, east, west and the south respectively.

On the other hand, Bawku West District was created in 1988 under the L. I. 1442. The district with a total land area of 1070 km^2, covers about 12 percent of the total land area of the Upper East Region. It lies roughly between latitude 10 30 N and 11 10 N, and between longitude 0 20E and 0 35E. The district shares boundaries with Burkina Faso in the north, Binduri District to the east, Talensi-Nabdam District to the west, East Mamprusi District to the south and Garu-Tempane District to the south east.

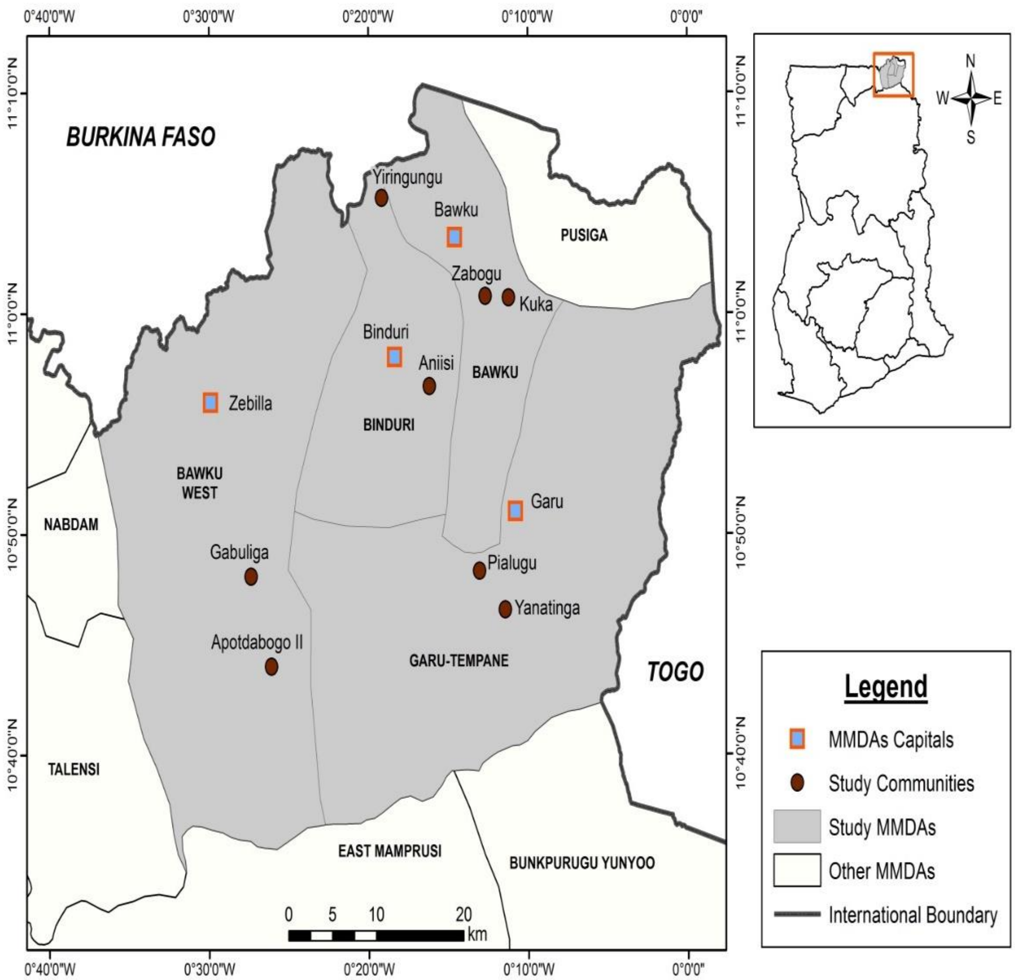

Figure 11: Study areas in regional and national context.

Source: Cartography Unit, Department of Geography and Regional Planning, UCC (2016).

Furthermore, located on approximately between latitudes 11N and longitude 0^0 18^1 W and 0^0 6^1 E, the Binduri District was carved out of the Bawku Municipality and established in 2012 by L.I. 2146. Binduri Distrisct is bordered by Burkina Faso to the north, Bawku Municipality to the east, Bawku West District to the west, and Garu-Tempane District to the south. Lastly, the Garu-Tempane

District was established by L.I. 1769 in 2004. It is located approximately on latitude 10^0 38lN and110N and longitude 0o 06l E and 00 23l E, and covers a total land area of 1230 km^2. It shares boundaries with, Bawku Municipal to the North, Binduri to the North West, Pusiga District to North East, East Mamprusi District to the South West, Bunkpurugu-Yunyoo District to South East, Bawku West District to the West and the Republic of Togo to the East.

Climate

While it is quite cumbersome to relate climate and conflict, it comes with ease to link the phenomenon of climate change to resource scarcity and competition. This is because the three main categories of natural resource scarcity – natural limitations to resource availability; depletion of the natural resource base; and reduced access to the natural resource base are most likely impacted by the varying degrees of climate change (Campbell, 2009). The author continues that the "climatic factors form the basis for categorising land as arid or semi-arid, whereby the limited, unequal and unpredictable distribution of rainfall and the extended periods of drought determine the availability and distribution of pasture and water resources" (p. 18). Hence, there was the need to briefly look at the climate of the study area.

The general climate of the Bawku Area, as with the whole of the Upper East Region, falls within the interior continental climatic zone of the country which is characterized by pronounced dry and wet seasons propelled by two oscillating air masses of North-East Trade Winds and the South-West Monsoon Winds respectively. The dry season, called harmattan, experienced from late November to early March, comes with dry and dusty air mass from the Sahara Desert which results in an entirely no rain within the period. Temperature at this time could reach 42^0C during the day, especially in the month of February, and drops to as low as 18^0C during the night. Relative humidity barely exceeds 20 percent. This season lasts between six to eight months.

On the other hand, the area experiences a uni-modal rainfall regime (wet season) of four to six months from May to October. This condition is brought about by the Tropical Maritime Air Mass which blows from the Atlantic Ocean, and comes with conversion currents, causing torrential, unpredictable and unreliable rainfall averaging 800mm per annum. In spite of the torrential nature of the rains, large quantity of the rain that is poured is lost through evapotranspiration from open surfaces partly due to the bare and dry nature of the ground. With estimated loss of 1.55 to 1.65 cubic metres through evapotranspiration, the availability of water for agriculture and domestic consumption is affected.

Drainage

The White Volta River and its tributaries predominantly drain the Bawku Area, while the Red Volta River is seen around some few areas in the Bawku West District. Other significant rivers including the Tamne River, Pawnaba-Kiyinchongo stream are located in the Garu-Tempane District. The rivers in the area have strong irregular seasonal flow patterns. In the wet season, they flow excessively from June to December with peaks in August and September. Rivers at this time overflow their banks, and flooding becomes common, especially when the Bagri Dam in the neighbouring Burkina Faso is opened. The result in most cases is that, the Bawku

Area becomes inaccessible from the regional capital of Bolgatanga and its environs. The water from the river overflows supports onion, water melon and vegetable cultivation in the dry season.

However, in the dry season, most of these rivers excessively dry up, such that the beds of most of the tributary river and other streams are exposed. This makes it even possible for residents in the area to commute across the White Volta River on foot or by motor bikes around Sapeliga and Burkina Faso border (GSS, 2014). This form of dryness or stress negatively impacts on the livelihoods of residents since they spend most of their time and energy to access water from other sources – boreholes, wells, dams, and dug-outs for their domestic and agricultural needs. And while this (dryness) by itself may not cause violence, other factors such as failure of economic institutions, political instability, history of violent past, etc. may coincide to bring about violent conflict (FDI, 2012).

Vegetation

The vegetation belt of the study region falls within the Sudan Savanna ecological belt where frequent drought and high variability in rainfall and temperature have resulted in the area dominated by fire-swept short grasses interspersed with low-density savanna woodland of short, low branching, thin-leaved, deciduous species that are drought and fire-resistant (Dickson & Benneh, 1988). The grass cover in the area is sparse with severe erosion always exposing the bare land (Menczer & Quaye, 2006). Shea nut, African locust beans (parkia biglobosa) (locally known as dawadawa), baobab, kapok, thorn tree, mango and neem are the most common tree species found in this area, with those areas along the banks of the White Volta River accommodating the forested part of the districts since trees in those sections are protected. Among some of the forest reserves in the Bawku Area are the Denugu, Siisi, Kpatua, Nakinting, Kariyata, Wakpesi, Karateshie, Tarivargo, Morago West and Kuka forest reserves. The grass areas have common species such as Andropogan gayanus (Northern Gamber Grass) in the less eroded areas and *Hyparhenia spp, Aristida spp, and Heteropogon spp*. (Spear grass) in the severely eroded areas. These trees and grasses in the region highly support residents' livelihoods by boosting crop production and livestock rearing.

Apart from the climatic condition which makes the vegetation in the area susceptible to bushfire, human activities also greatly cause degradation of the environment. Some of these human activities include clearing the land for farming, fuel wood extraction, overgrazing, indiscriminate annual bushfires, harvesting of poles for construction, and illegal mining. These activities have serious implications on soil fertility for sustainable crop production.

Population

With a total population of 384,151, the four study districts make up about 36.7 percent of the regional figure of 1,046,545, (GSS, 2012; 2014). Like the national situation, close to 60 percent of the population of the four districts are females, with sex ratio hovering around 90 percent – 92.5 percent. Greater proportion of the districts' population are youthful, representing about 50 percent, followed by those within the age bracket of 0-14 years who constitute about 41 percent of the total population. This means a lot to the active population (15-64 years) since those in the other brackets depend on them for their livelihoods. The average household size for the districts is about 6.5, with children constituting greater portion (about 58.5%) of this figure. With the exception of the Bawku Municipality which has an urban population of 63.6 percent, the remaining three districts are largely rural (over 95%).

Close to 60 percent of the 11 years and above population in the districts is non-literate, with males forming the majority (about 53.2%) of the few literate population (averaging 43%). Quite a significant number of the literate population is able to express themselves in English Language and other local languages such as Kusale. This gives an indication that Kussasis of the Mole Dagbani group are the predominant ethnic group in the Bawku Area of Ghana. Other ethnic groups that co-exist with the Kussasis are the Mamprusis, Moshies, Bimobas, Bisas, Busangas, Frafras, and Fulanis. All these diverse ethnic groups join the Kussasis to celebrate the most distinct festival in the district, *Samanpid*, a post-harvest festival, meant to give thanks to God for a successful harvest season. There are other festivals such as *Yong* for the Kussasis, *Ziisar* of the Kusasis and Bimobas, *Zekula* for Bissas, and the *Danjuar* festival of the Bimobas. Aside thanking God for successful harvest season, these festivals are also meant to serve as period for reconciliation and stocktaking for the people. The dominant religions are Islam, Christianity (especially Catholic) and Traditional African Religion.

The districts are engaged in three main economic activities including agriculture, forestry and fishing; wholesale and retail, and manufacturing. Yet, the predominantly rural districts have subsistence agriculture as the main economic sector. Farmers here are engaged in the production of both cash and food crops, and rearing of livestock and fowl. The major food crops grown are millet, sorghum, maize, rice, sweet potato, groundnuts, leafy vegetables, and pepper. Water melon, onion and tomatoes which are cultivated in the dry season are the popular cash crops. Examples of livestock reared in the districts are cattle, sheep, goats, donkeys, and pigs. Poultry, especially guinea fowl production, is quite significant. The agricultural practices in the districts are extremely labour intensive and nature-dependent, especially with strict reliance on nature for rain.

Target Population

Jaeger (1988) defines target population as "the group of persons, objects or institutions that define the objects of the investigation". Hence, some individuals and institutions were targeted for this study. They included community leaders, principally chiefs, elders or opinion leaders, community residents who were mainly farmers and were above the age of 18 years of age, district agricultural (extension) officers, officials from Ghana Irrigation Development Authority (GIDA), Ghana Police Service, Water Resource Commission, Environmental Protection Agency and security analysts from the Kofi Annan International Peacekeeping Training Center (KAIPTC).

Views were solicited from all these individuals and representatives of institutions because of their knowledge on the issues under investigation, either in the study communities or beyond. Thus, while opinion leaders and residents threw light on the climate, water and security situation in their various communities, officials from GIDA and the agricultural agency focused largely on the provision of alternative sources of water for dry season farming activities. The security service and analysts also gave their perspectives, especially on the security and human right implications of hydro-climatic events in the area.

Sample size and sampling procedure

Sample size is often misconstrued in qualitative research. This is premised from "a common misconception about sampling in qualitative research that numbers are unimportant in ensuring the adequacy of a sampling strategy" (Sandelowski, 1995, p. 179). Yet, Onwuegbuzie and Leech (2005b) argue that it is relevant to consider the choice of sample size in any qualitative enquiry. Perhaps, based on the arguments raised, some qualitative research methodologists have come out with some general rules for sample size of interviews (Subramanian & Peslak, 2010). Though these rules persist, it is not a "one-size-fit-all" situation since variations exist among methodologies (Marshall, Cardon, Poddar, & Fontenot, 2013). According to Creswell (2007), Denzin and Lincoln (2005), and Morse (2000), one's study design, be it phenomenology, grounded theory, ethnography, and case study, will determine the appropriate sample size for a study.

With respect to case study, regarded as one of the most difficult types of qualitative research, Yin (2009) recommended at least six sources of evidence, while Creswell (2007) advices researchers to choose between 4 or 5 cases with 3 to 5 interviewees per case study. However, Onwuegbuzie and Leech (2007) have warned that problems arise when qualitative investigators do concern themselves with number ranges for appropriate sample size. The authors feared such investigations will fail to explain the purpose for their investigation. On one hand, according to Onwuegbuzie and Leech (2007), makes it easy to extract thick and rich data. On the other hand, the researcher did not fall on too small number, to prevent making it difficult to achieve data saturation (Flick, 1998; Morse, 1995; Sandelowski, 1995), theoretical saturation (Strauss & Corbin, 1990), even or informational redundancy (Lincoln & Guba, 1985).

In this regard, a total of 187 respondents (comprising of 15 in-depth interviewees and 169 focus group discussants who participated in 16 FGDs) participated in this study, until saturation was reached. Saturation occurs when the researcher gathers data to the point of diminishing returns, and when nothing new is being added. Thus, it entails bringing on board, new research participants continually into the study until the data set is complete, as indicated by data replication or redundancy (Bowen, 2008; Miles & Huberman, 1994; Ritchie, Lewis, & Elam, 2003). Hence, from this study, as data collected from respondents were coded into themes, it got to a point where responses of any new respondent (especially, the focus group discussants) did not necessarily add anything new to the overall story, model, theory or framework. Again, saturation was easily known to be achieved due to the homogeneity of the respondents. Thus, greater number of the respondents were (either IDI or FGD) local farmers who continued to give similar responses on issues raised for discussion. Furthermore, since statements about incidence and prevalence are not of concern in qualitative research, the total number of respondents for this study was deemed fit (Ritchie et al.).

In the first place, a simple random sampling technique was used to select the commnunities studied. Thus, by simply basing on Ohlsson's (2000) Social Water Stress Index and the Agricultural Water Poverty Index (Forouzani & Karami, 2010), some communities in the study district were considered by the district agriculture offices and the Upper East Regional Regional Office of the Ghana Irrigation Developemnt Authority to be greatly affected by water scarcity phenomenon. All of such communities were listed for each of the four selected districts, and two communities each were randomly selected for the study.

Respondents for this study were purposively selected to discuss issues reflecting climate change, conflicts built around water sources, ownership, utilization and management of it, and human security issues. The purposive sampling is a non-probability sampling technique which deliberately chooses an informant with some peculiar qualities. The technique does not necessarily need any underlying theories or a set number of informants, giving the researcher the urge to decide what needs to be known and the kind of people who can and are willing to share their information by virtue of knowledge or experience (Bernard 2002; Lewis & Sheppard, 2006). Aside this nature of the technique that makes it appropriate for this study, the approach has been used for similar studies by some researchers such as Asamoah (2014), Audu (2013), Awen-Naam, (2011), Facius (2008), Noagah (2013), etc. to investigate water scarcity and conflict, climate change perception and adaptation among farmers in developing worlds, conflict analysis, and several others.

Since they met the criteria or purpose of the study (as in purposive sampling), some respondents were sampled for the IDIs. They included opinion leaders from the eight (8) study communities, security officer (Ghana Police Service), security analyst, district agricultural officers, and an officer from the Ghana Irrigation Development Authority in the Upper East Region. These respondents shared their views based on their lived experiences (in the communities), and the information they had about the communities and/or the topic under discussion. Thus, the issues for discussion with these key informants bothered on the climate situation in the communities, water (availability and accessibility), conflict and human security of the Bawku Area.

In addition to these respondents, FGD technique was used to source information from some residents of the selected communities. These were male and female adults (18 years old and above) who have resided in the communities for considerable number of years, (i.e. at least five years), and have experienced various climatic phases. These people, as well, also engaged in at least one economic activity – such as farming, petty trading, etc. in the community as at the time of the study. Directly or indirectly, extreme climatic events affected the kind of economic activities they engaged in or their livelihood in general.

Therefore, after observing all the protocols with the opinion leaders of the various communities, announcements were made for residents to gather at a chosen location on appointed dates for discussion. When present, those residents who got to the venue first, and were willing (volunteer sampling) to take part in the study, were selected. Though volunteer sampling is often seen as having a quantitative origin, Davis and Gallardo (n.d.) agree that it can conveniently be used in qualitative studies as well. In all the study communities, this approach was used to select a minimum of 10, and a maximum of 12 discussants for both male and female discussion groups.

Data collection instruments

This study employed the use of several instruments to collect both primary and secondary data for analysis. The instruments used to solicit primary data included in-depth interview guide, focus group discussion guide and observation checklist. Based on the objectives for the study, and conceptual framework adapted, IDI and FGD (Apendices A, B and C) were designed and presented in ten (10) sections. The first two sections, "A" and "B", emphasized respectively, the identity of the data (date of data collection, name of district and community, etc.) and the demographic characteristics of respondents. The rest of the sections, "C" to "J" respectively dwelt on respondents' knowledge about climate change; climate change versus availability and access to water; impacts of water-related hazards; aadaptation to water-related hazards; water-related hazards and conflicts or corporation; social, economic and political factors to conflict or corporation; human security situation; and policy and institutional framework for climate-related water conflict resolution.

These sections also run through all the instruments developed for FGDs and IDIs. There was no major difference between the instrument used for the FGDs and the IDIs which were used to collect data from community residents, and key informants and public officials respectively. It was to ensure that respondents, especially, public official respond to issues to either confirm or reject assertion or views raised by those at the communities.

The other primary sources of data were gathered with the help of Tremble GPS device to collect data on the various water sources in the study communities. Also, some observations were made in the study communities. Thus, a list of the various water sources was made, where GPS coordinates were taken. Other observations were made with the help of camera to take some still photos of some phenomenon in the study communities, including vegetable farms, food storage facilities, and seeral others.

To verify respondents' description of phenomenon in the communities studied, observation checklist (Apendix D) was designed to solicit information on water sources and facilities available in the communities. Specifically, it sought to find out the availability and quantity of dams, mechanized boreholes, standpipes, hand-dug wells, etc. It was also to provide information on the availability of irrigation facilities which residents relied on for their farming activities, especially in the dry season. Lastly, since the presence of these amenities have some bearing on security, the checklist sought to find out wheather for instance, there were security or police post in or around the communities. In all, 'Yes' and 'No', and 'Quantity' columns were created in the checklist to help in the identification

Secondary data which was mainly sourced from the Ghana Meteorological Agency. From this source, temperature and rainfall data were collected from three weather stations at Binduri, Garu and Manga in the Upper East Region of Ghana.

This data was collected and analyse to compliment and/or compare and contrast respondents' view on the climatic situation in the study communities over some forty-year period from 1976 to 2015.

The selection of multiple sources, according to Yin (2003), represents replication logic, where additional participants are chosen for discussion because they are expected to offer similar data or different but predictable findings. This, according to Stake (2000), is referred to as collective case studies: "study [of] a number of cases in order to investigate a phenomenon, population, or general condition…[who] are chosen because it is believed that understanding them will lead to better understanding, perhaps better theorizing, about a still larger collection of cases" (p. 437).

Pre-test of research instruments

After being certain on the research topic, questions, the techniques and methods to be applied, the researcher scheduled for pre-testing of the instruments for the data collection. The pre-test, as described by Baker (1994), Polit, Beck, and Hungler (2001), and Van Teijlingen and Hundley (2001), the mini-version of a full-scale study or a trial version of the main project which is used to test whether the components of the main study can all work together.

The main motivation of this phase of the research process is its ability to give advance warning about where the main research project could fail, where research protocols may not be followed, or whether proposed methods or instruments are inappropriate or too complicated (Van Teijlingen & Hundley, 2001,

p. 1). In other words, it helps the researcher to: test research methods (Kim, 2011); forestall some of the challenges to be faced (Arain, Campbell, Cooper, & Lancaster, 2010); understand resource implications of the method used (Van Teijlingen & Hundley, 2001); and estimate study parameters (NETSCC, 2014).

Hence, a pre-testing of the instruments was conducted in Zontrokuom, a farming community in the Garu-Tempane District in December 9, 2015. The chosen community bore similar characteristics as those of the study areas, hence its selection. Results from the pre-testing helped in making some relevant changes to the instruments, including some in the sections on social, economic and political factors to conflict or cooperation, and the human security situation in the communities. Again, it became apparent from the pre-testing of the instruments that communication was going to be a problem. This was noticed because the researcher used an interpreter who could barely understand the questions, but tried "anyhow" to respondents, and on the other hand struggled to interpret respondents' views to me in English Language. I was therefore informed to get research assistants who understood the dominant language of Kusale, and were well versed in the subject of study. These lessons enhanced the actual data collection process in terms of communication, and hence the quality of data collected.

Ethical considerations

Various ethical issues were considered before, during and after the data collection exercises. First, ethical clearance was taken from the Institutional Review Board of the University of Cape Coast. This initial ethics approval was applied, with the intent and procedure for the study well explained. All necessary documents were provided to the board for their perusal in order to grant the permission to undertake the study. Again, the researcher made efforts to inform the board on any modification to the strategies that were adopted to recruit and even gather data from respondent. It was necessary that such was done for obvious reasons, including the open and flexible nature of qualitative collection, and more particularly in case study research.

The first point of entry into a community was to see an assemblyperson or a unit committee member (where the assemblyman was not available) of the community, who in turn sent me (and research assistants) to the chief of the community. Our purpose of being in the communities was explained, and then those (both males and females) with knowledge and experience on the subject of discussion were consulted and purposively sampled or recruited for IDIs and FGDs. It should be noted that these exercises were done a day or two before the actual dates for data collection in each community. On another level, as in any sensitive issue such as conflict, the researcher had to ensure that participation was voluntary, and that respondents were given the option to withdraw at any point in the data collection process, while their confidentiality was assured. All responses were anonymized before analysis, and a particular care was taken not to reveal any respondent or any identifying details such as names, places, ethnicity, religious practices, etc. In the opinions of Leary (2001) and Sarantakos (2005), this assurance given to research respondents offer them with the confidence of participation.

Data Collection/fieldwork Procedures

Focus group discussions and in-depth interviews at the study communities commenced on 10th February, 2016. By 24th February, 2016, all, but data collected from the security analyst and Ghana Meteorological Agency, had been sourced. Data was collected from the security analyst on the 22nd August, 2016, while rainfall and temperature data (1961-2015) from three weather stations in the UER – Manga, Garu and Binduri, was sourced on the 7th November, 2016. This section therefore discusses how data were collected using IDIs, FGDs, GPS device, and observation. Also, rainfall and temperature data collected from the Ghana Meteorological Agency office were discussed.

In-depth interviews (IDI's)

In-depth interviews were employed to source opinions from some key informants, including community opinion leaders, district agriculture officers. Most of the data collections were done during the latter part of the mornings (around 10:00 AM to 11:30 AM), with few of them in the afternoons. Interviews were conducted in various locations – community center, chief's house or in an open (often under a tree), respondents' offices, and via phone. Responses were tape or audio recorded. Other observations, including facial expressions, and gestures, were however written in a field notebook.

Due to their fluency in the English Language, I interviewed these respondents on their opinions on climate change, water availability and accessibility, conflict and human security issues which were mostly specific to the study communities. Interviews with opinion leaders who were not fluent in either

English or Akan languages were conducted by a research assistant. The duration for the interviews lasted between a minimum of 28 minutes and a maximum of 65 minutes.

Focus group discussions (FGD)

Two FGDs each (one for male and female groups) were conducted in all communities visited. Assisted by research assistants, discussions were held concurrently in each community, while I also observed and took notes in my field notebook. Discussions were held at identified convenient locations within the communities – community centers, chief's house or under trees. Of course, Kusale Language was used for all the discussions which focused on respondents' lived experiences on the climate, water, conflict, and human security situations in the communities. On the average, discussions were done between 30 and 85 minutes.

Water source data

Tremble, a GPS device, was used to map out various water sources in the study communities. The device was used to collect point data of dams, mechanised boreholes, and hand-dug wells to ascertain the availability of the water resources, and even how accessible they are to residents. Moreover, the exact locations of communities, and some dry season farms (largely, onion plantations) were mapped with the help of the device.

Temperature and rainfall data

Data for the assessment of the extent of climate change (and variability) in the study districts were sourced from the Ghana Meteorological Agency (GMet) for analysis. Thus, rainfall and temperature data were sourced from three stations within the Bawku Area – the Manga (at Bawku Municipality), Garu (Garu-Tempane District) and Binduri weather stations.

Data Trustworthiness

Trustworthiness of qualitative research is criticized by many. The concept is seen as more obscure since qualitative researchers do not use instruments with established metrics about validity and reliability. Thus, it is indicated that concepts of validity and reliability cannot be addressed in the same way in naturalistic work (Shenton, 2004). Yet, it was relevant to address this issues by incorporating measures that have been prescribed by Pitts (1994) and Silverman (2001), that a qualitative investigator's study findings should be credible, transferable, dependable and confirmable.

Credibility

Credibility was ensured with the involvement of wide range of key informants whose responses acted as a check on assertions or previous information shared. This form of triangulation involved the use of different methods, including IDIs, FGDs, GPS data, climatic data from GMet, observations, and content analysis of different documents to compensate for their individual respondents' limitations. As indicated by Brewer and Hunter (1989), Guba and Lincoln (1994), and Shenton (2004), the method served as a *back-up* or supporting evidence which provided extra data to explaining the background of the respondents and the phenomenon under study**.**

Furthermore, the sampling procedures was deemed fit to ensure credibility. Though purposive sampling dominated the procedure for selection, the accidental and voluntary nature, according to Shenton (2004), negate any form of researcher's bias in the selection of respondents. On the part of Preece (1994), the accidental and/or random nature of the sampling aides to ensure that any "unknown influences" are distributed evenly within the sample. All the respondents were given the free-will to opt out of the discussions or interviews at any time they deemed fit, to ensure that respondents were only people who genuinely offered to take part in the study.

In addition, Shenton (2004) advices that since there could be elements of lies and exaggerations, there is the need for conscious efforts of mitigation. The author suggested the use of probing to source for detailed data. This approach was employed in the designing of the data collection instruments, and during the fieldwork. Lastly, one key criteria observed, was the researcher's ability to relate its findings to volumes of existing body of knowledge in the subject of inquiry, which according to Silverman (2001), is imperative for evaluating works of qualitative inquiry.

Transferability

The prospect of transferability could not be rejected in this study since the findings, though are unique and specific to the study communities, are a reflection of the broader group. One other means of ensuring transferability was to give a thick and detailed description or sufficient contextual information about the subject of inquiry and fieldwork site for future researchers to follow to attain a similar outcome (Firestone, 1993; Lincoln & Guba, 1985). That is the reason for the authors' submission that this is the only responsibility of the researcher, and not to make transferability inferences.

Again, Cole and Gardner (1979), Marchionini and Teague (1987) and Pitts (1994) prescribed that a full description of the type of people who contributed data; the number of study participants; the data collection methods employed; the number and length of the data collection sessions; and the time period over which the data was collected, should be provided. The recommendation of the authors has been carried in this study with the details provided in the statement of the problem, and the methodology adopted for this study. It is expected that once these steps were followed and applied within a broader context or other similar situation, similar outcomes should be realized. "Even when different investigations offer results that are not entirely consistent with one another, this does not, of course, necessarily imply that one or more is untrustworthy. It may be that they simply reflect multiple realities" (Shenton, 2004, p. 71).

Dependability

To some extent, credibility and dependability go hand-in-hand, in the sense that in trying to satisfy the former, the latter is achieved (Lincoln & Guba, 1985). In other words, dependability is the extent to which one's study could be repeated by other researchers and achieving results that are consistent with the former. The use of multiple means of data collection such as the FGDs and IDIs or triangulation could lead one to ensuring dependability (Shenton, 2004). It is also marked as relevant for the researcher to resort to 'inquiry audit', where supervisors review and examine the research process and the data analysis in order to ensure that the findings are consistent and could be repeated (Statistics Solution, n.d.). Therefore, by virtue of ensuring credibility, and this study having been supervised by competent assessors, dependability is seen to be realized.

Confirmability

In spite of the difficulty in reducing or eliminating investigator bias (Patton, 1990), frantic efforts were made to ensure confirmability, which is the degree of neutrality of the researcher in the study's findings and analysis (Shenton, 2004; Statistics Solution, n.d.). These efforts included the provision of detailed description of the methodologies used for the study, and again, as recommended, employing triangulation as a methodological approach especially in the data collection phase of the study (Shenton).

Fieldwork challenges

In all, there was no major problem encountered in collecting data at the community level, aside having to deal with travelling long distances from one community to the other with motor bikes. At the institutional level were some minor challenges. Thus, with the exception of the Bawku Municipality, the researcher was unable to get rainfall and temperature data for the other districts. I was however able to surmount this challenge by getting such data from the head office of the Ghana Meteorological Agency in Accra.

Data processing and analysis

Generally, there are no strict laid down rules agreed on for the analysis of case study results, rather an ideal case study analysis is recommended to follow some principles, including the fact that the analysis will have to make use of all of the relevant evidence gathered, and the analysis considers all of the key conflicting interpretations, and exploring each of them in turn. Others are that the analysis should address the most substantial aspect of the case study, and that the researcher should rely on his/her unbiased and objective previous expertise for the analysis (Rowley, 2002). Hence, after data were collected, analysis was done based on the examination and categorization of evidence into themes, to assess whether the findings support or reject the initial propositions of the study that encapsulate the objectives of the research.

After data were collected, the research assistants recruited had to transcribe the information from Kusale Language to English Language for me to have first-hand knowledge about respondents' responses. Those IDIs conducted in English Language were promptly transcribed. After the transcription, the researcher manually went through all the data to familiarize myself with it and edit for clarity, so as to be able to do the coding according to themes that were in line with the objectives and research questions for the study. The coding was done using NVIVO 11.

Regarding the secondary data, time-series and variability of rainfall and temperature data from three meteorological stations analysed for the period from 1976 to 2015. This Highly dependable forty-year period climate data were credible for its consistency, accuracy and reliability. Data were collected from these stations on daily basis for both rainfall and temperature after which they were calculated on monthly, annual and seasonal bases using excel spreadsheet. This generated 480 months of data or 40 years of annual data from the three meteorological stations.

Softwares used for the data analysis were XLSTAT, Microsoft Excel and SPSS packages. Frequencies, means and Standard Deviations and percentages were first used to describe the data in both tabular and graphical presentations. Homogeneity test was carried out to test for homogeneity and suitability of data for trend testing using the Standard Normal Homogeneity Test (SNHT), the Buishand Range Test and the Pettitt Test (Alexandersson, 1986). These three tests had similar null hypothesis which states that data is homogenously identical.

Moreover, to determine statistical significance of existence of trend, the Mann-Kendall (MK) trend test was applied in this analysis to the annual rainfall and temperature values to find trends in the data. This is a monotonic non parametric test which is widely used for trend testing in climate data (Karpouzos, Kavalieratau, & Babajimopoulos, 2010). A positive and negative MK test results signify an increasing and decreasing trend in dataset respectively and this was supported by the Sen's Slope Estimator test. The MK was adopted because of its robustness and generally acceptability and consequent application in many climate analysis (Keredin, Annisa, Surendra, & Solomon, 2013). Lastly, One-Way ANOVA post hoc test of multiple comparison was applied to test for differences in means of the temperature and rainfall data. This was done by grouping the 40-year data into four groups of 10 decades, each to ascertain if there were any differences in means of rainfall and temperature during the past 40 years. This was to identify which decade actually was responsible for the trends detected in the data.

Mann-Kendall Trend test

Analysing a non-normally distributed trend data required the Mann-Kendall test analysis. The test which aims to find whether the values of 'y' are increasing or decreasing over the set time period is termed as a nonparametric monotonic trend regression analysis. The test compared the differences of the currently measured values and previously measured values. The assumptions were that the Mann-Kendall test assumes a value of 'less than', 'greater than' or 'equal to' another value; independence of data; and constant distribution of data (Helsel & Hirsch, 1992). Mann-Kendall test statistics is easy and more dependable in trend testing in that the test statistics will be the same for either raw or log-transformed data hence, the Mann-Kendall test is applied in many situations (Meals, Spooner, Dressing, & Harcum, 2011).

In calculating the Mann-Kendall test, the differences between the current and previous values of your data (y_j-y_i) were found, where j > i. In correspondence order, 1, 0 or -1 were assigned to imply a positive, zero or no, and negative differences. The formula for the trend test (S) is given as

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sign}(y_j - y_i)$$

Where sign (yj-yi), is equal to +1, 0, or -1 as indicated above.

In cases where S is a large positive number, then the result suggests that there is an increasing trend, and where S is a large negative number, it implies a declining trend and when the value of S is small it means there is no trend. The test statistic (τ) is given as:

$$\tau = \frac{S}{n(n - 1)/2}$$

The range of τ is –1 to +1 which is equivalent to the correlation coefficient in regression analysis. Null hypothesis is rejected if S and τ are significantly different from zero whereas the null hypothesis is accepted when S and τ are similar to zero. Where there is a significant trend, the rate of change is calculated with the Sen's slope estimator with the formula (Helsel & Hirsch, 1992):

$${}^{1}\beta = \left(\frac{yj - yi}{xj - xi} \right)$$

Where, β = slope between data points y_j and x_i, y_j = data at time j, xi = data at time i; and j = time after i. A positive value of β means an 'increasing trend'; and a negative value means a 'declining trend'

Summary

Epistemologically, constructionism or interpretivism philosophy underpins this study. The philosopy opines that reality of a phenomenon is well presented when constructed by the group of people who are faced with the phenomenon. This knowledge guided the selection of case study design, a qualitative research technique to investigate the reality or otherwise of the hydro-climatic conflict or cooperation phenomenon in the Bawku Area of the Upper East Region of Ghana. Informed by the approached used, I used in-depth interview and focus group discussion guides to source for information from varied respondents (local residents who were largely farmers, opinion leaders, security agencies, agricultural experts, criminologists, and several others). Largely, these respondents were purposively sampled based on their knowledge and lived experiences concerning the subject under investigation. Data was collected mainly in Kusale and English languages between the months on February and July, 2016 with the help of two research assistants recruited for the exercise. Qualitative data which were collected were transcribed and analysed with the help of NVIVo software. The rainfall and temperature data (1976 to 2015) from three meteorological stations sourced from the Ghana Meteorological Agency were also analysed using XLSTAT, Microsoft Excel and SPSS packages.

A number of problems were encountered on and out of the field, though these did not mar the quality of data collected, and analysis made. Among the challenges included the fact that the study could not cover Pusiga District as part of the Bawku Area districts. This was due largely to cost implication of such a venture. Yet the fact that four out of the five districts were captured in the study gives a general impression for all other uncovered areas. Also, the fact that I could not directly communicate with majority local residents due to language gap was worrisome. However, the two research assistants who had had in-depth knowledge about the content of the study were able to conduct interview and focus group discussions in Kusale Language. Lastly on the field, the distances apart from one community to the other could not pose much challenge to the study since I, together with the research assistants relied greatly on motor bikes, the predominant means of transportation, to commute from place to place. Out of the field, transcribing the data from Kusale Language to English Language for me was time-consuming. Yet I was able to have access to the entire transcripts before the close of July for analysis.

CHAPTER FIVE

METEOROLOGICAL EVIDENCE AND RESIDENTS' PERCEPTION OF HYDRO-CLIMATIC EVENTS

Introduction

This chapter presents climatic events as evidenced in the study communities. Thus, time series analysis of both rainfall and temperature data have been analysed to show the climatic patterns in the selected communities studied a 40-year period, from 1976-2015. Generally, this was done to substantiate the perceptions of residents on temperature and rainfall patterns in the communities, which forms another section of this chapter. Specifically, residents' perceptions on rainfall and temperature were explored as a conduit to assessing their views of climate change. These residents' perceptions of climate change are compared with analysis of the meteorological data for the study districts, even though in most cases, the two do not always match since according to Ovuka and Lindqvist (2000) farmers and scientist observe, measure and analyse especially, rainfall in different ways. The chapter however starts with the presentation of the socio-demographic characteristics of the respondents.

Background Characteristics of Respondents

A total of 187 individuals participated in this study, with majority (104) of them being males. Fifteen respondent out of the total 187 participated in 15 in-depth interviews, while the remaining 169 respondents were involved in sixteen focus group discussions. The majority of interviewees and focus group discussants were Kusaasis, the dominant ethnic group in the area. The data also revealed respondents with similar socio-demographic characteristics. For instance, 137 of the respondents from the communities were Muslims, with very few, 21 and 18 belonging to the Christian and Traditional religions respectively. Other characteristics among respondents include the age, education, occupation and profession or position, and are briefly discussed below.

A total of 114 of the respondents belonged to the active working age category of 18-45 years. They are the economically active group in the communities with the responsibility of working to feed their dependents. On the other hand, the remaining 73 of the respondents belonged to the other age category, 46 years and above. The involvement of thes age brackets was relevant to the study as they were able to offer past and current information on climatic events of their communities over the 40-year period.

In terms of educational attainment of respondents in the study communities, several of them (146) of them had no formal education, with only 31 having primary and secondary school education. Males formed the majority (24) of those who have had some level of formal education. A simple reason that may account for this is gender stereotyping and early marriage (mainly age group 20-24 years) (GSS, 2014) in the northern parts of the country. With respect to their occupation, farming was found to be the major economic activity for all respondents. Aside farming, 56 of the femal respondents or participants were engaged in other economic activities to supplement their household's livelihoods. These activities included 'pito' brewing, rice pebbling, shea butter extraction, sale of cow dungs and firewood, dress making and hair dressing. This finding corroborated the official statistics of Ghana Statistical Service's 2010 Population and Housing Census (2014) that the above mentioned economic activities are undertaken by women in the region to support their livelihoods.

With the civil and public servants interviewed, all seven of them were males from different professional backgrounds including security analysts, security officers, engineers, and agricultural experts (extension officers). Four of these key informants fell within the active working age category, while the remaining three were nearing their retirement age of 60 years. The highest level of education was doctorate degree (1). The rest were masters' degree (2), bachelors' degree (3), and an HND holder. Regarding the religious background of these category of respondents, five were Christians, and the remaining two belonged to the Islamic faith.

Climate Pattern in the Bawku Area of Ghana from 1976 to 2015: Time-Series Analysis of Rainfall and Temperature in the 40-Year Period

Aside the primary data collected from respondents using in-depth interviews and focus group discussions, meteorological data sources from the study districts were analysed to understand the climatic conditions of the area. Data from the meteorological stations were depended upon for the annual maximum temperature, annual minimum temperature, mean annual temperature, mean monthly and the mean annual rainfall, mean annual wet and dry season rainfall and mean monthly rainfall. The data were analysed and interpreted with graphs and linear regression models. Descriptive statistics were used to further elaborate the interpretation while, data were statistically tested with Pettitt's, SNHT, Buishand, Mann-Kendall, Sen's Slope and ANOVA post hoc to determine the homogeneity, trend and periods within which changes occurred correspondingly. These test were undertaking at P-values of 0.05 and confidence intervals of 95% and 99%. The analysis was done separately for each meteorological station and results were presented as such.

Trend in mean monthly, annual and seasonal changes in rainfall and temperature at the Binduri Meteorological Station

Mean monthly rainfall

Mean monthly rainfall distribution at the Binduri Meteorological Station is presented Figure 12. The mean monthly rainfall over the areas from 1976 to 2015 is 75.27 mm. Rainfall during August is the highest with 228.6mm which contributes 25.3% of the total mean monthly rainfall (903.5mm) in the area throughout the period. This was followed by 19.6% and 16.9% respectively of July and September. Throughout the period, January did record the least amount of rainfall with the value of 0.0mm, followed by 0.8 mm and 1.7 mm of monthly rain in February and December correspondingly. That is, whereas on the average August (which falls within the wet period) recorded the highest amount of rain throughout the period, February recorded the least amount of rainfall taken out January. It is therefore obvious that wet season (May, June, July, August, and September) contributed a whopping 86.89% of rainfall in the Binduri Meteorological Station. Figure 12 further shows that rainfall has an increasing trend (with a positive slope of [5.0416x]) with regards to the monthly variations.

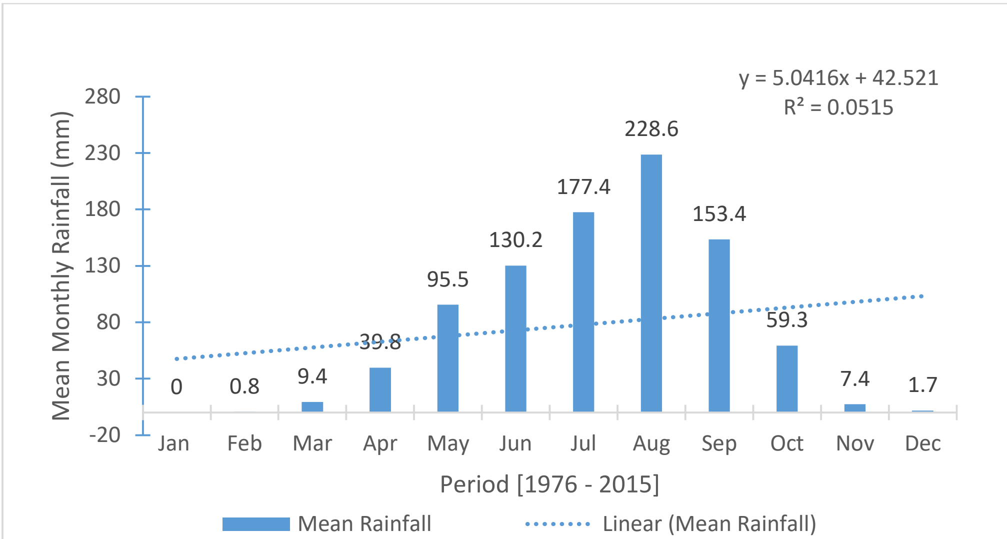

Figure 12: Mean Monthly Rainfall for Binduri (1976-2015)

Source: Field survey (2016)

Mean Annual and Seasonal Rainfall

The mean annual rainfall over Binduri showed a long-term fluctuation (declines and excess rainfall) in the rainfall pattern over the period under investigation. It is observed from Figure 13 that all the years recorded some amount of rainfall. On the average rainfall was relatively low and varied at Binduri with the average annual of 75.27mm. The highest amount of rainfall over the period was 109.9mm recorded in 1999, whereas the lowest amount of rainfall was 3.5mm recorded in 2008. The linear trend line equation indicates a general slight decline (which is seen from the negative slope -0.0033x) in the mean annual rainfall win the years under review. This decline was very significant in 2008 where there was a 71.77mm decline of rainfall from the mean and a 34.63mm rise (the highest rise in rainfall over the period) in rainfall since/in 1989.

Notwithstanding the erratic nature of rainfall over the area, wet season recorded significantly high amount of rainfall compared to dry season. During the wet season, the year 2010 recorded the lowest (110.4mm) amount of rainfall whereas 1989 recorded the highest (233.0mm) amount of rainfall. It is further seen that the average rainfall over the wet season is 152.3mm annually which is about twice higher than the general mean annual rainfall over the 40 year period. It is also worthy to note that there is a general rise in the wet season rainfall at Binduri as shown by the linear trend line equation (regression goodness of fit). The positive slope (0.0637x) indicate a linear upward trend in the wet season rainfall from 1976 to 2015. This implies that rainfall has been increasing every wet season (major rainfall season) at Binduri since 1976 till 2015. While the lowest (41.9mm) decline in wet seasonal rainfall from the average annual wet seasonal rainfall was in 2010 the highest rise in was 80.7mm in 1989.

Meanwhile, in the dry season, rainfall was comparatively lower ranging from 4.00mm to 50.2mm across all years. With an average dry seasonal rainfall of 24.1, it is observed that there was a 20.0mm reduction in rainfall during 1987 and a 26.1mm rise in rainfall during 1991. The linear regression trend line shows a declining trend in the wet seasonal rainfall over the period with a slope of -0.0499x. By inferences, the amount of rainfall received throughout the 40-year period reduced considerably from year to year in the dry season at Binduri.

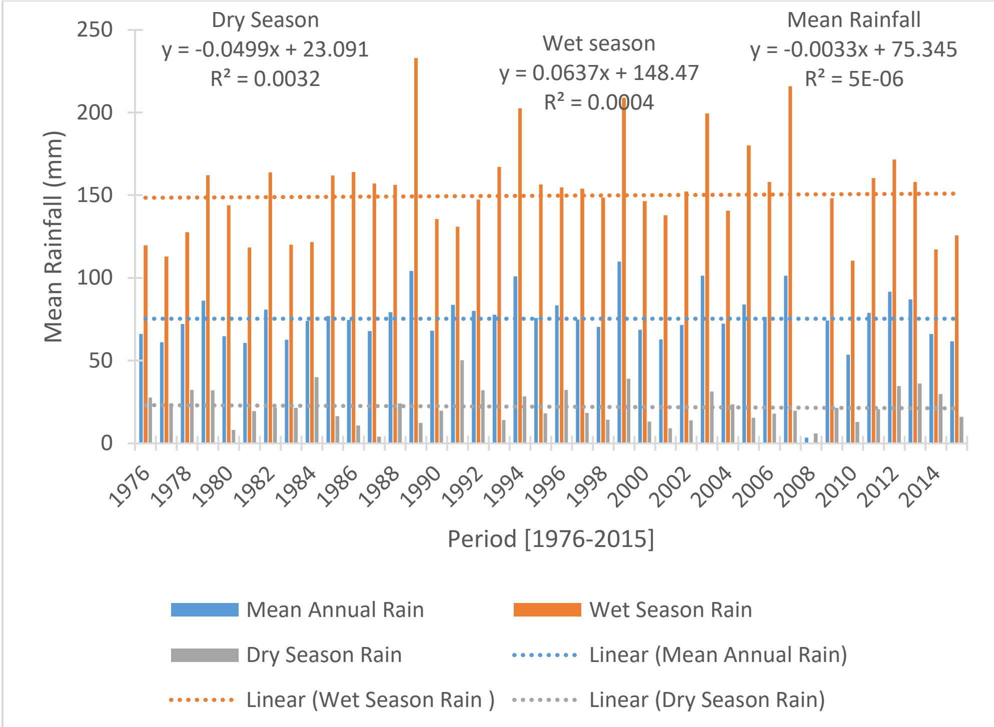

Figure 13: Annual and Seasonal Rainfall for Binduri (1976-2015)

Source: Field survey (2016)

Mean Annual Rainfall Change:

The mean annual rainfall of the forty (40) years was deducted from each of the years to ascertain the rate of rainfall change per year. This was done by establishing a true zero (0) as the starting point in a horizontal line shown in the Figures 14. The result is shown as residuals for visual yearly variations in rainfall since 1976. The rainfall change in the Binduri Meteorological Station seems to be at par over the 40-year period as 20 out of the forty years witnessed decline in rainfall in comparison to the 40 years mean rainfall. It is observed that among the years that witnessed excess rainfall from the mean value, 2007 stood out with +49.9% increase from the mean, whereas 1988 witnessed the least increase with

0.21%. Among the years with decline in rainfall, 2014 experienced the maximum reduction in the annual amount of rainfall with -23.12%.

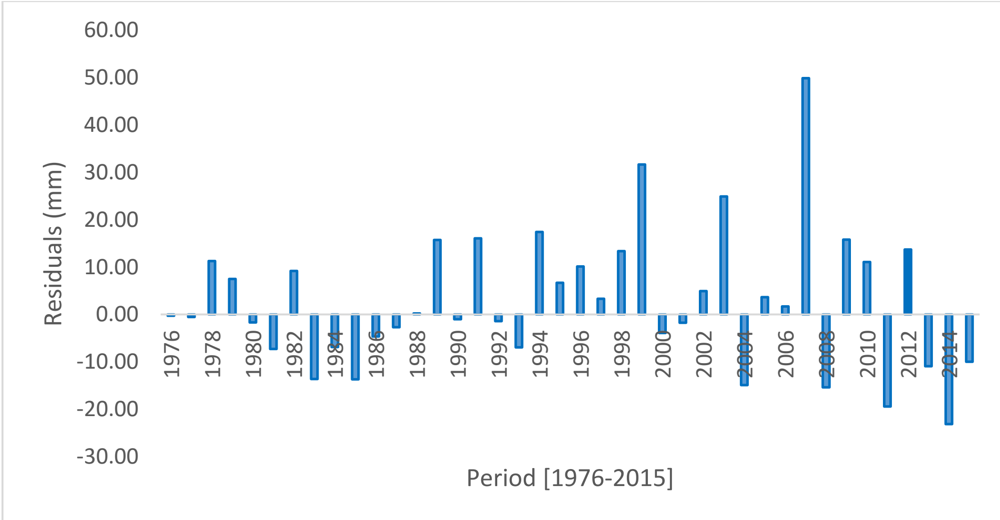

Figure 14: Mean Rainfall Change for Binduri (1976-2015)

Source: Field Survey (2016)

Mean Monthly Temperature

Mean monthly temperatures, thus the average monthly minimum and maximum temperatures are shown in Figure 15. It is seen that monthly temperatures are generally high over the period with high variations. Linear regression (trend line) further shows that there is a decline in the average monthly temperatures (including the maximum and minimum) over the area from 1976 to 2015. This is shown by the negative slopes of -0.3388x, -0.2178x, and -0.1x respectively of mean monthly maximum, mean monthly, and mean monthly minimum temperatures. Expectedly, Figure 15 further indicate that months with high records of temperatures were within the dry season. March recorded the highest (39.5^{0}C) maximum temperature while April recorded the highest minimum and mean temperatures of 25.3^{0}C and 32.1^{0}C respectively.

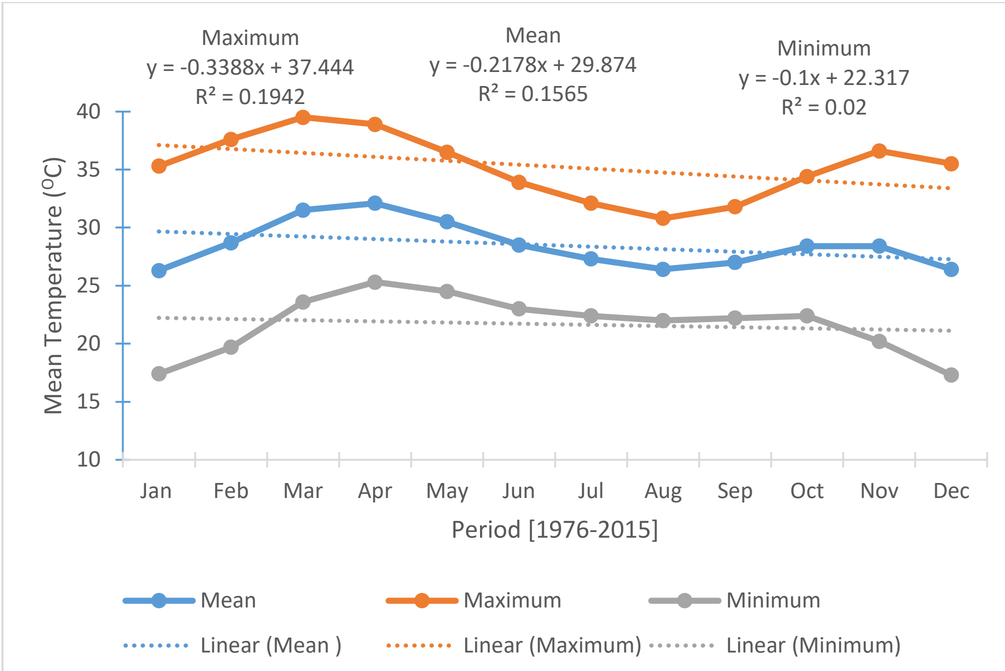

Figure 15: Mean Monthly Temperature for Binduri (1976-2015)

Source: Field survey (2016)

Mean Annual Temperature

As observed in Figure 16, the trend line indicates that a significant annual maximum temperature change was observed from 1976 to 2015. The mean annual temperature (average of the minimum and maximum temperatures), mean annual maximum temperature and mean annual minimum temperature were changed by of -0.0085x, 0.0129x, and -0.028x respectively as per the trend line shown in Figure 16. The change in the mean minimum temperature were more pronounced than the others. The trend of mean maximum temperature shows a positive change (0.0129x) whereas mean annual temperature and mean minimum temperature changes witnessed negative slopes. This therefore indicates that whereas mean annual maximum temperature has been rising since 1976, mean annual minimum and mean annual temperatures have both declined throughout the forty-year period.

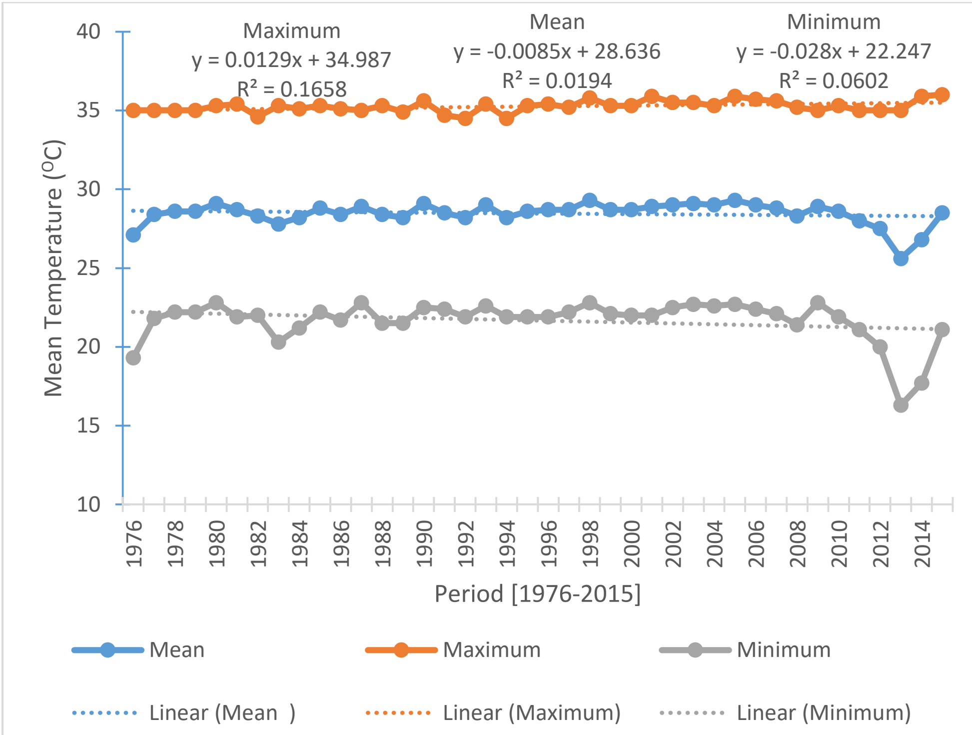

Figure 16: Mean Annual Temperature for Binduri (1976-2015)

Source: Field survey (2016)

From Table 4, the descriptive statistics indicate mean and standard deviation values of 35.26 ^{0}C and .3693, 21.67^{0}C and 1.34, and 28.48 ^{0}C and .7014 correspondingly of mean maximum, mean minimum and mean annual temperatures. The relatively small values of deviation imply a consistent values of temperature increasing concentrated around the mean. Meanwhile, mean annual temperature of 28.48 indicate a uniformly high temperature over Binduri.

Table 4: Discriptive statistics of rainfall and temperature and percentage distribution of mean monthly rainfall for Binduri

	Mean Temperature	**Minimum Temperature**	**Maximum Temperature**	**Rainfall**
Mean	28.48	21.67	35.26	75.27
Std. D	.7014	1.3392	.3693	80.104

Monthly contribution of Rainfall to total rainfall over the study period 1996-2015

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry
Rainfall	0	0.8	9.4	39.8	95.5	130.2	177.4	228.6	153.4	59.3	7.4	1.7	785.1	118.4
Percent	0	0.09	1.04	4.41	10.57	14.41	19.63	25.30	16.98	6.53	0.82	0.19	86.89	13.11

Source: Field survey (2016)

Mean Annual Temperature Change

The rate of change of temperature was also calculated from the residuals, having the mean temperature change at zero (0 ^{O}C) the annual rate of negative temperature change were more pronounced in the year 2013 (-3.05%) followed by 1976 (-1.50%) and 2014 (-1.83%), whereas the least decline was observed in 2015 (-0.15%). Similarly, increase in temperature ranged between 0.0 ^{O}C and 1.0 ^{O}C, with 1998 and 2005 equally experiencing the highest positive change in 0.67% followed by 1980 (0.50%) (see Figure 17). The rate of temperature change was accurately estimated with the Sen's estimator at 99% confidence interval.

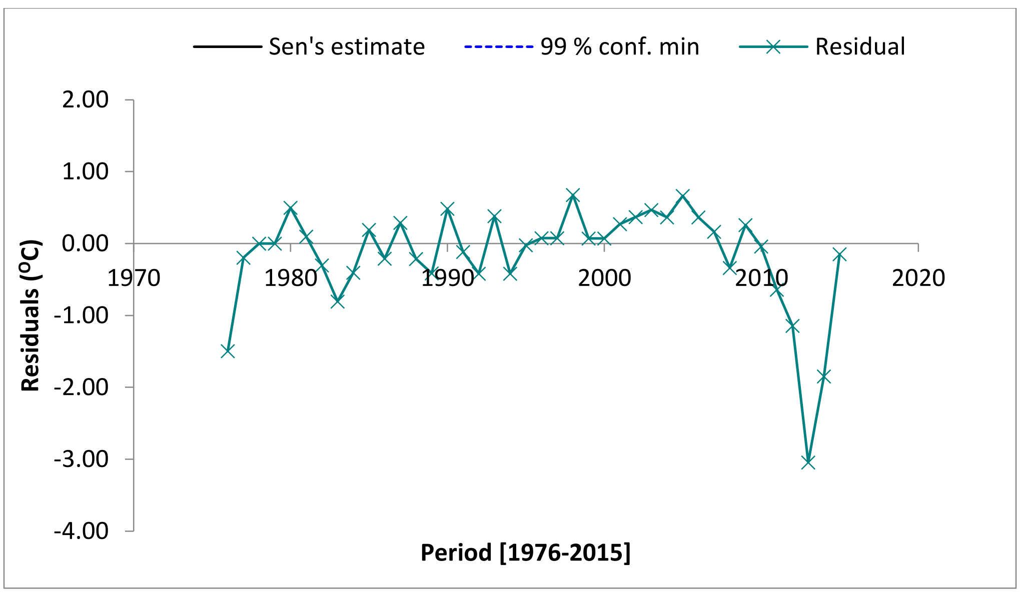

Figure 17: Mean Annual Temperature Change at Binduri

Source: Field survey (2016)

Trend in mean monthly, annual and seasonal changes in rainfall and temperature at the Garu meteorological station

Mean Monthly Rainfall

The mean monthly rainfall amount in the past four decades from the Garu Meteorological Station was aggregated and average values for each month was taken for analysis. The results in Figure 18 show that there was no month without rainfall in the years under study. However, in dry seasons, rainfall was critically low and somewhat low in the months of January, February, November and December, and March, April and October respectively. As expected, each month in the wet seasons recorded over 100mm of rainfall, with the highest rainfall amount occurring in August (25.4% of the overall rainfall) followed by September (19.4%). Whereas the total contribution of wet season to the total rainfall amount was 86.23%, that of the dry season was 13.77%. There is a positive (5.6409x) trend of rainfall over the twelve months as shown in the regression equation.

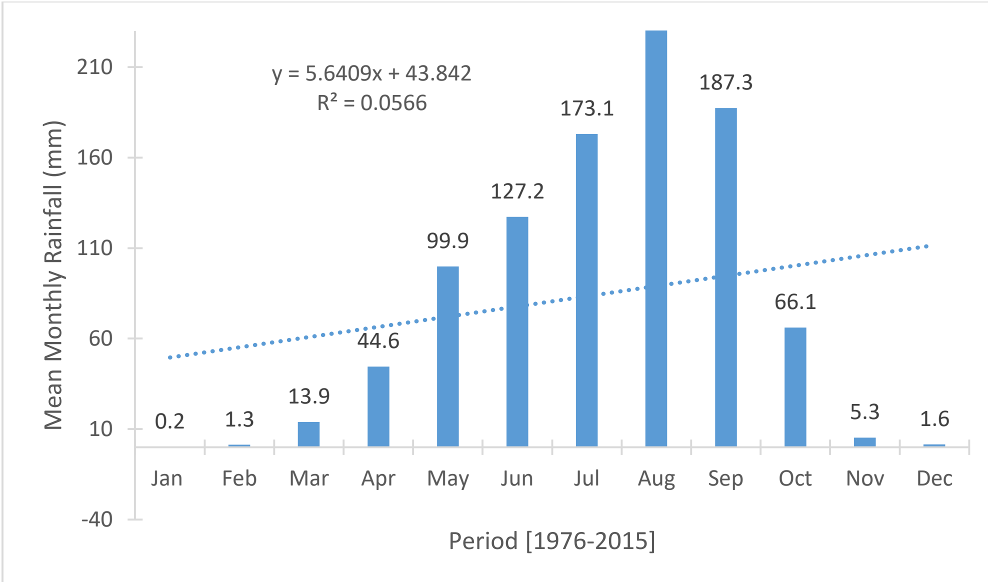

Figure 18: Mean Monthly Rainfall for Garu (1976-2015)

Source: Field survey (2016)

Mean Annual and Seasonal Rainfall

Figure 19 generally shows a positive rainfall (mean, wet and dry season rainfall) pattern at Garu, with all years under review recording some significant amount of rainfall. During the wet season, rainfall was lowest (114.8mm) in 1985 and highest (224.1mm) in 2007. There was however average recording of over 100mm of rainfall in the mentioned season throughout the 40-year period. Meanwhile, the mean rainfall recorded at this weather station ranged from 58.0mm in 1985 to 103.3mm in 2007. In the dry season, the lowest (8.2mm) rainfall occurred in 1987 and the highest (58.0mm) recorded in 1991. Besides the deviations from the means 80.5mm, 159.9mm, and 23.8mm respectively of the mean, wet and dry seasons, all years irrespective of the season recorded some amount of rainfall.

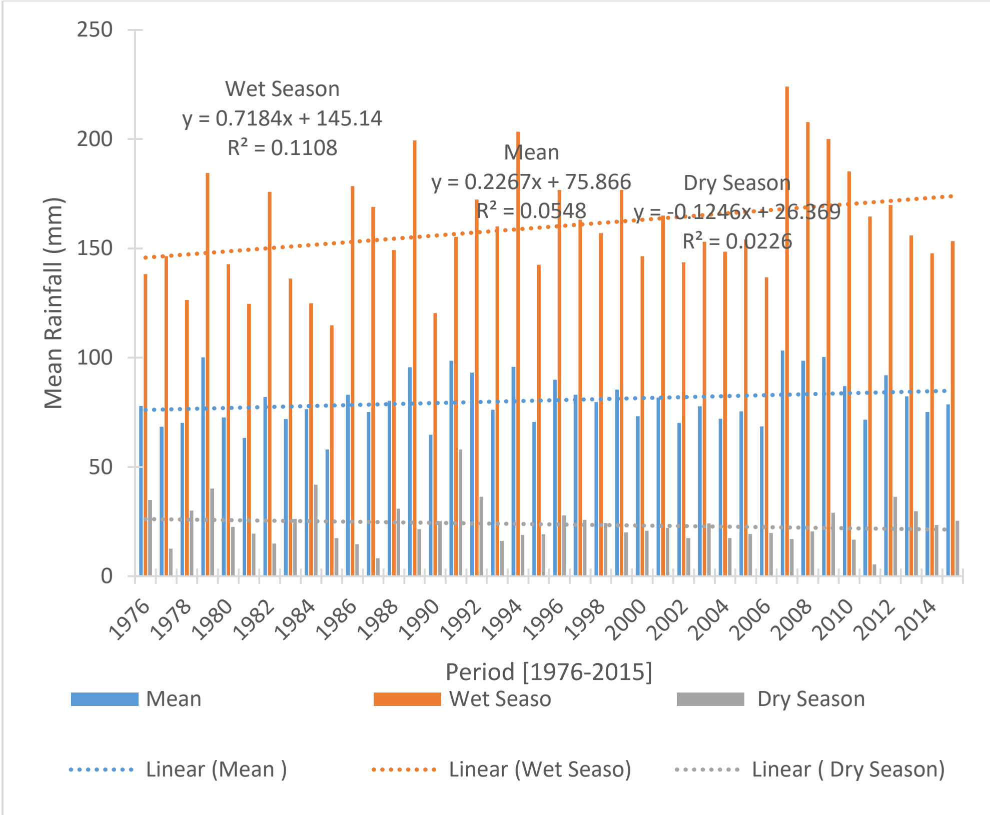

Figure 19: Mean Annual and Seasonal Rainfall for Garu (1976-2015)

Source: Field survey (2016)

It is further observed from Figure 19 that there has been a positive trend (shown with the trend line equation) in wet season rainfall (0.7184x) and mean annual rainfall (0.2267x) while dry season has a negative (-0.1246x) trend. These indicate that, rainfall has been declining over the past forty years during dry seasons, but with some increasing trend in the wet season. The trend further shows that the rate of change of the wet season rainfall is highest (0.72), and moderate (0.23), and its lowest with regards to the dry seasonal change (-0.12).

Mean Annual Rainfall Change

Similar to the case at Binduri, the result at the Garu weather station shows rainfall as recording a positive change (based on the residuals) to be in the range of 0.0mm to 25.0mm over the 40-year period. As seen in Figure 20, rainfall change in 1979 was the highest positive change with 24.5% change excess over the mean and the least in 1998 (0.39%) and 2013 (0.11%). It is further seen that 1985 and 1984 experienced highest (-18.80%) and lowest (-0.11%) reduction respectively in annual rainfall change over period.

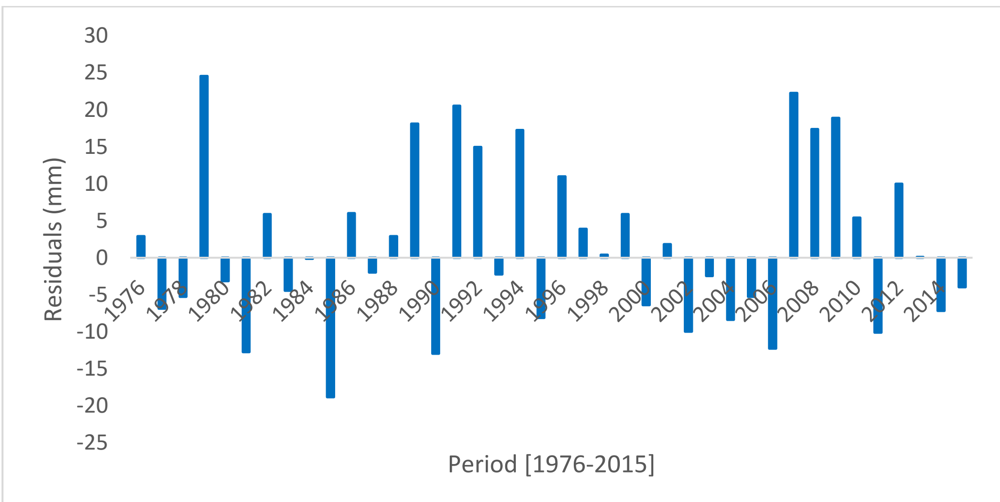

Figure 20: Mean Annual Rainfall Change for Garu (1976-2015)

Source: Field survey (2016)

Mean Monthly Temperature

Contrary to the rising annual temperatures in the area, the monthly temperatures show an overall declining trend in the mean, maximum and minimum values (Figure 21). The trend of temperature again shows high and low peaks in dry and wet months respectively. As observed from the regression equation, the decline in maximum (-0.3073x) is slightly higher than the mean (-0.2692x) and the minimum (-0.2395x) which could be interpreted to mean that the rate of change in the maximum temperature is rapid as compared to the minimum and average temperatures.

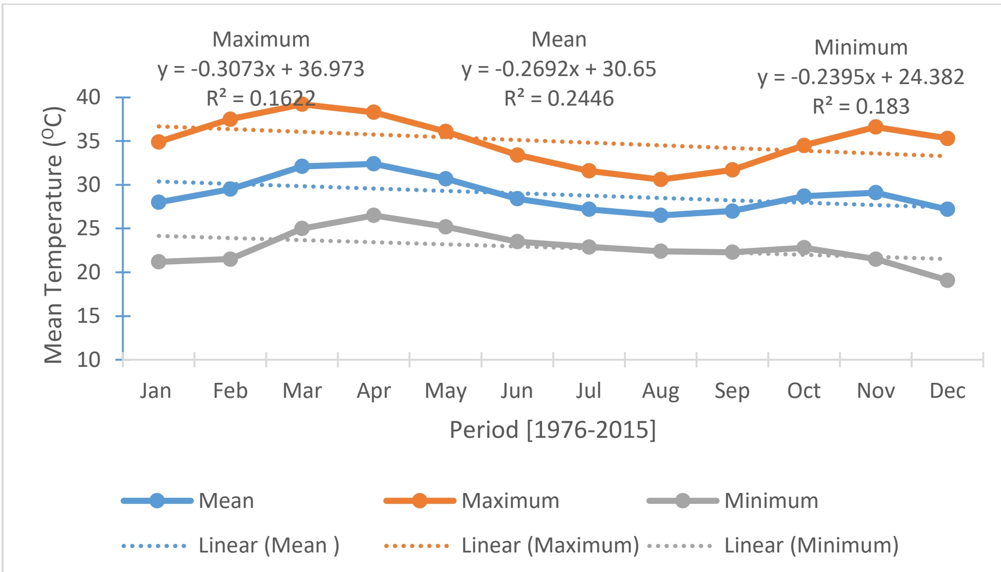

Figure 21: Mean Monthly Temperature for Garu (1976-2015)

Source: Field survey (2016)

Mean Annual and Seasonal Temperature

Annual temperatures of Garu were also analysed and the result is shown in Figure 22, with largely high temperatures over the years in the area. This is supported by the annual mean, minimum and maximum temperatures for the area separately show 28.9 ºC and .8660; 22.83 ºC and 1.4034; and 34.98 ºC and .7669 of mean and standard deviation as shown in Table 5. The result suggest that temperature values are all concentrated around the mean with low variations. Moreover, observation from Figure 22 indicate a positive trend in the temperature of the area; it is more pronounced in the maximum temperature and less pronounced in the minimum temperature as shown in the regression line equation. This means that on the average temperatures has been rising annually as recorded in the Garu Meteorological Station in the past forty years to the extent that even the minimum temperature is rising. In other words, there is been a positive temperature change since 1976 in the maximum (0.0529x), minimum (0.003x), and mean (0.0279x) temperatures.

Table 5: Discriptive statistics of rainfall and temperature, and percentage distribution of mean monthly rainfall for Garu

	Mean Temperature	Minimum Temperature	Maximum Temperature	Rainfall
Mean	28.90	22.83	34.98	80.505
Std. D	.8660	1.4034	.7669	85.467

Monthly contribution of Rainfall to total rainfall over the study period 1996-2015

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry
Rainfall	0.2	1.3	13.9	44.6	99.9	127.2	173.1	245.6	187.3	66.1	5.3	1.6	832.8	163.3
Percent	0.02	0.13	1.44	4.62	10.34	13.17	17.92	25.42	19.39	6.84	0.55	0.17	86.2	13.8

Source: Field survey (2016)

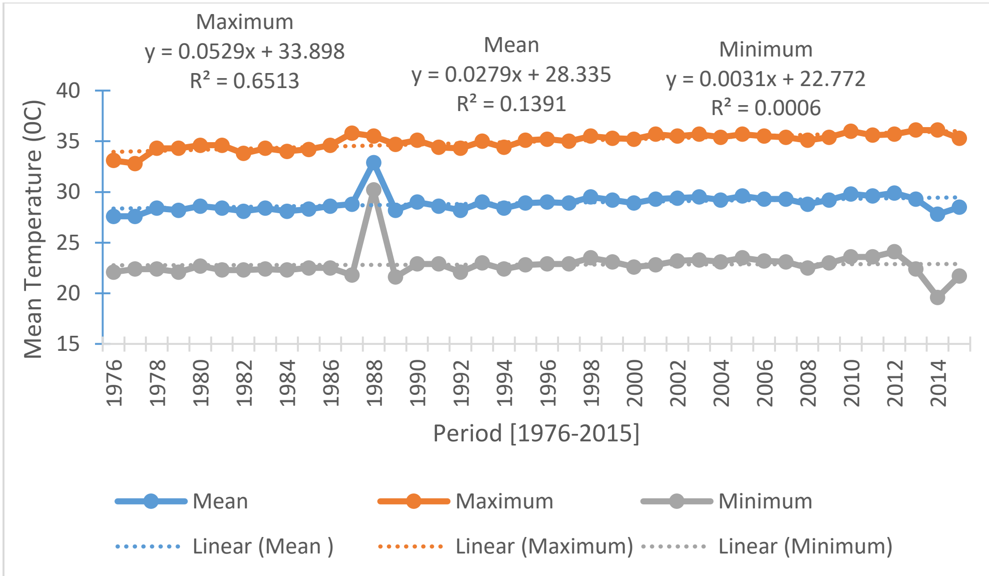

Figure 22: Mean Annual and Seasonal Temperature for Garu (1976-2015)

Source: Field survey (2016)

Mean Annual Temperature Change

Unlike the Binduri and Manga temperature changes, there was a more pronounce positive change in mean annual temperature at Garu though there are many variations. The maximum positive change in temperature was 4.31% during 1988 followed by 0.51% in 1998. The 1988 temperature change is an extreme case in comparison to the other positive changes. On the contrarily, the highest and lowest negative (decline) change in temperature were respectively witnessed in 2014 (-1.84%) followed by 2015 (-1.17%) (Figure23)

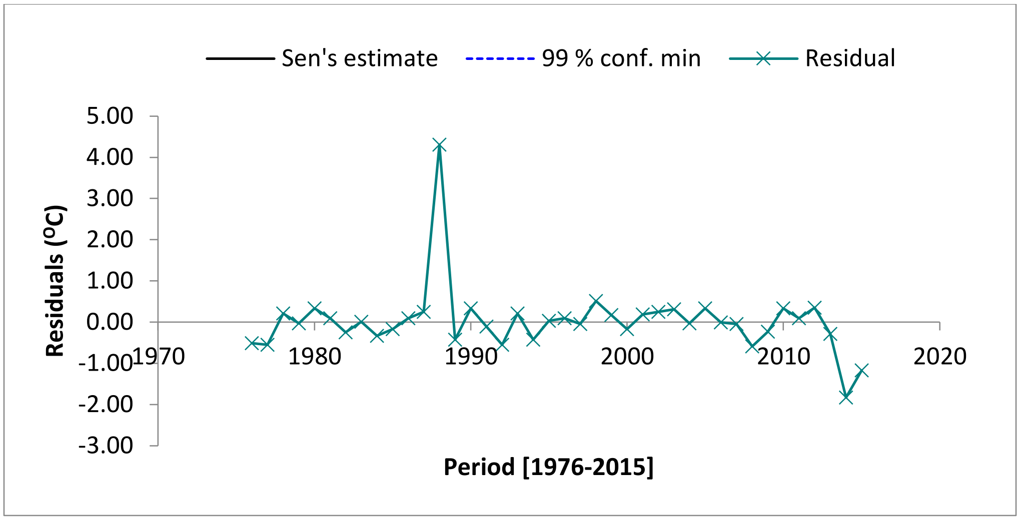

Figure 23: Annual Temperature Change at Garu (1976-2015)

Source: Field survey (2016)

Trend in mean monthly, annual and seasonal changes in rainfall and temperature at the Manga meteorological station

Mean monthly rainfall

The distribution of the monthly mean rainfall from 1976 to 2015 is shown in Figure 24, with an average of 78.1mm with a standard deviation of 86.8321 which implies that variations in the monthly distribution of rainfall is high. While there was no month without rainfall, the amount varied considerably. Almost 90% of the entire rainfall is recorded in the wet season with only 11.6% occurring in the dry season. During the period under observation, August recorded the highest (251.3mm) amount of rainfall followed by July (185mm) and September (165.6mm), while the least rainfall amount was recorded in January (0.1mm) followed by February (1.1mm) correspondingly constituting 26.83%, 19.75% 17.68%, 0.01%, and 0.12% (Table 6). The linear regression trend line shows evidence of an increasing trend in the monthly rainfall data irrespective of the rise and falls in the distribution. The trend indicates a 5.47% change of the rate of rainfall in the past 40 years.

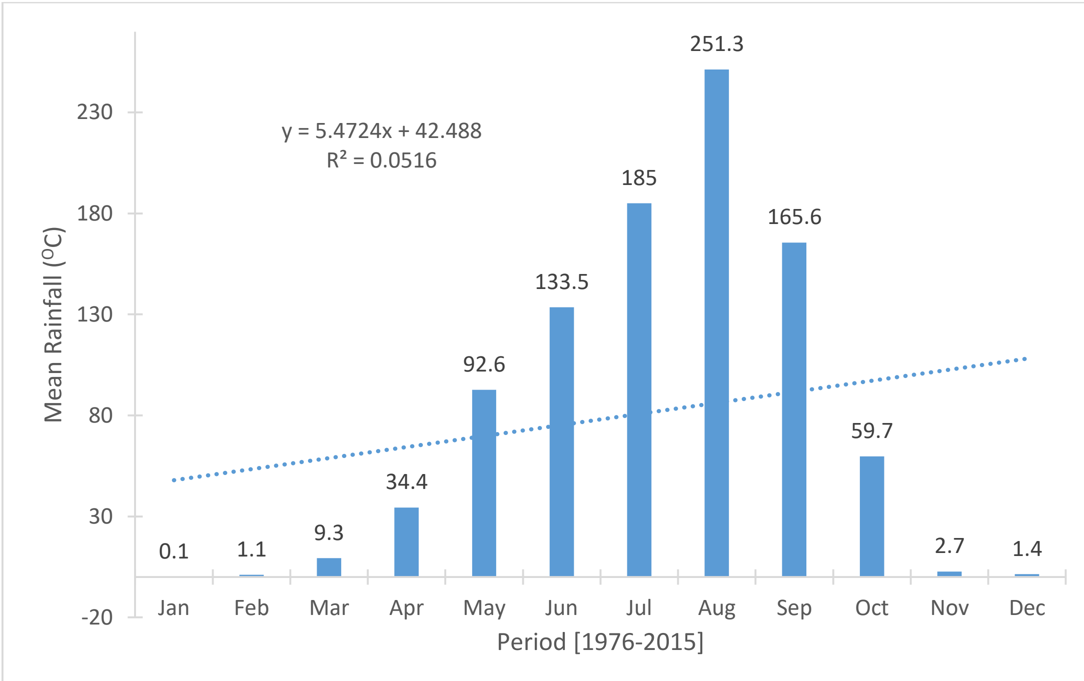

Figure 24: Mean Monthly Rainfall for Manga (1976-2015)

Source: Field survey (2016)

Table 6: Percentage distribution of mean monthly rainfall

Months	Bind.	% of rainfall [1976-2015]	Garu	% of rainfall [1976-2015]	Manga	% of rainfall [1976-2015]
January	0.0	0.0	0.2	0.02	0.1	0.01
February	0.8	0.09	1.3	0.13	1.1	0.12
March	9.4	1.04	13.9	1.44	9.3	0.99
April	39.8	4.41	44.6	4.62	34.4	3.67
May	95.5	10.57	99.9	10.34	92.6	9.89
June	130.2	14.41	127.2	13.17	133.5	14.25
July	177.4	19.63	173.1	17.92	185.0	19.75
August	228.6	25.30	245.6	25.42	251.3	26.83
September	153.4	16.98	187.3	19.39	165.6	17.68
October	59.3	6.53	66.1	6.84	59.7	6.37
November	7.4	0.82	5.3	0.55	2.7	0.29
December	1.7	0.19	1.6	0.17	1.4	0.15
Wet season	785.1	86.89	832.8	86.2	828.0	88.4
Dry season	118.4	13.11	163.3	13.8	108.7	11.6

Source: Field survey (2016

Mean Annual and Seasonal Rainfall

Figure 25 shows the annual trends in mean rainfall and wet and dry period's rainfall at Manga Meteorological Station. It is observed that the distribution of rainfall over the forty-year period is irregular in either the wet or dry season. Again, it is seen that the trend of the mean and wet season are upward, while that of the dry season show a downward (-0.0163x) trend. The rising trend indicate that rainfall on the average increased on yearly basis, whereas the downward trend indicate reduction in rainfall over the years. However, the change in the wet season rainfall is more noticeable (1.1156x) than that of the mean (0.4551x). Over the period, the average rainfall over the mean annual, wet season and dry season were 78.1mm, 159.1mm and 20.2mm correspondingly.

Thus, even though there is rainfall in either season in all years, the pattern varies. The highest and lowest rainfall during the wet season were 283.5mm in 2007 and 109.8 mm 1981 respectively, which were 124.4mm and 49.3 higher and lower than the mean (159.1mm) rainfall of the wet season. The observation is similar with respect to the dry season and mean annual rainfall of the Manga Meteorological Station. During the dry season the lowest and highest amount of rainfall were recorded in 2015 (6.1mm) and 1991 (50.8mm) respectively. Again, this shows 14.1mm and 30.6mm deficit and excess of the mean dry season rainfall. Equally, the discrepancies in the wet and dry seasons are moderated by the mean annual rainfall which is seen lying in the middle of the two. With that, the highest was recorded in 2007 (130.2) and the lowest in 1983 (56.3mm)

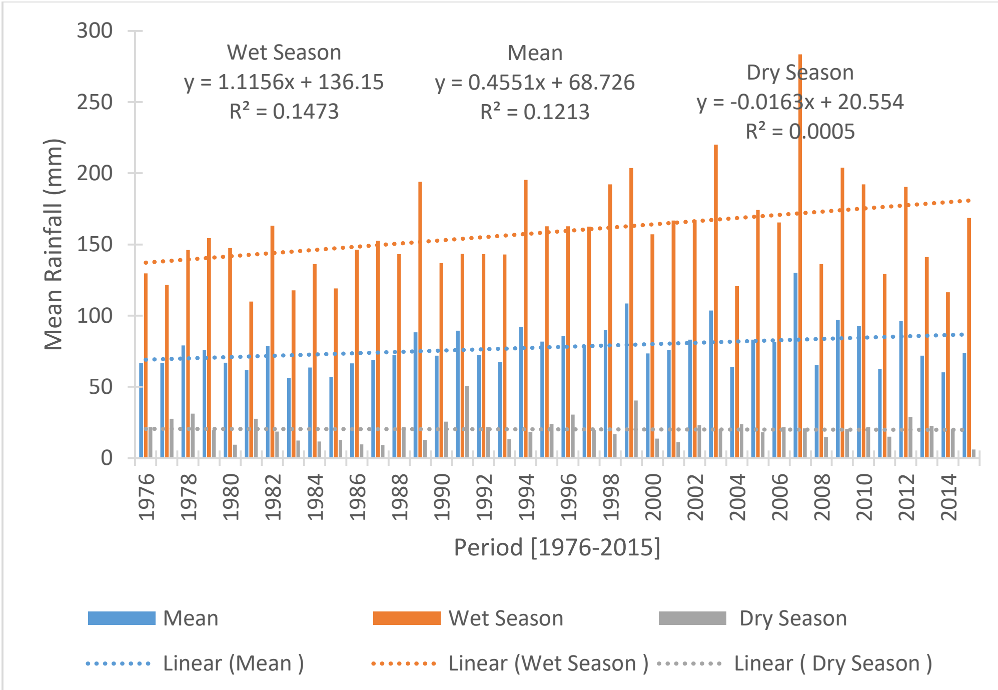

Figure 25:Mean Annual and Seasonal Rainfall for Manga (1976-2015)

Source: Field survey (2016)

Mean Annual Rainfall Change

Figure 26 shows the result of rainfall change in the Manga Meteorological Station with erratic and irregular rainfall distribution. It is observed that there are excess and shortage in rainfall supply differently during the study period. Among the excess rainfall years, 2007 stood out as the extreme year with +49.9% increase in rainfall from the mean, whereas 2006 witnessed the least increase with 1.7%. Among the years with decline in rainfall, 2014 experienced the maximum reduction in the annual amount of rainfall with -23.12%.

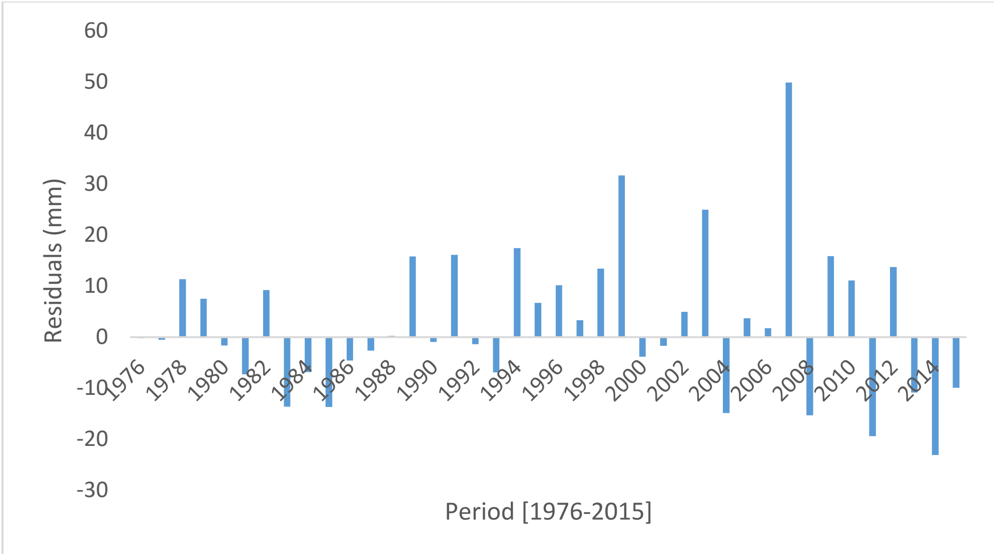

Figure 26: Mean Annual Rainfall Change for Manga (1976-2015)

Source: Field survey (2016)

Mean Monthly Temperature

In sharp contrast to averagely increasing temperatures on yearly basis, Manga experienced monthly decline in temperature from 1976 to 2015 (Figure 27). Temperature varies by months in correspondence to the wet and dry seasons. The decline in maximum (-0.3266x) temperature is the highest followed by mean (-0.257x), whereas the minimum temperature recorded a decline of -0.1846x. In other words, the rate of change in the maximum temperature is more visible than that of minimum and mean temperatures.

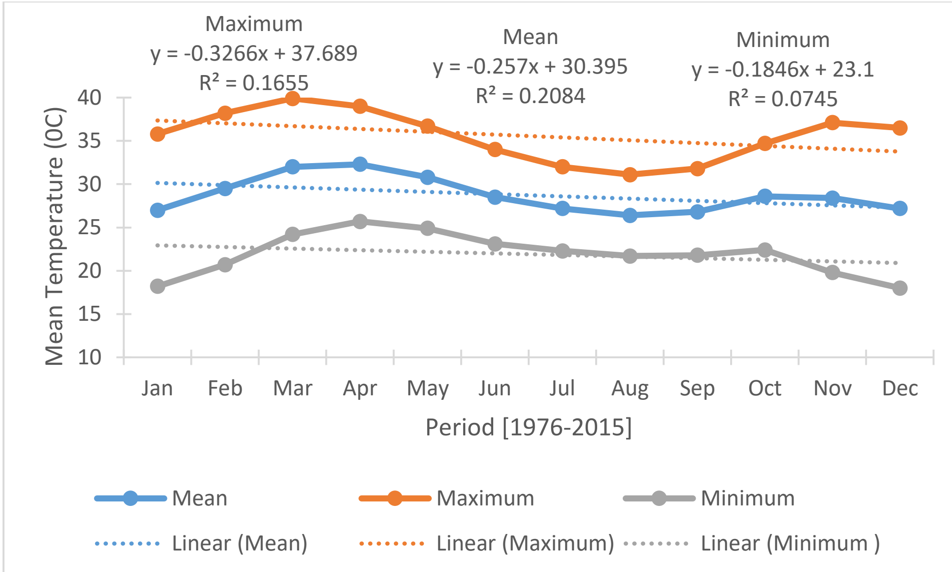

Figure 27: Mean Monthly Temperature for Manga (1976-2015)

Source: Field survey (2016)

Mean Annual Temperature

From Figure 28, the annual temperature change witnessed positive trend over the forty-year period (1976 – 2015). The trend lines show positive slope 0.0314x, 0.05x, and 0.0668x in the maximum, mean and minimum temperature respectively. The positive slope implies a rise in temperature since 1976. It is astonishing to note that the rise in temperature is witnessed markedly in minimum temperatures, implying that temperature rise in Manga is rapid to the extent that minimum temperatures are rising.

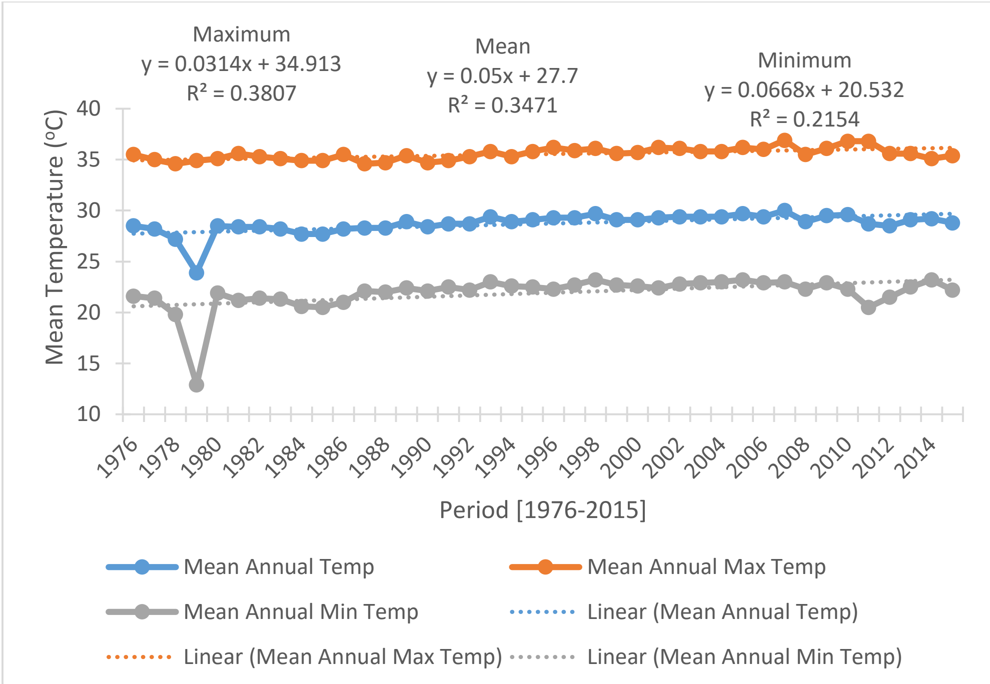

Figure 28: Annual Mean Temperature for Manga (1976-2015)

Source: Field survey (2016)

It could be inferred from Table 7 that the deviations witnessed in the mean (.9926), maximum (.5999) and minimum (1.6928) that majority of the temperature values are concentrated around the mean which further implies that the distribution is fairly or normally distributed.

Table 7: Discriptive statistics of rainfall and temperature, and percentage distribution of mean monthly rainfall for Manga

	Mean Temperature	Minimum Temperature	Maximum Temperature	Rainfall
Mean	28.72	21.89	35.55	78.052
Std. D	.9926	1.6928	.5999	86.8321

Monthly contribution of Rainfall to total rainfall over the study period 1996-2015

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Wet	Dry
Rainfall	0.1	1.1	9.3	34.4	92.6	133.5	185.0	251.3	165.6	59.7	2.7	1.4	828.0	108.7
Percent	0.01	0.12	0.99	3.67	9.89	14.25	19.75	26.83	17.68	6.37	0.29	0.15	88.4	11.6

Source: Field survey (2016)

Mean Annual Temperature Change

The Sen's estimator for rate of temperature change was used to accurately estimate the changes at 99% confidence interval. Using the mean annual temperature to calculate the residuals, the annual rate of temperature change (negative) was more pronounced in the year 1979 (-4.38%) followed by 2012 (-1.14%) and 1985 (-0.82%), while the least decline was observed in 1992 (-0.11%). Similarly, increase in temperature ranged between 0.0 ^{O}C and 1.0 ^{O}C, with 1998 experiencing the highest positive change in 0.64% (Figure 29).

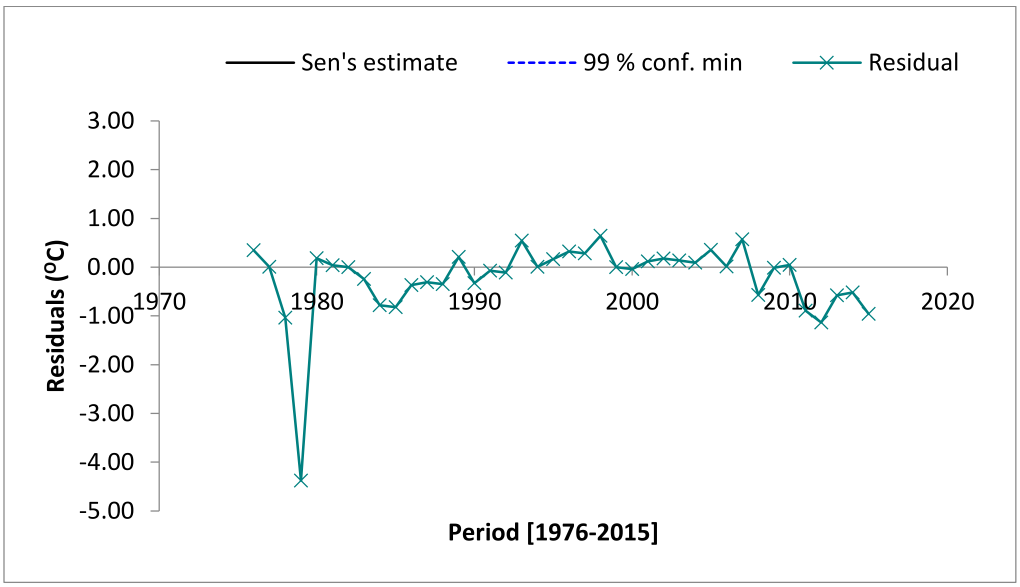

Figure 29: Mean Annual Temperature Change for Manga (1976-2015)

Source: Field survey (2016)

Statistical analysis of trends at three meteorological stations in the Bawku Area

This section aimed to use statistical tools to quantify and test the level of significance of the quantification on the variability and trends in the rainfall and temperature in the Bawku Area. As such, test of homogeneity, trend and ANOVA have been applied to that effect.

Description of the monthly contribution of each months and seasons to the mean average rainfall of the study area

As expected, in all the three meteorological stations, wet season recorded over 85% of the mean 40-year period rainfall as shown in the Table 6. Again, August received the highest (over 25% in each case) rainfall in all three stations, while January experienced the least (less than 0.3%) amount of rainfall in each station. Moreover, during the wet season, all months recorded over 100mm of rainfall.

Test Statistics of Annual Rainfall Series for Pettitt Test, SNHT and Buishand Test of the Rainfall and Temperature data (1976 – 2015)

An XLSTAT software package was applied in this study to test the homogeneity of the rainfall and temperature data. Here, three types of homogeneity testing were done including the Pettitt test, the SNHT test, and the Buishand. Significance level of 5% was adopted for the testing at the three meteorological stations. These test were necessary as they were used to determine if indeed the datasets were significantly homogenous for the trend test analysis.

Test of Homogeneity

In Figure 30a and 30b, whereas SNHT and the Buishand test detected the same break point (T) during 2007 at both Binduri and Garu, Pettitt test was met with a break point at Binduri and Garu during 1987 in mean annual rainfall. However, all three test had p-value of greater than 0.05 and hence meeting the assumption of homogeneity of rainfall data's suitability for trend testing. This further means that at least 30 continuous data were found by the test to be of homogenous series and hence useful for the trend analysis.

Figure 30a: Homogeneity Test in Annual Rainfall and Temperature

Source: Field Survey (2016)

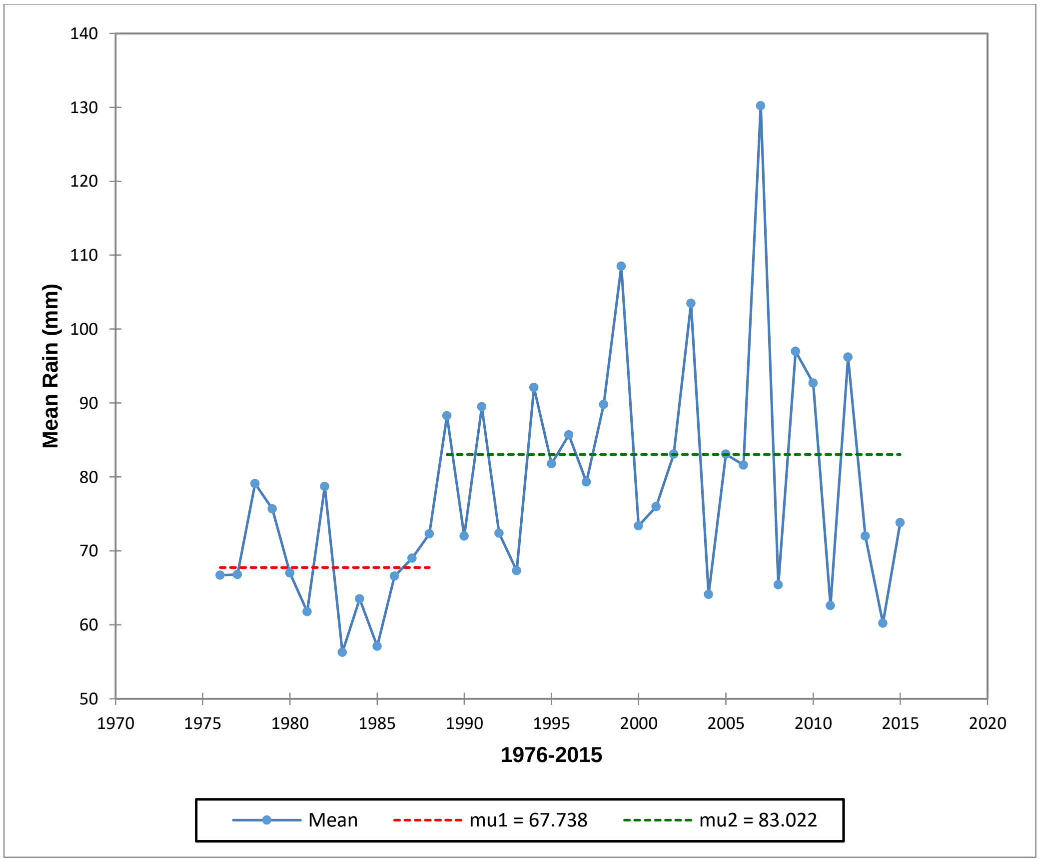

Figure 30b: Homogeneity Test in Annual Rainfall and Temperature

Source: Field survey (2016)

Description of the homogeneity tests results are shown in Table 8 with both rainfall and temperature and their comparative test statistics (Pettitt's test, SNHT and Buishand test). It is clear from the table that amongst the 40 years' period, only 2 separate years were identified by the three homogeneity tests in all the meteorological station for mean annual rainfall. In the mean temperature however, three inhomogenous years were detected at Binduri and Garu (2009, 2010, 2011) and two (1992, 1998) at Manga. Hence, based on the results shown in Table 8, there is sufficient evidence of homogeneity in the dataset for trend analysis.

Table 8: Homogeneity Test Statistics

Meteo Station	Pettitt's Test		SNHT Test		Buishand Test	
Rainfall	T	Sig.	T	Sig	T	Sig.
Binduri	1987	0.628	2007	0.449	2007	0.447
Garu	1987	0.625	2007	0.471	2007	0.460
Manga	1988	0.016*	1988	0.091	1993	0.017*
Temperature						
Binduri	2009	0.365	2011	0.052	2010	0.020*
Garu	2009	0.371	2011	0.052	2010	0.022*
Manga	1992	<0.0001*	1998	0.053	1992	<0.0001*

*****Sig. at 0.05

Source: Field survey (2016)

Mann-Kendall Trend Test - Annual Rainfall

A Mann–Kendall's (MK) non-parametric test was used to test the trends available in the rainfall and temperature data whose results are presented in tables 9a and 9b. The results are based on three separate meteorological stations located in the Bawku Area of Ghana. As a measure of the link between two subsequent annual rainfall and temperature data, the MK result is based on the computations of the Kendall's tau. It is clearly seen from the Table 9a that, with the exception of Binduri, the other two stations experienced a positive trend in mean annual rainfall over the areas.

Table 9a: Annual Rainfall MK Trend Test

		Mann-Kendall's Trend Test of mean rainfall (H0: there is no trend)			
Meteo Station	No. of Yrs	Mann-Kendall stat (S)	Var. (S)	Kendall's tau	p-value
Binduri	40	-72.000	7366.667	-0.092	0.408
Garu	40	72.000	7366.667	0.092	0.408
Manga	40	196.000	7364.667	0.252	0.023

*Reject H0 at ≤0.05 level or accept H0 at ≥0.05

Source: Field survey (2016)

However, the positive trend in annual rainfall amount is only statistically significant (<0.05) at the Manga Meteorological Station but not significant (>0.05) at both Binduri and Garu stations. Hence on the basis of the null hypothesis (H0: there is no trend), the alternate hypothesis (H1) is accepted at the Manga Meteorological Station whereas H0 is accepted at the Binduri and Garu stations.

Notwithstanding the insignificance of the other two rainfall stations and a decline in rainfall at Binduri, it is quite a welcome result for the residents in the areas because of its potential agricultural, hydrological and socio-economic effects in an area which is highly populated by farmers who are highly dependent on rainfall for their farming activities. This could influence future planning towards agriculture in the areas as well. This is especially important because it could relieve other people who have been vulnerable to inadequate rainfall in the past and could prepare them for future production.

Mann Kendall Trend Test - Annual Temperature

Table 9b presents the results of the MK trend test of the three stations on mean temperature of the area. As witnessed in the graphical analysis, the result indicates a rise in temperature in many of the tests over the past 40 years in all three stations. It is observed that at Binduri Meteorological Station, mean and minimum temperature of the area showed a decreasing trend, implying that average and minimum temperature of the areas has declined over the years even though these decline were statistically insignificant (≥ 0.05).

Table 9b: Annual Temperature MK Trend Test

			Mann-Kendall's Trend Test of temperature (H0: there is no trend)			
Meteo Station		No of Yrs	MK Stat (S)	Var. (S)	K. tau	p-value
Bind.	Mean	40	-41.000	7309.000	-0.054	0.640
	Max	40	195.000	7170.333	0.264	0.022*
	Min	40	-29.000	7310.333	-0.038	0.743
Garu	Mean	40	403.000	7316.333	0.529	<0.0001*
	Max	40	484.000	7324.667	0.634	<0.0001*
	Min	40	269.000	7321.000	0.352	0.002*
Mang.	Mean	40	403.000	7316.333	0.529	<0.0001*
	Max	40	329.000	7318.333	0.432	<0.000*
	Min	40	352.00	7341.333	0.458	<0.0001*

*Reject H0 at ≤0.05 level or accept H0 at ≥0.05

Source: Field survey (2016)

On the contrary, only maximum temperature of the Binduri Meteorological Station showed positive and significant trend. The H0 of the mean and minimum temperature is hence accepted as the H1 is rejected. Furthermore, it is observed that at p-value of 0.05, minimum, maximum and mean temperatures of the Garu and Manga Meteorological Stations had positive change. Thus, the null hypothesis (H0) is rejected and the alternate (H1) is accepted. In explaining this, it is observed that over the 40-year period, Garu and Manga have witnessed rising temperatures on the average because alpha value is larger than the calculated p-value.

Astonishingly, both temperature and rainfall trends showed positive change. It is important to note that the positive trend in temperature was more significant than that of the rainfall. This further suggests that rate of evaporation could be high in the area regardless of the rainfall increase which could be a threat to water security in the area for both farming and off farm activities.

One-Way ANOVA Post Hoc Analysis

A one-way between-groups analysis of variance was conducted to explore the impact of the years on level of rainfall and temperature measured in millimetre and degree celsius respectively. The years were divided into four groups based on their 10-year period from the year in which recording begun as far as this research is concerned (Group 1: 1976-1985; Group 2: 1986-1995; Group 3: 1996-2005; and Group 4; 2006-2015). This analysis was done separately for the three meteorological stations.

Binduri Meteorological Station

The ANOVA results show no statistical significant difference in the year groups with respect to rainfall. However, there was a statistically significant difference in the year groups at the $p < .05$ level in temperature for the four age groups: F (3, 476) = 3.623, p = .013. Despite reaching statistical significance, the actual difference in mean scores between the groups was quite small. The effect size, calculated using eta squared, was .02. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Group 3 (*M* = 28.93, *SD* = 2.15) was significantly different from Group 4 (*M* = 28.02, *SD* = 2.25). There was however, no significant difference between Group 3 (*M* = 28.93, *SD* = 2.15) and 1 or 2. Again, there was no significant difference in means between Group 1 (*M = 28.35, SD = 2.23*) and 2 or 4; and there was no significant difference in means between Group 2 *(M = 28.35, SD = 2.19)* and 4.

Table 10a: ANOVA Test Statistics, Binduri

Binduri	**SS**	**df**	**MS**	**F**	**Sig.**	**Eta. square**
Rainfall:						
Between Groups	13620.562	3	4540.18	.570	.635	0.0035
Within Groups	3794549.32	476	7971.74			
Total	3808169.88	479				
Temperature:						
Between Groups	52.980	3	17.660	3.623	.013	0.0223
Within Groups	2320.352	476	4.875			
Total	2373.332	479				

Source: Field survey (2016) *Sig at 0.05 level

Garu Meteorological Station

The results show that there was no significant difference in means of the year groups with respect to rainfall but, temperature showed evidence of statistical significant differences in the means of the year groups at the $p < .05$ level for the four age groups: F (3, 476) = 3.158, p = .025. Notwithstanding the level of significance, the actual difference in mean scores between the groups was low. As such, the effect size was calculated using eta square and the result was approximately .02. Meanwhile, in the post-hoc comparisons using the Tukey HSD test it was found that there was significant difference in the mean scores of Group 1 (M = 28.17, SD = 2.17) and Group 3 (M = 29.25, SD = 2.12) and that there were no significant differences between any other groups.

Table 10b: ANOVA Test Statistics, Garu

Garu	SS	df	MS	F	Sig.	Eta. square
Rainfall:						
Between Groups	9451.697	3	3150.57	.380	.768	0.002
Within Groups	3947291.13	476	8292.63			
Total	3956742.83	479				
Temperature:						
Between Groups	88.512	3	29.504	3.158	.025	0.019
Within Groups	4446.946	476	9.342			
Total	4535.461	479				

Source: Field survey (2016) *Sig at 0.05 level

Manga Meteorological Station

It is observed from the Table 10c that there was no statistical difference in mean rainfall at $p < .05$ for the year groups F (3, 263.226) = 1.267, p = .286 nor F (3, 458.467) = 1.111, p = .344 based on Welch and Brown-Forsythe test for equality of means respectively. But there was significant difference in means of temperature at $p < .05$ level for the age groups: F (3, 476) = 12.821, p = .000. The actual difference in mean temperature values was moderate evidence from the effect size 0.07 calculated using eta squared. Post-hoc multiple comparisons using the Tukey HSD further indicated that the mean score for Group 1 (M = 27.66, SD = 2.78) was significantly different from Group 2 (M = 28.71, SD = 2.16); Group 3 (M =29.36, SD = 2.16); and Group 4 (M = 29.16, SD = 2.11). Group 2 (M = 28.71, SD = 2.16) did not differ significantly from either Group 3, or 4; Group 3 (M =29.36, SD = 2.16) did not differ significantly from Group 4.

Table 10c: ANOVA Test Statistics, Manga

Manga	SS	df	MS	F	Sig.	Eta. square
Rainfall:						
Between Groups	30578.238	3	10192.75	1.111	.344	0.007
Within Groups	4367338.58	476	9175.081			
Total	4397916.82	479				
Temperature:						
Between Groups	206.743	3	68.914	12.82	.000*	0.075
Within Groups	2558.597	476	5.375			
Total	2765.340	479				

Source: Field survey (2016) *Sig at 0.05 level

Time-series analysis of rainfall and temperature discussed.

The outcomes of the annual temperature and rainfall trends as analysed in this study is somewhat consistent with the findings of some earlier studies conducted, with data collected from the same stations. For example, Frimpong, Oosthuizen, and Van Etten (2014) and Issahaku, Campion and Edziyie (2016) have all noticed a statistically significant rise in the mean annual temperature in the Upper East Region, and the Bawku Area in particular. Specifically, as found by this study, all weather stations recorded increases or rising trends in terms of annual temperature, even though mean monthly temperature did not necessarily follow this pattern. It had earlier been found by Frimpong et al. that while the temperatures at two stations (Manga and Garu) were significantly rising, there was an inconsistent pattern of trend observed at the third station at Binduri (p. 69). Again, as found by Frimpong et al., Garu's temperature increased higher than all the other two areas.

The findings of this study largely corroborated those of Frimpong et al. as Mann Kendall Trend Test of the annual temperature of the three stations revealed a rise in temperature, particularly at Garu and Manga, while Binduri's showed some statistically insignificant declines (≥ 0.05).The reality is that projections made by some of these studies done at these locations by especially, Issahaku et al. (2016) and Tachie-Obeng, Gyasi, Adiku, Abekoe, & Zierrogel (2010), suggest that temperature will increase with a reduction in the number of cool nights and an increase in the number of hot days.

It was obvious that some substantial amount of rainfall was recorded since 1976. This has been evident in the positive nature of the linear (mean rainfall) trend line, even though these have not been very significant, especially at the Binduri weather stations. In particular, Binduri have experienced very erratic pattern of rainfall, with the mean annual values falling to as low as 41.9mm even in the wet season of 2010. These observations have been made by Jung and Kunstmann (2007) and had further predicted that a moderate increase in rainfall is expected in the coming years in the northern regions of Ghana. Kundzewicz et al. (2007) similarly have predicted a more seasonal rainfall, with prolonged dry periods between rainfall events in the Savannah regions. Perhaps, the 2007 flood, experienced in the northern regions of the country, which affected about 332,600 people and caused the death of 56 (Kankam-Yeboah, Amisigio, & Obuobi, 2010) was a confirmation.

This finding however contradicts those found by some other authors who report a decreasing trend of rainfall in the area (EPA, 2015; Issahaku et al., 2016). For instance, the unimodal nature of the rainy season and general decline of it has been found by Issahaku et al. similarly, Ghana's EPA earlier had realised a variation in rainfall, and had projected a further reduction of rainfall figures on average between 2.8 percent and 10.9 percent by 2050 in the Savannah agro-ecological zone.

Whether an increase or a decrease in rainfall pattern may mean nothing to the residents of this part of the country (the Bawku Area) because this may not necessarily translate into abundance of water resources due to the increase positive trend in temperature which are seen to be more significant than that of the rainfall. This significant rise in temperature trend is likely to increase the rate of evaporation, drying up any amount of rain which will fall.

Residents' perception of climate change

The study sought to find out residents' understanding of the climate change phenomenon. Changes in temperature and rainfall patterns were mainly used as a measure of climate change. In some respects, residents' observations or assertions on rainfall especially, contravened those analysed from meteorological data. This was not unexpected since according to Ovuka and Lindqvist (2000), in most cases, residents' perception and findings from meteorological data analysis, do not always match.

Yet, there was a general concern by respondents that their climate has been changing, a phenomenon, some attributed to the global climate change. This, according to respondents, were observable through the significant changes in the rainfall and temperature patterns experienced over the years in the communities. For example, respondents complained about the reduction and the erratic pattern of rainfall. Some were equally worried about increased intensity of the rainfall sometimes. Farmers, especially lamented that while it barely rains, high intensity of rain sometimes occur, and causes havoc to their crops. According to respondents, it was common to have their farms flooded during such heavy downpours. Some of the worries of respondents are carried in the quotes below:

> *We are all experiencing this harsh weather condition that we call climate change...Yes, the small amount of rainfall we experience is due to climate change…*
>
> (79 years old male opinion leader, Kuka)

For about three or more years now, it does not rain very much here. And when it does too, it doesn't rain anymore in March, April or May as we used to experience when I was young. Even for the past 10 or 15 years, it was better as compared to these past years. In fact, the climate has changed significantly!

(A 75-year old female FGD participant, Aniisi)

Those days we used to plant in April when it starts to rain, but now we plant in June since the rains starts around this period. These days, just when we start planting with the onset of the rain in June, the rain will stop in August. When this happens, our crops get damaged. We don't get anything like how we used to be in the past when it was raining in April. And sometimes too, it rains for about a month continuously and spoils our crops. The same is the case when it fails to rain for months.

(53-year old female FGD participant, Zabugu)

Regarding high temperature, respondents agreed that it has also been changing significantly over the years. They reported that long period of intense dryness with severe consequences characterises most part of the year. A 35-years old opinion leader in an interview at Pialugu had this to say about the temperature in the area:

Out of the 12months, the rainy season takes only 3 months. The rest of the year is dry. What we experience during dry season is

> *high temperature. That is the period when you experience heat and severe hamattan around November to this time (February).*

This experience was confirmed by a 37-year old officer at the Municipal Agricultural Office at the Garu-Tempane District, that:

> *We are currently experiencing high temperatures. Just about three months ago (November), it wasn't this severe, but now, we are really experiencing the high temperatures. This condition makes life difficult for all of us in this area…That is the global warming we have been talking about.*

Indeed, respondents' awareness of the phenomenon of climate change is in line with Ndamani and Watanaba's (2015) conclusion that farmers in general are knowledgeable about climate change. Again, the finding is consistent with those made by Limantol, Keith, Azabre and Lennartz (2016) and Ndamani and Watanaba that the use of changes in rainfall and temperature patterns as a measure of climate change by smallholder farmers in most developing countries and Africa to be specific, is common.

Summary

Over the period of 40 years, 1976 to 2015, the study found that the climatic factors, temperature and rainfall, of the Bawku Area in the Upper East Region have been changing. The area experienced a considerable amount of rainfall in all years especially during the wet seasons. At least, there was over 100mm of rainfall during the wet seasons. The 2007 rainfall figure of 224.1mm at Garu attests to this. Yet in the dry seasons, the value could drop to as low as 3.5mm as recorded in the year

2008 at Binduri. However, similar trend could not be said about temperature values in the area. It emerged from the study that the mean annual temperature in the area have witnessed a rise with the average values – 28.480^{0}C for Binduri, 28.9^{0}C for Garu, and 28.72^{0}C at Manga. Indeed, Garu among the three stations, witnessed high values in temperature, and was confirmed by the pronounced positive change of 4.31% in mean annual temperature in 1988. In all these, the eventual outcome of the erratic patterns of the rainfall values and the increasing temperature figures was water scarcity phenomenon since the high temperature meant high rate of evaporation.

It was obvious that the responses of residents in the study communities did not wholly agree with some of the rainfall and temperature data analysed. For instance, whereas the climate data from the agency showed a slightly increasing amount of rainfall in communities, there were contradicting views from the respondents in the communities. Conversely, the two sets of data (from agency and community respondents) were in agreement with the temperature pattern. This was made known through the discussions of residents' perception of climate change.

Regarding respondents' view on climate change, temperature and rainfall patterns were the two main indicators for assessment. Respondents in the communities studied were generally worried about the high or increasing temperature, and the erratic and decreasing nature of the rainfall pattern. These extreme climatic event, according to them, have had negative impacts on their day-to-day activities, especially, farming.

CHAPTER SIX

WATER SOURCES FOR RESIDENTS AND THEIR ADAPTATION PRACTICES TOWARDS WATER SCARCITY CONDITIONS

Introduction

This chapter discusses the various sources from where respondents source water for their agricultural and domestic activities. The issue of water scarcity situation, and the strategies used by residents to adapt to the perceived water scarcity challenges emanating from climate change/variability are discussed in this chapter. The chapter is presented under the following headings: water sources and use, residents' perception on water availability and water scarcity situation in the Bawku Area, implications of water scarcity for food crop production and animal rearing, and residents' adaptation mechanisms to hydro-climatic events or water scarcity situation.

Water Sources and Use

According to Steduto, Faurès, Hoogeveen, Winpenny, & Burke (2012), there is uneven distribution of water over, time and space, and that, greater proportion of global water resources available for use is far away from population centres, or in places where demand is low. This occurrence could be interpreted in the light of two major factors – natural and anthropogenic. The natural annual volumes of flow, their distribution in time and space depend on climatic and geomorphological conditions. For several reasons, the availability of water for human use is much less than the total water flowing into various systems (Steduto et al.). However, anthropogenic interventions can increase the volumes of water available for use through water control mechanisms including the construction of reservoirs such as dams and ponds, and the drawing of water from underground water storage systems.

This section discusses the sources of water and use of the same by the residents of the study communities. The relevance of this section is informed by the fact that access to water sources has been linked to an improvement in the quality of lives of people (Ishaku, Rafee-Majid, Ajayi, & Haruna, 2011). In order to identify and map the types of water sources for each of the communities, point and line data were picked with Tremble GPS device for this studyRespondents were asked to indicate their sources of water for their various activities. The following sources of water were identified, (Table 11).

Table 11: Water sources in the study communities in dry season

Community	District	Borehole	Well	Dam	Stream
Yaanatinga	Garu-Tempane	1	0	0	0
Pialugu	Garu-Tempane	1(1*)	0	0	0
Kuka	Bawku Mun.	2	0	1(3*)	0
Zabugo	Bawku Mun.	3	1	0	0
Anisi	Binduri	2	1	0	0
Yirigungu	Binduri	2(2*)	4	0	0
Gabuliga	Bawku West	1	1	0	0
Apotdabogo II	Bawku West	2(1*)	1	0	1

Source: Field survey (2016) * = Broken down or dried water source

Rain water

The responses gathered from the study participants showed that rain water was the major source of water, especially in the rainy season. While this source provided water for domestic activities, it was also found to be the major source of water for agricultural activities, be it crop production or livestock rearing. Thus, farmers prepared their land in anticipation of the rainy season in May/June-August/September, and sowed their crops accordingly. This opinion is captured in an expression by a 48-year-old female farmer in an FGD at Zabugo:

> *As for the rainy season, we don't have any problem at all because we are all able to get water for everything we do. That is the period you see all of us busy with our farm work. We plant in order to take advantage of the short period of rain, because if you miss it, life will be unbearable for you.*

For livestock rearing, the study revealed that animals graze and drink water without travelling long distances since fodder and water are always readily available. The period is seen as an opportune time to engage in crop production and animal rearing with less stress since farmers do not spend much time to take their livestock out in search of water and fodder. A 49-year old respondent summarises this view in the statement below:

> *During this time, there is always grass for them to graze, and the children will lead them to drink water in the dam. We therefore have enough time to concentrate on the crops.*
>
> (Male FGD participant, Kuka)

Specifically, relying on the rain water for farming is consistent with the notion that agricultural practices in Ghana, as is with most developing countries is rain-fed (Diao, 2010; CARE International & Adaptive Learning Programme [ALP], n.d.). And according to Awen-Naam (2011), farmers are always eager to meet the rainy season to start the cultivation or planting of crops.

Domestic use of rain water was common in the study communities. Rain water was harvested largely by women and children for drinking, cooking, bathing and washing. Whereas in most rural communities, fetching of water for domestic use have been the duty of women and children (Jean-Charles, 2007; World Overview of Conservation Approaches and Technologies [WOCAT], 2014), same could not be said about rain water harvesting, as some men indicated that there was nothing wrong for them to help their wives to harvest rain water when it became critical to do so. In all the study communities, this source of water was harvested with buckets, barrels and large basins. Response from some focus group discussants summarise these thoughts as follows:

> *It is only in the rainy season that you will see our barrels and buckets filled with water for our domestic activities, since we are able to collect enough water when it rains. Apart from that period, you will always find empty buckets here, unless you go and queue for long period at the borehole.*
>
> (45-year old female FGD participant, Yirigungu)

Why do you have to sleep at night for your wife and children to collect rain water when the water is meant for all of you to use? It is only the small children that I don't wake up in those times, but for the rest of us, we all wake up to collect the water so that the woman will not go and fight at the borehole site.

(36-year old male FGD participant, Apotdabogo II)

This finding corroborates that of Kabo-Bah, Andoh, Odai & Osei (2008) and Siabi, Van-Ess, Engmann, Mensah, and Tagoe (2013) that rainwater harvesting has been practiced for long in most homes in Ghana, and that, small water storage containers are normally used to collect and store water during storms.

This finding also show that water from streams were only available to residents in the rainy season, and got dried up in the dry season. About 2 or 3 months after the rainy season, these streams dry in such a manner that residents are only able to dig temporary dug-outs at the beds of the streams to get water for irrigation. Hence, residents did not see them (streams) as any reliable source of water. This notion is summed by a 55-year old male farmer at Pialugu in a focus group discussion. He noted:

You can't call that a river! We get water from it only in the rainy season, but after two or three months after the rains, you don't see it again. It totally dries up. Unless you dig in the bed to get some small water to irrigate your crops, you only see water in it again in the next rainy season.

This phenomenon has been reported by Liebe, Andreini, van de Giesen and Steenhuis (2008) that in rural semi-arid areas including the Upper East Region of Ghana, temporary wells dug into the beds of dried up rivers are really widespread, and are used to especially support dry season agricultural activities.

Boreholes and hand-dug wells

The study further revealed that apart from rain harvesting, underground water sources were also used the respondents. This source of water was accessed from mechanised boreholes (herein referred to as boreholes), wells, and sometimes, dug-outs. From the discussions, it was clear that boreholes were the major source of water for domestic activities in all the sampled communities. In spite of a number of broken down boreholes which were common in communities such as Pialugu, Yirigungu and Apotdabogo II, every community had at least one functioning borehole to provide them with regular water supply for domestic purpose. Apart from the few boreholes provided by government, most of these boreholes were provided by non-governmental and faith-based organisations. An opinion leader at Yaanatinga confirms with the expression below:

> *Our main source of drinking water is the borehole...It is not sufficient for us! How can one borehole be sufficient for a whole community? We applied to the NGO* [World Vision Ghana] *to give us another one.*
>
> (Opinion leader, 90 years old, Yaanatinga)

In relation to this finding, Oboubie and Barry's (2010) asserts that most boreholes in rural communities in northern Ghana are provided by non-governmental organisations (including World Vision Ghana). Specifically, Amisah, Khalatyan, Kiango, and Mikava (2002) support with findings made in the Upper East in a study that households in the region are mostly supplied with drinking water from boreholes which are provided by different organisations such as religious associations, NGOs and government funded projects.

As it is typical of most rural communities in developing countries, fetching of water from nearby boreholes was assigned to women and children (Jean-Charles, 2007; WOCAT, 2014). Thus, women and children used buckets, basins or gallons to fetch water (see Figure 31) to their houses for drinking, cooking, bathing, and dish washing. Other times too, some women and children had their clothes washed at the borehole.

Figure 31: Women and children fetching water at a borehole at Kuka

*[Note the presence of the cattle. These livestock were always found at the boreholes to drink water from the water troughs whenever people gather to fetch water. This was major means through which the livestock get water to drink in all the study communities].

Source: Field survey (2016)

All the communities studied faced a challenge of relying on inadequate number of boreholes or broken down ones, resulting in complaints from respondents about the inadequacy of water for their domestic activities. For instance, a 35-year old female FGD participant from Gabuliga lamented that:

> *We have been relying on the only borehole in this community for more than 30 years now. We have never had a new borehole in this community...the water in the borehole has never been enough for us.*

Responses gleaned from the study participants revealed that broken down boreholes were fixed with monies contributed by residents. But at the time of the study, residents had given up on these contributions since the boreholes continually breaking down. Residents claimed they had no money to be paying for the high cost of repairs. One Ayisha (pseudonym), a 57-year old female discussant confirmed this at Pialugu in an FGD:

> *When the borehole broke down initially, we contributed GHC 1 each to fix it. As we are talking with you now, the borehole is broken down again, but we don't have money to repair it again. We always repair it, but within a short time it breaks down again.*

To supplement the inadequacy of the mechanised boreholes, it was found from the study that residents constructed hand-dug wells at some locations in the communities. However, most of these wells were almost dried-up in the dry seasons because residents are unable to dig deep enough through hard rock surfaces or places to source water from the lowest point of the aquifer. For instance, a 45-year old female discussant of a FGD at Yirigungu said that:

> *Our husbands have dug so many wells in the community but only a few of them give us water. The rest are just wasted efforts. It is difficult to get a good place for water because the whole of our community is rocky.*

In fact, the reliance on boreholes and hand-dug wells by the three region in northern Ghana has been noted by Kortatsi (1994a) whose table on “Distribution of boreholes by region as at 1994” saw the three regions scoring the top positions of having the highest number of boreholes in Ghana; Upper East (1680), while the Northern and Upper West regions both had 1350 boreholes. Perhaps, this pattern has not changed that much since from the 2010 Population and Housing Census, the GSS (2012) reported that higher proportions of households in Upper East (70.2%), [followed by those in the Upper West (67.9%)] use protected wells and boreholes as their main sources of drinking water.

Apart from the use of boreholes and hand-dug wells for domestic activities, the source was also used for agricultural purposes. In other words, residents relied on boreholes and hand-dug wells to irrigate their farms, as well as to feed their livestock. This however was not a reliable means of farming since water was always not enough for domestic use. This view could be found in an expression by a 57-year old male FGD participant at Yirigungu as quoted below:

As I talk to you now the wells are dried up, and we can't farm. We dig the well so that we can get water to plant our crops, but now we can't talk of any farming at this time because there is no water in them. We only depend on one borehole during the dry season. Imagine a whole community sharing only one borehole. We put a lot of pressure on it.

Dam water

Another important source of water for the study communities was dams. It was observed that dams were scarcely found in the communities studied, and this was attributed to the fact that government alone was not well resourced to construct them for residents. This assertion was confirmed in an interview by an officer at the Upper East Regional office of the Ghana Irrigation Development Authority, who said:

No, I can't say we have enough. And we can't have enough now because of limited government resources.

Though dams were not found in all the communities, it was found to be an important source of water for agricultural activities in communities where they were present. Thus, farmers, especially those at Kuka, largely relied on a community dam during the dry season for the cultivation of vegetables (Figure 32).

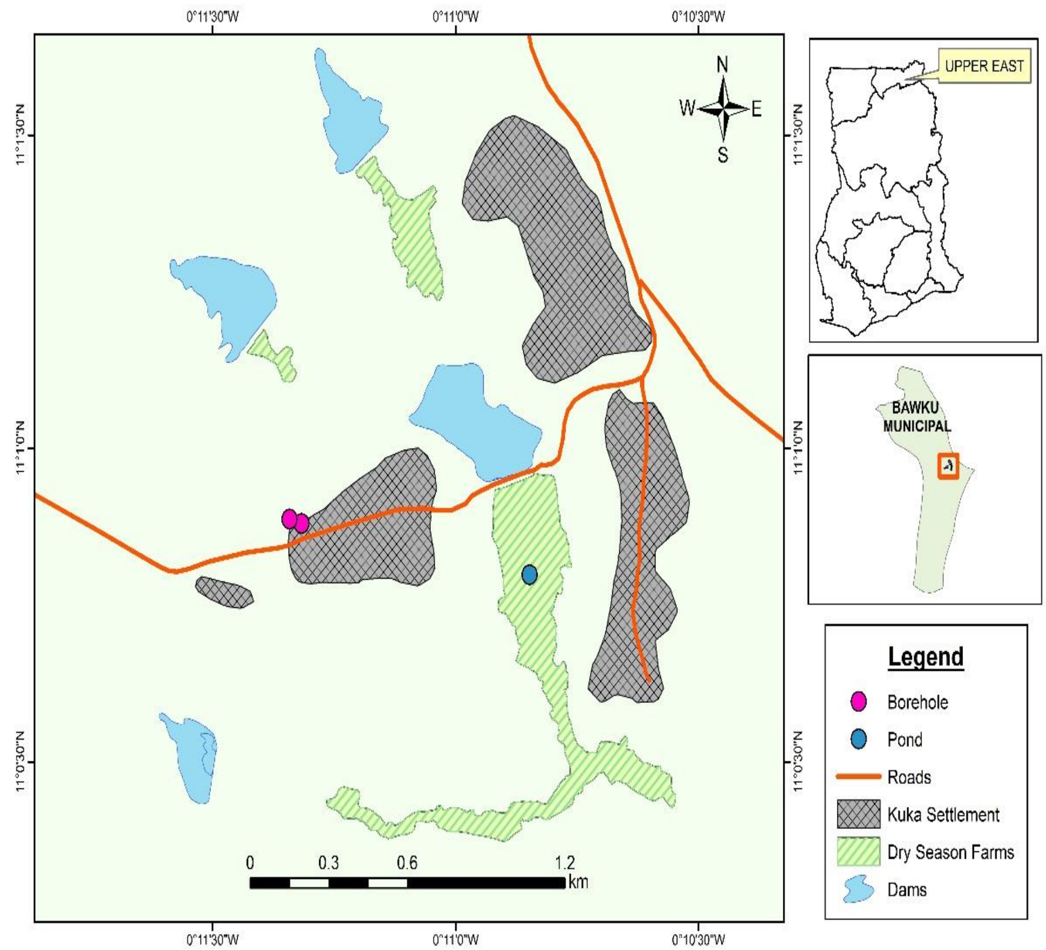

Figure 32: Map of Kuka community, showing water sources and dry season farms.

Source: Cartography Unit, DGRP, UCC (2016)

In all, four dams were identified at Kuka. Out of this number, only one was allowed to be used by the community (Figure 33), while the remaining three were strictly used by the Ministry of Food and Agriculture (MoFA) for nursing crops and planting seedlings for their afforestation projects in the Bawku enclave. Farmers were able to get access to the community dam for their dry season vegetable farming by channeling the water through some constructed vents or tubes (Figure

34B & 34C). A 79-year old opinion leader at Kuka in an interview confirmed this assertion and said:

> *In this community, we have as many as four (4) dams, and this is the largest one* [pointing to the direction of one of the dams in the community]. *There are other three which belong to the Ministry of Food and Agriculture.*

Figure 33: The community dam at Kuka. [In the picture is the researcher standing at the bank of the dam].

Source: Field survey (2016)

Figure 34 (A&B): Tube and canals to source water from dam to farms at Kuka; (C) – Irrigation channels at an onion farm at Kuka.

Source: Field survey (2016)

Even though Gabuliga in the Bawku West District had no dam (Figure 35), they always benefited from the overspill from a nearby dam at Binaba. The overspill came to Gabuliga in the form of a stream which farmers channelled to their farms. But the availability of water from this dam for their activities was dependent on events that took place in the upstream community of Binaba.

At the time of the study, a dam which was funded by the Municipal Assembly was under construction at Zabugo (Figure 36A). Farmers hoped to have some amount of water collected in the dam they were constructing in order to aid them in their farming activities during the dry season.

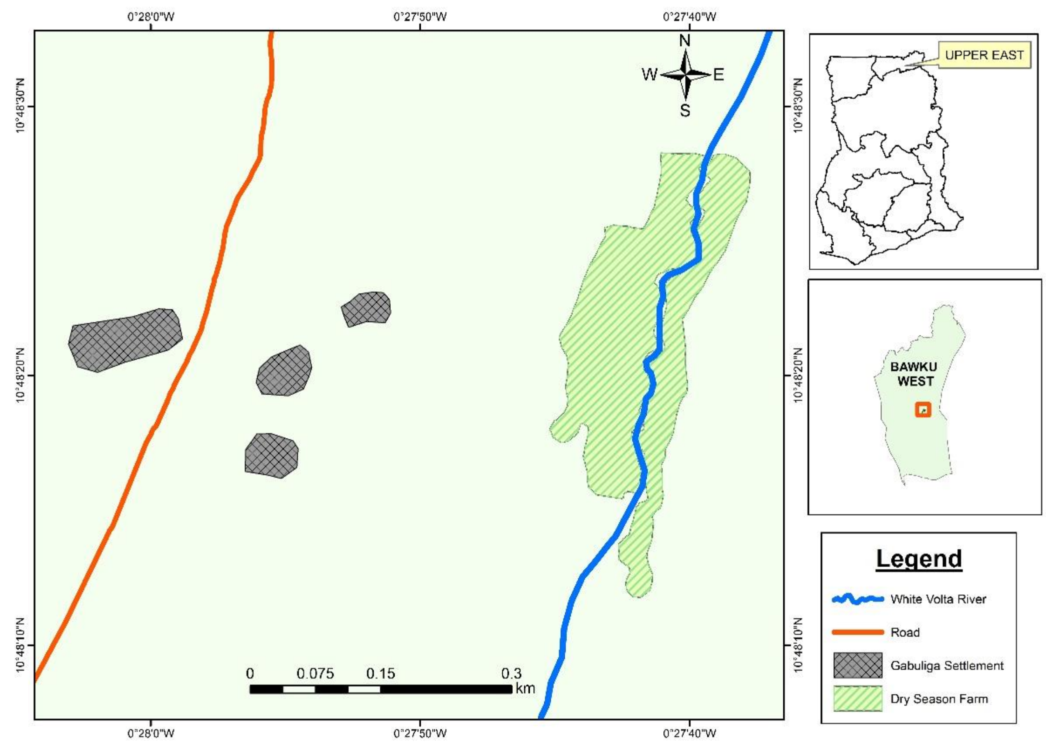

Figure 35: Map of Gabuliga community showing water sources and dry season farms.

Source: Cartography, DGRP, UCC (2016)

On the other hand, a low-lying (a depression) location where volumes of water were collected during the rainy season was used as a dam by residents and farmers at Yirigungu (see Figure 36B). However, this improvised dam was able to serve its purpose only for a short period of time. Thus, just about two months after the rainy season, the 'dam' becomes dry. The statement below summarizes the views of residents concerning the situation of the 'dam' at Yirigungu.

> *Our sources of water are from wells, boreholes, a 'dam' and a river which is currently dried up. As for the dam, you don't see it anymore after the rainy season; it dries up completely just*

about two months after the rainy season, and for that matter, we are unable to farm in the dry season. As you can see, we are just sitting down like lazy people, but we are not lazy at all!

(A 39-year old male FGD participant, Yiringungu)

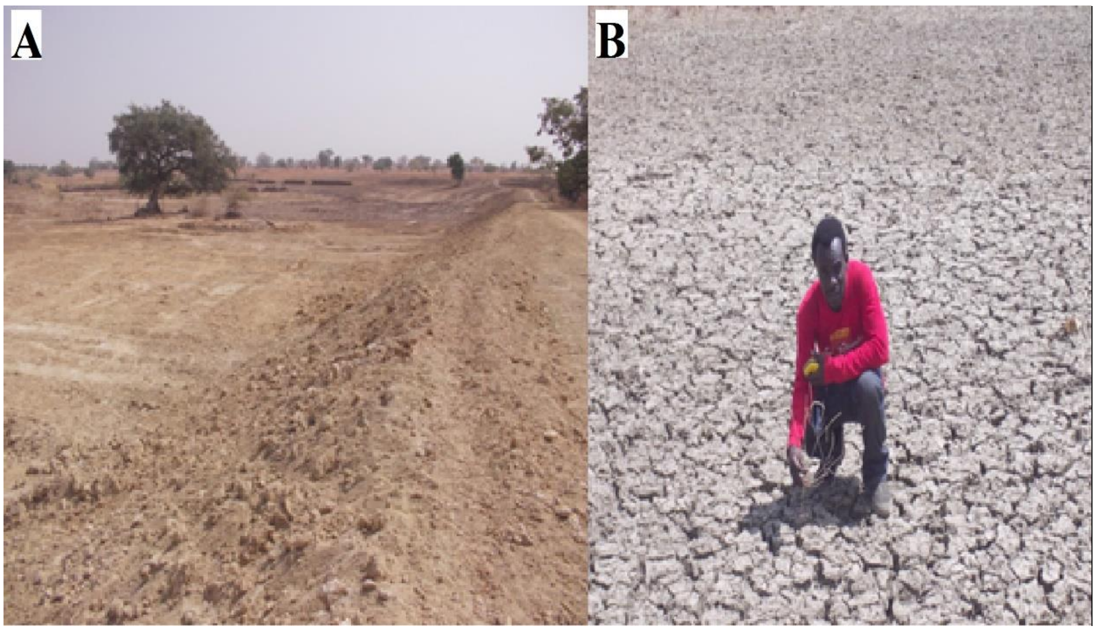

Figure 36: (A) Dam under construction at Zabugo; (B) – Researcher at the dried community 'dam' at Yirigungu.

Source: Field survey (2016)

Dug-outs

Dug-outs were very common source of water in the sampled communities because it could be found in almost every dry season farm or garden one comes across. Though they came in their numbers, most of dug-outs were dried up, forcing farmers to dig at any space at their farms with the hope of getting. This situation was very common at Zabugo and Pialugu (Figures 38), but not at Kuka because of the presence of the community dam.

A 56-year old male respondent affirms this in a FGD at Zabugo as follows:

> *Because our streams are always dried up we normally reserve portions of our gardens for dug-outs in order to get water for out crops. But in most cases, these dug-outs dry up at certain stage of the season.*

Attempt of dug-outs at Yirigungu and Yaanatinga was uncommon since it proved almost always a difficult task and impossible to get water. In the case of Yirigungu, farmers faced a challenge of digging through rocks which characterise the area (Figure 37).

Figure 37: An image showing the rocky nature of Yirigungu landscape.

Source: Field survey (2016)

Figure 38: A dug-out in a vegetable farm at Zabugo in the Bawku Municipality
Source: Field survey (2016)

Respondents' Perception of Water Availability and Scarcity Situation

Generally, respondents reported that the climate change, which they experienced, and visible in the reduction in rainfall and increasing temperature in their communities, have had adverse effects on them in terms of availability of water for their regular activities – agricultural and domestic use. These climatic extreme events have led to drought, which eventually results in drying up of rivers, dams, wells, and dug-outs (Issahaku et al., 2016). In fact, dried up streams, marshy areas, dams, wells, and dug-outs were observed and reported by respondents at the time of the study, resulting in these communities faced with water scarcity situations.

For instance, at Kuka, water channels connected to the community dam were not open to full capacity probably due to the low water level resulting from relatively low rainfall. From Figure 39A, it is shown that during its full capacity, the water level could reach up to about six to 10-feet, as indicated by the pointer. Yet, during the prolonged dry season, the water level falls as low as one or two feet.

Figure 39: (A) – A stick pointing to the level of Kuka dam at full capacity; (B) – Receding water of the Kuka community dam; (C) – Some dried portion of the Kuka dam.

Source: Field survey (2016)

Evidently, farmers whose gardens were quite far from the water channel were at disadvantage since they could not easily get water to their farms for use.

Such farmers in most cases had their vegetable crops withered or destroyed. A female farmer in the community lamented that:

We have a dam in this community that we use to irrigate our crops, but it is almost dried up. There used to be enough water in the dam, but that is not the case now. Even when they opened the dam, those of us whose farms are a little bit distant away from the channels of the dam are not able to get water to irrigate our crops. This leads to our crops getting damaged.

(Female FGD participant, Kuka)

In communities such as Yaanatinga, Anisi, Yirigungu and Apotdabogo II, the water scarcity challenge was deeply felt because respondents reported that apart from rainwater, water from dams, hand-dug wells and streams were either not enough or totally dried during dry seasons. In the case of Yaanatinga, water could only be collected in gullies (Figure 40A), which is used for only some few weeks after the rainy season. Though residents tried to dig wells in one of the tributaries of the White Volta, in most cases, they are not able to reach the water table. Yiringungu's situation (Figure 40B) is quite challenging because in addition to dried-up wells, the area is entirely rocky. This made it extremely difficult to engage in farming during the dry season. Below are some of the concerns expressed by a number of respondents in FGDs at Yaanatinga and Yirigungu respectively:

We don't engage in onion farming here. Where do we get water to do that? What other women do in some communities is to dig small wells to get some water for their crops. We don't have enough water *to drink and prepare food, not to even talk of water for our crops. We don't also have something to do to support ourselves. We just have to sit idle during the dry season.*

(28-year old male FGD participant, Yaanatinga)

In the farms where we cultivate onion, we dig wells so deep just to get small water to irrigate our crops. Sometimes we don't get any. It is just a pity.

(30-year old female FGD participant, Yirigungu)

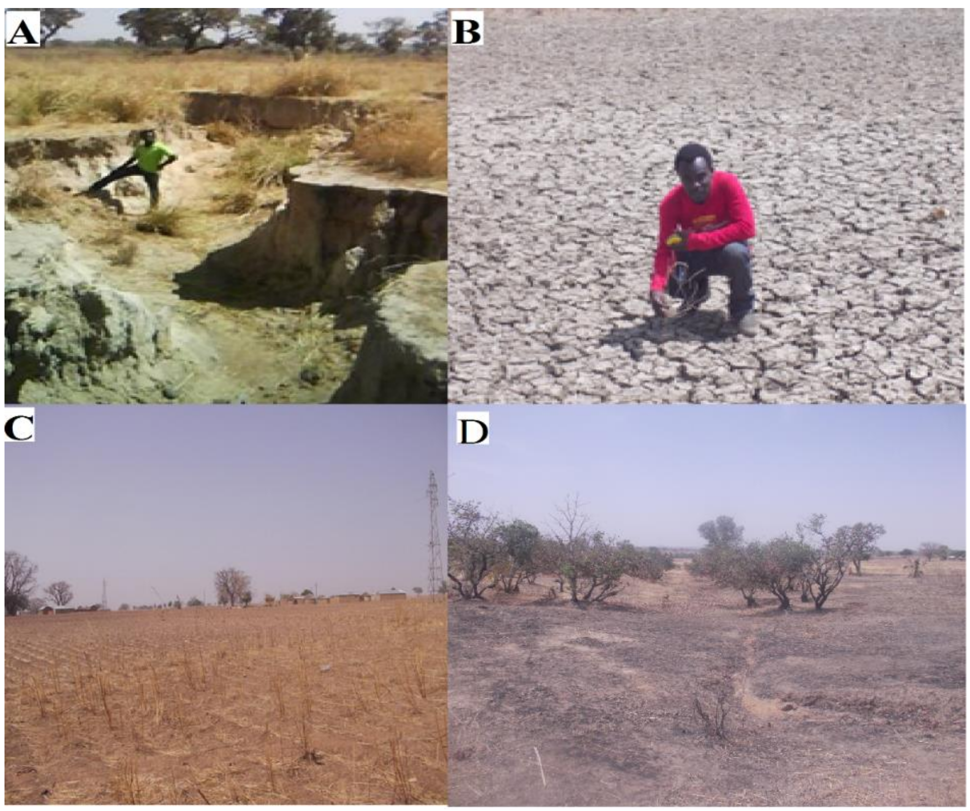

Figure 40: (A) – Gullies at Yaanatinga where water is collected during rainy season; (B) – A dried 'dam' at Yirigungu; (C & D) – Dried farms/environments at Anisi and Apotdabogo II respectively.

Source: Field survey (2016)

Like Yiringungu, Anisi had no dam nor stream for farmers to collect water from for their dry season vegetable farming. With the exception of the community mechanized boreholes, the only hand-dug well in the community had dried up. The situation at Apotdabogo II was not different from that of Anisi. Farmers only had to wait on the rain to be able to start their farming activities since a number of boreholes had broken down. Efforts to dig wells or dug-outs at Apotdabogo was seen as a wasteful one since much as they tried, they found it difficult to access water. According to respondents, this has been the case in the past five to ten years, and their community had become too dry for any meaningful farming (Figure 40C and 40D). These frustrations are captured in the quotes below:

> *We don't have a river or a stream in this community to irrigate our onions. We dig small wells at the gardens in order to get water to irrigate our crops, but even with that, we hardly get water at the peak of the dry season. This has been the case for close to ten years now. This community is not like other communities where they have rivers or streams to irrigate their crops.*
>
> (46-year old female FGD participant, Anisi)
>
> *We have been getting water from boreholes which were constructed for us since the era of Former President Acheampong* [between 1972-1978]. *We have about 5 or 6 of them spotted in so many areas in the community. But as I am talking to you now, we have just two of them working, and this is woefully inadequate…As for dam, we don't have at all…we used to dig wells to support us*

to farm in the dry season, but for about four years now, we are not able to do the farm because we can't get water in the wells. You can go round and you will see a lot of dug-outs around people's farms but there is no water in them.

(Opinion leader, 50 years old, Apotdabogo II)

This periodic extreme weather events and weather related disasters, such as high temperatures, highly variable and erratic rainfall, long spells of droughts, as well as late start of crops cultivation have been reported by Simon and Arkum (2013) in most communities in the Upper East Region, including the Bawku Area. On the other hand, other studies by CARE International and ALP (n.d.), Rademacher-Schulz and Mahama (2012), and Yaro (2010) have specifically mentioned that rainfall, which is the main source of agricultural activities in Ghana and most developing countries have been erratic and for that matter, not favourable for growing crops and rearing animals. This assertion corroborates the findinds of this study.

Ghana in general may not be described as water stressed or scarce region when measured in the light of the scientific indicators (Falkenmark, 2013a; 1989; UNEP, 2002). Yet it will also be erroneous to admit that the respondents in the communities studied were not faced with water stressed conditions, when judged from 'drought' conditions observed and reported by the study participants. Furthermore, since water scarcity is often described as socially-constructed or relative concept (Noemdoe, Jonker, & Swatuk, 2006), the assertions of the respondents in the Bawku Area is difficult to be dismissed. In other words, their conception of water scarcity is in line with notions expressed by other authors who perceive that water scarcity occurs when there is an imbalance between water made available (natural runoff) and the water needs of a people within a specific period of time, especially for their agricultural activities (Rijsberman, 2006; Schulte, 2014; Veldkamp et al., 2015).

While the three months of rainfall was inadequate for agricultural activities, it was observed that in spite of the occasional shortages, water for domestic activities was not scarce. This is in line with the assertion made by Rijsberman (2006) that since the total amount of water needed for domestic purposes is usually small, it cannot be affected by water scarcity.

Respondents' views on climate change as the cause of water scarcity in the Bawku Area was worth noting as it tied in with views found in other studies. Thus, it is important to note that several reasons account for people's perceptions about water scarcity situations in their localities. While other will attribute the phenomenon to climate change alone, others do not solely blame it on the changing climate, rather, a combination of some other unfavourable factors which may be interacting with climate change (Mudombi & Muchie, 2013). Yet, according to Nelson, Meadows, Cannon, Morton, & Martin (2002, p. 52), "it may be difficult to disentangle the effects of…long-term climate change" on water availability. This assertion is shared by Homer-Dixon (1994) and the UN-Water and FAO (2007), who agree that climate change is among the environmental drivers of water scarcity.

Some studies are available to support the perceptions of the residents of the study communities in the Bawku Area, that, climate change has been the main factor for the water scarcity situation they were facing. For example, residents of Seke and Murewa districts in Zimbabwe held the view that climate variability has had a major adverse impact on availability and access to water (Mudombi & Muchie, 2013). Also, there was a general acceptance among farmers at the Kakamega County, in Kenya, that climate change badly affected them in terms of water availability for their farming activities (Ochenje, Ritho, Guthiga, & Mbatia, 2016). Also on their part, Nguyen et al. (2016) reported that farmers in the Western Mediterranean Region largely believe that climate change has been responsible for both surface and groundwater availability, especially, for their farming activities.

Implications of Erratic Rainfall and Water Scarcity on Food and Animal Production

The erratic and reduced rainfall, and the long period of drought and water scarcity as faced by the people in the research locations have implication for food and livestock production. Although food crop production and livestock rearing are impacted by the harsh hydro-climatic events, food production seems to be severely struck since livestock is more resistant to climate change than crops due to formers' their ability to move to access feeds (Rota, 2009). At this section, the study focus on the impacts that the scarcity situations on agricultural productivity in the communities sampled for the study.

Food crop production

One major concern expressed by the respondents was food production. It was clear that access to water, particularly rain water, has an implication for food production. Thus, rainy seasons were moments for farmers to have access to enough food for their households, while the absence of rain, brought about dire consequences of food insecurity. While it was welcoming to approach the rainy season, it emerged from the data collection that respondents preferred the right amount of rain since according to them anything abnormal came with negative outcomes. Farmers lamented greatly about harsh hydro-climatic events of flood and drought because of their over reliance on rain-fed agriculture for their food supply. Some of these views are captured below:

> *…there is not enough water for us to do dry season farming. It doesn't rain that much in the rainy season for us to plant and get enough food for our families. We are just suffering!*
>
> (71-year old male FGD participant, Yaanatinga)

> *When it rains too much, it normally destroys our crops, especially, our sorghum farms. The crops are either washed away or get rotten. That explains why we had poor yield this year. On the other hand, scanty rainfall makes it difficult for us to farm and get food to eat and take care of our children's school fees.*
>
> (35-year old female FGD participant, Gabuliga)

> *I can say we are insecure in terms of food…I say so because when we struggle to get some small food to feed our children in the*

evening, then we start thinking of how to get food to feed them the following morning…

(75-year old female FGD participant, Yaanatinga)

The experiences described here is nothing different from those observed by other studies. For example, Al-hassan (2015) found that over-reliance on rain-fed farming is the major cause of food insecurity in northern Ghana. The UER is hard hit in this phenomenon because households in the region largely derive their food from their own staple food production under rain-fed agriculture, and sometimes from market purchase. Again, according to GSS (2014), food security challenge is not unexpected in the UER since agriculture and particular food crop production (mainly maize and other cereals) are done on subsistence basis. Hence, anytime there is scanty amount of rain than expected, food production is severely hampered, forcing households to depend on inadequate food stock until the next harvest. This is what Bilinsky and Swindale (2007) describes as a household suffering from food insecurity. It was therefore not out of place for the World Food Programme (2012) to conclude that food security situation in the UER is more pronounced.

Livestock rearing

Livestock and poultry farming is widely practiced in the study communities. Thus, cattle, goat, sheep, donkey and pigs, as well as chicken and guinea fowls are reared in this suitable environmental and climatic conditions (MoFA, 2004). However, with prolonged dry season, farmers in the Bawku Area are now presented with the challenge of keeping their livestock, especially cattle, in terms of provision of water and fodder for them. Water becomes very critical for the cattle especially after eating very dry grass which may require water for easy digestion (Mati, Muchiri, Njenga, de Vries, & Merrey, 2006).

From the data gathered, some livestock farmers and owners worried about lack of water for the cattle which sometimes resulted in their cattle drinking waste water from bathrooms, dying after long period of thirst, or getting lost or stolen in their attempts to search for water. At other times too, the cattle create conflicts within and among neighbouring communities. These occurrences were particularly common in communities such as Yirigungu, Anisi, Yaanatinga and Apotdabogo II. For instance, in a FGD at Anisi, a 42-year old female respondent summarized that:

> *Our animals suffer because of the scarcity of water. Because our animals eat hard food* (very dry fodder/grass) *...I think at least, a little water for them to drink after grazing could aid in easy digestion which will enable them to grow well. Some of the animals drink waste water from our bathrooms ...*

Several studies within the Sub-Saharan African regions have reported similar findings on these challenges faced by livestock farmers (Baah, Tuah, Addah, & Tait, 2012; Dossa, Wollny, & Gauly, 2007; Fakoya and Oloruntoba, 2009; Kaboré et al., 2011; Naadam & Mbilla, 2010; Safu, Apori, Elijah-Mensah, & Oppong-Anane, 2009; Turkson & Naandam, 2006). Specifically, Kaboré et al. submit that the major constraint for especially, small ruminant production in peri-urban area of Ouagadougou is thefts which result from the livestock's attempt to wander for water. Also, Senbeta (2009) found that drought and delay in the onset of rain often lead to poor regeneration of grass, water shortage and heat stress on livestock, increased mortality of livestock, vulnerability to diseases and physical deterioration due to long distance livestock travel for water and pastures. These notions are also shared by Dahal (2011) who reasons that long period of drought negatively impacts on the growth of palatable grass species for livestock.

Respondents' Adaptation Mechanisms to Water Scarcity Condition

Adaptation, which have, in recent times have gained popularity, is one of the strategies to respond to climate change. The strategy is resorted to so as to reduce the adverse effects of climate change on humanity (Bates et al., 2008). While several farmers are already adapting by planting different varieties of the same crop, changing planting dates, and adapting practices to a shorter growing season (Abid, Scheffran, Schneider, & Ashfaq, 2015; Stanturf et al., 2011; www.siteresources.worldbank.org), a number of these farmers' adaptations strategies are in response to dry spell, drought and flood. These claims are confirmed by Ndamani and Watanabe's (2015) study on farmers' perception about adaptation to climate change in the Lawra District of Ghana who reported that, their adaptation strategies in farming are informed by particularly, the long period of drought they experience.

It is worthy to note that a number of these adaptation strategies mentioned are not new inventions, as they have been the practice in several arid and semi-arid regions. For instance, Hatibu and Mahoo (1999) opined that rain water harvesting (RWH), defined by Boers and Ben-Asher (1982) as a means whereby local surface runoff are induced, collected, stored and conserved for agriculture activitied in arid and semi-arid regions, have been traditionally relied upon throughout centuries. Thus, by these methods of RWH, water has had to flow from normally dry water courses onto agricultural fields, as in the case of "Wadi" in the Middle East, while others dug dug-outs in their farms, etc. as means of sourcing for water for the farminig activities (Hatibu & Mahoo).

The study location is not an exception to these practices due to the nature of the ecological zone (Sudan Savanna region). However, respondents revealed that in recent times, they have had to increasingly rely on these means of survival because compared to some years back, rainfall had substantially decreased, while on the other hand, temperature keeps rising steadily within the past five to ten years. For instance, residents indicated that it is very common recently to come across so many dug-outs in one's farms, thereby, limiting space for the real farming activities. The expressions below affirm this claim:

Because it doesn't rain these days…when you dig the dug-outs, you don't get water…this used not to be so….

(A 42-year old female FGD participant, Zabugo)

The following discussions in this section therefore reveals some of these measure adapted by residents, who were mainly farmers, in the Bawku Area in coping with these extreme weather events (such as drought and floods) and the associated water scarcity situation in the four districts studied. Among the adaptation or coping mechanisms are on-farm activities such as dry season vegetable farming, and other activities such as picking of cow dung for sale, food storage, migration, etc.

Expanding irrigation agriculture/Dry season vegetable farming

In order for farmers to engage in the cultivation of crops during the long period of dryness, it was found from this study that respondents largely preferred and resorted to dry season vegetable farming as their main adaptation strategy. This is simply a practice where farmers would engage in the cultivation of vegetable crops in the mist of dryness using water sourced from dams and/or underground water, be it mechanized boreholes, wells or dug-outs. To be able to irrigate their crops, water was pumped from dams via tubes or tunnels to various farms. Largely, water from streams or dams that are channeled into the vaious farms of gardens are fetched with perforated plastic watering cans (Figure 41) to irrigate the crops. The expression below represents this general assertion:

> *We have a dam in this community that we use to water our crops. When the water gets to our farm, we use our cans to fetch it to irrigate our crops.*
>
> (Female FGD participant, Kuka)

Figure 41: A -Researcher holding a perforated plastic watering (A) can used by farmers in irrigating crop.

B – A man irrigating crops with water from perforated watering can.
C – A woman fetching water from a dug-out with a perforated watering can.
D – A woman irrigating crops with water from perforated watering can.
Source: Field survey (2016)

Communities without dams or individual farmers with no access to dams depend on upstream communities for water or use of underground water sources for dry season vegetable farming. For instance, farmers at Gabuliga had to rely on water from a dam in a distant community called Binaba. This meant that unless Binaba opens the spillway of its dam, the downstream community of Gabuliga, could not get access to water for their dry season vegetable farming activities. This assertion was confirmed by a 35-year old female FGD participant at Gabuliga who said:

> *…with our onion farming, we always have to wait for the people of Binaba to open the spillway of their dam before we can get water to irrigate our crops.*

Where downstream communities were hard-pressed, they either appealed to, or contributed money for up-stream communities to open spillways in order for them to get water for their gardens. This view is summarized here with a statement by another 30-year-old female discussant in the same FGD at Gabuliga:

> *We always contribute GH¢1 or GH¢2 per individual before they open the dam for us. If we don't pay, they will not open it for us…*

In other instances, where water had to be sourced from underground source such as wells and dug-outs, it is manually fetched with perforated plastic watering cans (see Figure 41) and/or cans fitted with ropes to draw water to irrigate crops. While this was reported to be a tedious practice, they had no option either. This was confirmed by some farmers in a FGD at Kuka in the Bawku Municipality where a 22 years old female recounted that:

> *We dig wells at our garden to water our crops. Just take a look at our legs, we dig wells from 6:00 in the morning to 6:00 in the evening in order to get water to irrigate our crops, and we all do this in other to survive with our families.*

Although the use of groundwater for irrigation is limited in Ghana (Oboubie & Barry, 2010), the practice is common in the three northern regions (Al-hassan, 2015; CARE International & ALP, n.d.). This measure was to reduce their over-reliance on rainfall as the major supplier of water for agricultural activities. As has been found in this present study, water from this source is used to irrigate vegetable crops such as onions. This is a practice which is found in other parts of the country including Accra Plains and the Keta Basin where Agodzo, Huibers, Chenini, Van Lier, & Duran (2003) submitted that ropes/buckets and low-powered irrigation pumps are usually used to draw water from hand-dug wells to irrigate shallots and other vegetables.

Aside the responses gathered from some IDIs and FGDs, it was observed from the study that both males and females were equally involved in the dry season vegetable farming practices. Thus, during this study, it was common to come across men and women equally involved in irrigating and harvesting of crops. They also indicated that, both sexes were involved in preparing the land and planting the crops. This they did, against the traditional notion that men are responsible for the clearing and the preparation of the land, and women are responsible for planting, weeding, fertilizer application, harvesting, and transportation to market centres, and marketing of the produce (Amu, 2005). The main motivation for the *"all-hands-on-deck"* practice where all household members would be involved in the dry season vegetable farming processes (Figure 42) was to make the best out of the little opportunity they have by way of the water available them, make enough yield for sale, and to sustain the household in the long dry season.

Figure 42: A woman and children working on harvested onions while researcher looks on at Kuka.

Source: Field survey (2016)

Changing planting periods and mixed-cropping

Apart from dry season, some farmers in the study communities tried to engage in early planting of crops in order to take advantage of available water and high moisture content of soil left behind by the rainy season. As described earlier, planting early seemed to be the major means of dry season farming for farmers at Yaanatinga, Anisi, Yirigungu and Apogtabogo II, where there is virtually no other source of water for farming purposes except rain water. This view was shared by an opinion leader at Kuka, during an interview session:

What we have advised ourselves to do is to try to plant early …For instance, as soon as the rainny season ends, we start the dry season gardens because at that time the water level in the dam will be good enough to serve everybody.

In another instance, farmers were engaged in the practice of mixed croping where more than one crop were planted on the same piece of land. With this practice, farmers had chances of falling on one crop if the other failed. This assertion was shared by a 59 years old officer at the agriculture office of the Bawku West District who said:

We used to cultivate early millet around May and harvest in July. Unfortunately, because the period of rainfall has shifted to June most of the farmers are no more cultivating the early millet. They rather wait and use all their resources to go into mixed cropping, where they do the cultivation of the early millet and other vegetable crops. At least with this, they are able to get some food if one crop fails them. With this strategy, they start the planting from the second week of June to the second week of July. Even, production from this practice has dwindled because of the decline in rainfall.

These findings are in line with those found by Hassan and Nhemachena (2008) and Ndamani and Watanabe (2015) who conveyed that in coping with climate change, some farmers in Africa vary their planting dates to periods when there is enough water in the soil. Furthermore, mixed cropping and diversification of crops as practice in most developing countries and arid regions are done because it allows smallholder farmers to avert risks associated with cultivating single crops, and maximize harvest security under unpredictable and unreliable climate (Abid et al., 2015; Babatolu & Akinnubi, 2016; Limantol et al., 2016; Mabe et al., 2014; Ndamani & Watanabe).

Cultivating drought-resistant crops

In response to their food insecurity needs, amidst the extreme hydro-climatic events, farmers engaged in the planting of drought-resistant variety of cereals. This has been advised by agricultural extension officers in the districts, as confirmed by the 59-year old District Agricultural Officer of Bawku West District who submitted that:

> *…we have also been encouraging the cereal farmers to go in for drought-tolerant varieties so that within the short period that the people plant them they should be able to harvest something.*

In most developing countries, farmers are fond of responding to harsh hydro-climatic events similar to their counterparts in the Bawku Area of Ghana. In Hassan and Nhemachena's (2008) paper, *"Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis"*, various strategies by farmers were spelt out. They included crop diversification, mixed cropping, varying of planting and harvesting dates, and the increasing use and expansion of irrigation systems.

Raising livestock with underground water sources and dried grass

The erratic rainfall pattern and water shortage challenges present opportunities of adaptation for livestock production in the study communities. In terms of accessing water for livestock, spill-over water was often collected and given to livestock to drink as a way to adapt. It was however common for farmers or concerned community members to pump water from the mechanized boreholes into a trough *attached* to the borehole for the animals to drink. It is therefore not surprising to see some livestock loitering around boreholes and/or wells (Figure 43). However, this source of water is often not enough for cattle, let alone a flock, as shared by a 35-year old female participant in a FGD at Apotdabogo II:

> *When we go to the borehole, we pump water into the borehole trough for the livestock to drink…If they don't get water to drink they can just die. That is the reason why we always have to pump water for the animals to drink.*

Also, a 39-year old male participant in a FGD at Yirigungu commented that:

> *When you see the livestock around the wells, it only tells you that they are thirsty. So what we do is to draw some of the water for them because if you don't do that, they try to get water themselves, and ends up falling in the wells.*

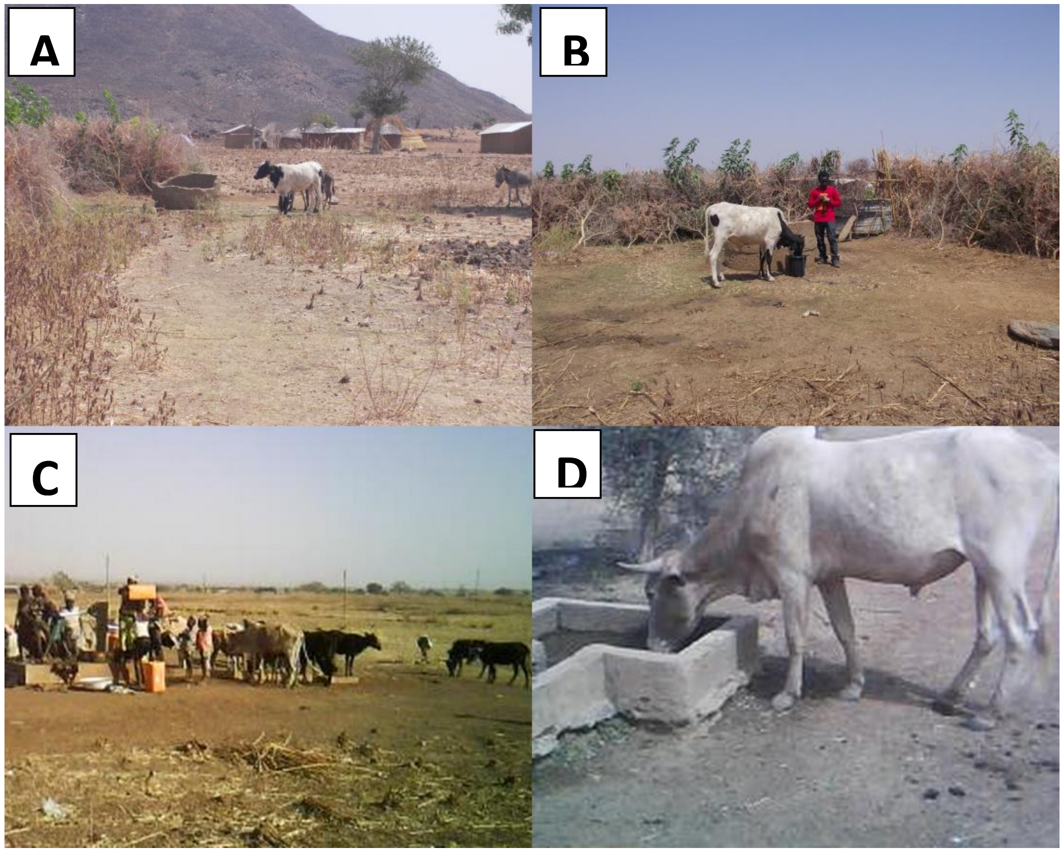

Figure 43: A - Livestock loitering around a well for water at Yirigungu

B – A cattle drinking water drawn from a well, while researcher looks on at Yirigungu.

C– Livestock loitering around a mechanized borehole while residents fetch water at Kuka.

D – A cattle drinking from a water trough at Zabugo.

Source: Field survey (2016)

Under normal conditions, one cow requires about 20 litres of water per day (Mati et al., 2006). Farmers complained they are unable to always come to the borehole to pump water for the animals since *"it is very stressful and tiresome"* (Opinion leader, Yaanatinga). The labour and stress in fetching water for livestock have been admitted by Ouma (2001), who believes that it requires two, three or more people to draw water from boreholes for large herds of cattle. However, the task becomes less tiring in areas where motorized pumps are fitted on wells or boreholes to pump water for the livestock.

Apart from water for the livestock, dried grass/fodder were greatly relied upon to feed the livestock (Figure 44). Again, it is worth noting that this was not a recent adaptation practice. This is because farmers admitted that they had always had to rely on dried grass or fodder for their livestock. They however acknowledged that in recent times, the practicehas almost become the only means through which they could get feeds for their animals. This is due to the non-availability of growing and fresh grass during the long dry season. Reasoned from the above, fodder is gathered by farmers as by-products from the cultivation of cereals (maize, millet, etc.), and are stored in barns or rooftops. The feed is then rationed to the livestock in such a way that the fodder can last through the lean season. A 40-year old opinion leader gives more insight on this issue and sums that:

> *"…livestock rearing which was a major activity in this community is retrogressing. Animals die because they don't get water to drink, and a field to graze. Conditions have indeed changed. Some years back, you would come and see our livestock grazing around from the field here. There was no need to even send them anywhere because there were grasses all over this place. Then, my father had a lot of cattle; but now, I can't even boost of five of them".*

Figure 44: Collected dried groundnut stalk (fodder) used as a feed for livestock

Source: Field survey (2016)

Community "Rationing" of domestic water sources

As already stated, the major source of water for domestic activities is boreholes that are provided to the rural communities by government, NGOs (especially, World Vision Ghana), and religious or faith-based organisations. However, the inadequacy of this source to support domestic chores compels residents to employ several strategies to cope with such scarcities. It was the responsibility of women and children to wake up early in the morning to queue for long hours for water. In some communities, agreements were reached among residents to ration water. The rationing was organised differently from one community to the other. For instance, while some communities would allow some households to fetch water at some times, others would allow individuals to fetch or draw few buckets or gallons of water at an instance. Yet the most popular practice was the first-come-first-serves basis of allocation. Though implemented by the women themselves, and supervised by the WUA, the practice has become necessary due to the limited water sources and quantity available to these rural dwellers. Of course, the adverse effects of these were obvious – quarrel among women and children, lateness and absenteeism from school by pupils, etc. Below are some of the concerns expressed by the women:

> *We don't get enough water from the borehole. For this reason, we manage it in such a way that, we fetch in the morning and fix a time in the evening so that when the water accumulates again, we come to fetch. If we are all going to fetch at the same time, we will not get water.... we normally quarrel and fight over queues at the borehole because of the water scarcity.*
>
> (35-year old female FGD participant, Gabuliga)

> *We make sure that not all the household come to fetch water at all times. Some are allowed to come in the morning, while other make it in the afternoon and evening. When the cycle ends, we re-organise ourselves…we really have to do that since the water in the well and the boreholes are not enough for use at all times.*

(39-year old female FGD participant, Yirigungu)

We barely sleep at night; we wake up very early to go and fetch water but there will be none.

(42-year old female FGD participant, Anisi)

This finding is indeed, not peculiar to the study communities in the Bawku Area of Ghana. It is seen as a common phenomenon for women to queue for water in the three regions in the northern part of the country, and any other areas where access to water is a challenge. Also in other countries in Africa such as Burkina Faso, Benin and Kenya, Canada's International Development Research Center (2015) has indicated that women and children not only walk several miles in search of water, they also have to queue and wait for hours in order to get their buckets filled. In the words of Waititu's (2009) in her feature article *Water and Women in East Africa,* "water collection has become a full-time job" for women in rural Kenya and other several countries in the region.

Though common and a 'normal' practice, women in the Bawku Area, due to the changing climate, have had to adopt this tighter measures in the past five years to making sure that the scanty water available to them are rationed in such a water that none within the communities will be left out in terms of water provision. The response of a 28-year female participant in a FGD at Yirigungu confirms this assertion. She indicated:

Getting water from the borehole has been very difficult these days…and that is because it doesn't rain these days…but that wasn't the case when I was in the Junior Secondary School. I *remember I could easily rush to the site [borehole] to fetch water to bath and go to school.*

Other supplementary practices: picking and sales, food storage

In addition to these, Al-hassan (2015) and CARE International and ALP (n.d.) mentioned that, when these attempts fail, irrigators and non-irrigators in northern Ghana resort to the sales of their livestock to purchase food. While this finding is undoubted, it was barely mentioned by farmers or residents in this study. Rather, respondents, especially females, mentioned selling of firewood, cow dungs and sometimes, shea butter, to buy food for survival. For instance, a female FGD participant at Yaanatinga explained that:

There is no support for us in this community. What we do is to manage and get some small money to buy a bowl of millet to feed our families…After the rainy season I don't think any of us still has even a bowl of their harvest left. Some of us go round to pick cow dung **(Figure 45)** *to sell and use the money to get some millet or maize to feed our families.*

(75-year old female FGD participant, Yaanatinga)

It should however be noted that shea nut extraction was not found to be a popular economic activity in the study communities since the *'tama'* (shea fruits) was not grown largely in these areas, and those who engaged in it commonly did it for household consumption. However, the practice of picking and processing of items such as 'dawadawa', shea, etc., according to Yaro (2010), is a common adaptation strategy in this area of the country.

Figure 45: Cow dung collected for sale

Source: Field survey (2016)

As an adaptation strategy, attempts were made to store up food for the lean season. It was also not uncommon to see farmers storing up food, particularly cereals such as millet, maize, sorghum, rice, etc. in barns or silos (Baare/Boore) (see Figure 46) and sacks with the view to depend on them during the scarcity period till the next harvest. The practice of storing up food has been an indeginous activity, yet farmers revealed that due to erratic and minimum rainfall, most of the storage facilities, especially the Baare/Boore spotted in their communities were empty since they barely get enough harvest, let alone to store the rest. The reserves they are able to realise were able to last just few weeks after the dry season.

Yes, we have been storing some grains after the harvest, but they are not enough…all these silos you see around are empty now.

(40-year old female FGD participant, Apotdabogo II)

Figure 46: Barn/silo (Baare/Boore) for the storage of food, particularly cereals at Apotdabogo II.

Source: Field survey (2016)

The phenomenon of food shortage in some households occasionally resulted in some sort of domestic disagreements and quarrels, as expressed by a 42-year-old female respondent, Fati (pseudonym) at Apotdabogo II, who said:

> *There is no water and food. The food we had from our farms during the rainy season has finished. We stored them in a barn, but as we are talking now, it is finished. We were only able to survive on it for about four months and that's all. You don't expect all of us* (about 17 people) *to feed on the small food we stored for a whole year. So*

it is finished. Whenever we are hungry and we complain to my husband, it doesn't solve the problem because he doesn't also have. This always leads to quarrels between us…

In the views of CARE International and ALP (n.d.) farmers in the northern part of Ghana scarcely are able to feed their households with the own harvest food crops since they (farmers/households) are barely able to produce more-than-enough of what they need.

Migration

Findings from this study also revealed that some residents from the Bawku Area resorted to migration as an adaptation strategy. Thus, young male household members and mostly students had to migrate to the southern part of the country during the drought season as means of survival for themselves and their households who were left behind. While some would return to the study communities after the drought, it was common for several of them to stay in their host regions for a very long time. As well, it normally marked the end of educational pursuit for the young ones who migrated. These are illustrated in the remarks below:

…I planted onion and it got spoilt because there was no water to irrigate the crops. Therefore, one of my children who was at the senior high school level had to stop schooling. I told him to stop the school and travel down south to get something to do. Should all of us lose? No! So he had to travel down south.

(53-year old female FGD participant, Zabugo)

This also affects our children significantly. Most of them travel down south during the dry season searching for jobs to do. At the end we lose control over them.

(40-year old male FGD participant, Yaanatinga)

The findings corroborate a common practice where some household members in the northern regions of Ghana migrate to the southern part of the country, particularly, Kumasi and Accra (Rademacher-Schulz & Mahama, 2012; Van der Geest, 2011), where presumably, favourable climatic conditions and job opportunities abound. Nonetheless, aside the pull factors prevailing in the south, migration to the south since the 1970s has been necessitated by drought in the northern regions (Antwi-Agyei et al., 2013). Specifically, migration has widely been adapted as a coping mechanism against climate change.

Summary

The findings in this chapter have indicated the various water sources for the communities studied. Even though it was considered unreliable, all the communities studied relied on rainfall as their main source of water for their agricultural activities. There were other sources of water including dams, hand-dug wells, dug-outs, streams, and mechanized boreholes available to the communities. These water sources were mainly used for dry season vegetable farming, as well as livestock rearing. Of course, the mechanized boreholes and water from the wells were mainly used for domestic activities, even though residents used it for farming purposes as well.

Water was generally perceived to be scarce in the communities studied since the resource was not available in the right or adequate volumes or quantities for residents to use for various purposes including cultivation crops, livestock rearing, and other domestic chores. The main factor that was noted to be responsible for this water scarcity condition was perceived to be the changing climate in the communities in particular, and the districts in general.

In the face of the scarcity, residents have had to rely on various adaption practices for their survival. Though the adaptation practices were not new as such had been resorted for many years. Yet residents indicated that the rate at which they had to rely on the adaptation practices have increased in recent years. For instance, residents engaged dry season farming, mainly to cultivate vegetables. Water was channelled to various farms mechanically (especially in Kuka) for irrigation. However, farmers in the other communities were manually drawing water with perforated plastic watering cans to irrigate their crops. They also varied or changed their planting period to coincide with the changing patterns of the rainy season. Some farmers also have to draw water from wells or dug-outs to feed their livestock which were mainly cattle, sheep and goats.

Other means of adapting to the water scarcity situation were storing up food in barns for the long dry and lean season. Others, predominantly females, also engaged in other economic ventures such as petty trading, selling of firewood or cow dungs, etc. It was also the reserve of mainly younger males to migrate to southern part of Ghana (Kumasi and Accra) to escape the unfavourable weather conditions.

CHAPTER SEVEN

EVIDENCE OF WATER CONFLICT AND COOPERATION

Introduction

This chapter discusses some evidence of conflicts and cooperation regarding the use of some shared water resources in the studied communities. The discussion is made based on the analysis of data sourced from respondents in the eight sampled communities, public officers and an expert in the field of conflict resolution and management. Firstly, residents' view on what constitute conflict is sought. Aside this, some identified water-related conflicts in the communities were analysed. The pathways for climate change to have caused the identified conflicts were analysed using the Political Ecology Theory and CLICO's conceptual framework. Furthermore, the chapter presents a discussion on potentials of violent conflict in the Bawku Area which could be triggered by future water scarcity phenomenon.

The chapter ends with how cooperations have been achieved in the communities amidst the scarcity situations. It reveals the emense role of traditional authorities in the conflict arbitration process

Residents' perception and awareness of conflict

When residents were asked whether they had engaged in any conflict in relation to water sources, use and management of it, it was realized that the concept of conflict meant something different. Even though some respondents were emphatic to respond that conflict over water resources had not existed in the communities studied, they were also quick to admit at some point that disagreements, quarrels and tension were rather a daily occurrence in their communities. Thus, residents' interpretation of conflict clearly had to do with the violent, rather than the subtle or mild form of the act. Indeed, degree of conflict (violent) over water, according to residents, have not been experienced among them. These views are captured in the expressions shared by some respondents in an IDI and FGDs at Pialugu and Yirigungu as follows:

> *We have not had conflict before. Rather, there has been some minor disputes we sometimes record, and to me, those are quite normal. The fact that we have not picked any weapon or destroyed anyone's property, then I think you can't talk of war or even conflict.*
>
> (Key informant, Pilalugu)

> *We fought and quarrelled at the boreholes, but we do not extend those quarrels to our various houses or the entire community.*
>
> (Female FGD participant, Yiringungu)

It is clear that residents' understanding of the concept of conflict was narrowly expressed as they limited it to those act of confrontation which involves hostility and physical destruction, etc., as carried by Jeong (2000). Thus, respondents only saw conflict to be any violent act that results in the destruction of properties and deaths of people. In this instance, residents in their views did not recognize the intra-state skirmishes among water users as conflicts since no arms had been involved. Indeed, the confrontation phase of conflict development as carried by Fisher et al. (2000) and Wehrmann (2008) was ignored. Perhaps, residents' worldview of the concept is shaped by what they have ever experience in the past when it comes to the decades old Bawku conflict (will be discussed later in this chapter) which had known to be hostile and destructive, involving destructive arms, and leading to the death and displacement of several people (Awedoba, 2010; Bombande, 2007; Kendie et al., 2014; Lund, 2003; Noagah, 2013).

Yet when juxtaposed with Barash and Webel (2002), Folarin (2015) and Nicholson's (1992) definition of conflict, it is clear to report of water conflict as a common phenomenon in the Bawku Area of Ghana. The bone of contention of those incidences of conflict bordered use and management of the scarce commodity, water. Especially, several of these conflicts were the fights and quarrels women and children picked up at borehole point. In other vien, residents saw these forms of hostility-free conflict as normal happenings within any human society where people have had to struggle over limited or scarce resources as explained by the realists in their explanation of the causes of conflict (Folarin, 2015).

While this finding may paint a positive picture for the study communities covered by this research, it may not be the case always, reasoning from the background that conflicts do go through stages of mild confrontations before they escalate to violent act, if not well managed (Fisher et al., 2000; Wehrmann, 2008).

As indicated by Galtung (2009), “conflict originates somewhere and becomes articulated”, signifying that, conflicts will have to begin from a point, which most often than not, are minute and insignificant. Though it was uncommon to find residents admitting the incidence of conflict among themselves and between communities, the mere mention of *fight, quarrel or tension* are indications of conflict, with hostility only ‘waiting’ to explode. This opinion is also carried by Tamas (2003) who refers to tensions, such as these, could be triggers of violent conflict. It will also be wrong to ignore these “signs of violent conflict” in such a highly ethno-politically polarised region, especially when guinea fowls could lead to violent conflict in a similar environment between Kokomba and Nanumba in the Northern Region of Ghana (Research and Information Services Section, 2009; Sulemana, 2009)

This assertion was further shared by a security expert at KAIPTC who mentioned that:

> *When we talk about conflict, it can be latent or obvious for everybody to see. So at a point where there are individual differences resulting in quarrels and tensions, they can be referred to as latent conflict. That is, the conflict that has not yet become obvious for all to see…people don’t recognise this type of conflict, and if it is not well managed, that is where violent conflict escalates because the people are aware that there are tensions among them, and that anything at all can trigger it into violent act…So every conflict starts from that level (latent stage).*

Again, the description of conflict as purported by the respondent of this study also relates to those put forward by Bijani and Hayati (2015), in their description of the types of water conflict. The authors' four types of conflict included 'no conflict', 'surface conflict', 'latent conflict' and 'open conflict'. While the first three were applicable, the fourth was absent in the current study. Though the first three could be described as mild forms of conflicts, they need to be attended to due to the potencies in them to escalate to 'open conflicts'. For example, Schmitz (1993) in Le Meur, Hochet, Shem, and Touré (2006) present that violent or open conflict between Senegalese and Mauritanians, and between Mauritanian social groups in the 1980s, had their roots in local tensions which ended up in open conflicts. Similar reports are made about studies conducted by Barrière & Barrière (2002) in Mali, and Thèbaud (2002) in Niger.

Furthermore, some earlier responses in Chapter Six regarding residents' adaptation strategies are indications of residents' awareness of the latent and minor conflicts that exist amongst them. This inference can be made from the kind of management approaches in relation to the rationing of domestic water sources, building of fence around farms/garden and above all, the role of the Water Users Association. The question one would ask is; what are the essence of these anti-conflict measures if conflict of that high degree is not anticipated? The measures had been taken, perhaps due to the tensions that had characterised the use and management of the scarce resource, and as such should be prevented from reaching a crescendo.

Some Identified Conflicts

This section presents some forms of conflicts which were identified in some of the communities studied. As reported by respondents, these conflicts, fought over water, were either between irrigation farmers within the same community, between farmers or members of neighbouring communities, and among women and children within the same community. From the study, the major motivation for conflict of any form were water scarcity, drought, and type of management practice, among others. Similar observations were made by Bijani and Hayati (2015) when they sought to find farmers' perception on agricultural water conflict in Doroodzan in Iran. Also, the major reason for conflict in as revealed by Gichuki (2002) Upper Ewaso Ng'iro North Basin in Kenya was not different from what was found in the current study. It should be noted that such conflicts are generally acceptable in areas where there are competing uses for a natural resource which can be put into different productive uses (Gefu & Kolawole, 2002).

Conflict between Kuka and Lansa

In spite of the earlier observation about the absence of the incidence of water conflict, the water conflict situation between the residents of Kuka and Lansa in the Bawku Municipality about two years earlier (since 2014) was found. Thus, Kuka community which is at the upstream was accused by the downstream community (Lansa) of denying them access to water for their dry season irrigation farming. The expression below by an opinion leader in Lansa in an interview reflects the general notion of the people in the community.

…That was not the case about ten or more years ago. But for the past three to six years, things have become worse because we are not getting water for anything. We no more get water from Kuka because they alone are using it for their farming, which made us angry.

Though the Kuka community did not deny the accusation, they (Kuka) did not intentionally deny Lansa community water for any callous reason, rather, the problem lied with the amount of water available for them (Kuka) and the neighbouring community. Thus, residents of Kuka explained that the water level in the only dam in the community was very low, especially during the dry season as a result of climate change. According to them, they would be willing to share if they had enough water in the dam, but not when it was not even enough for themselves in their community. The accounts of an opinion leader and a female resident in an interview and an FGD respectively summarise why Lansa was denied water for their dry season farming activities.

We don't have enough of the water stored at the dam and that affects our dry season farming. Apart from that, the dam is supposed to serve other downstream communities; so sometimes if we don't have enough water in the dam, the other communities begin to complain that we are rather cheating them…Sometimes it results into misunderstanding between us and them. About two years ago **[2014]**, *we had a problem with the people of Lansa…The problem was that the water level at the dam was very low and they wanted us to open* *the spillway to supply them with more water because they were running short of water at their farmlands. Since we couldn't do what they requested, it resulted into fight or conflict…We couldn't* do *that* **[fail to supply them with water]** *because we have a lot of crops still there to be irrigated, and so if we had opened the dam, there would have been little left for us in this community…The Lansa people came here themselves and saw the reason why we couldn't supply them with water. The water serves so many purposes; for irrigation, for our livestock, and other domestic activities like building, etc. So if we supply all, there would be a time that we would have nothing.*

(Opinion leader, Kuka)

We had problems over the dam with the people of Lansa. Anytime the water level in the dam is low, and it does not flow to them, they always suspect that we intentionally do that; but that is not the case. Everybody wants to eat, why we will deny them of water. It is the water scarcity issue that has brought about this problem between us.

(Female FGD participant, Kuka)

This finding is corroborated by a similar finding made in the Usangu Plain in the Rufiji Basin of Tanzania (Facius, 2008), where downstream farmers always complained of not getting water from the Kioga River which serves Mawindi and Isunura communities. Also, this has been a common phenomenon in the Upper

Ewaso Ng'iro North Basin in Kenya (Gichuki, 2002). In Iran, farmers in the Doroodzan Dam Irrigation Network, saw conflict between farmers in downstream and upstream as the second most prioritised form of conflict, as most farmers were of the views that water available for their use were captured by those upstream (winners), leaving little for farmers downstream (losers) (Bijani & Hayati, 2015). The above instances and the findings made by this study reflect notions shared by Gichuki (2002) and Kashaigili, Kadigi, Sokile, and Mahoo (2003) that conflicts normally persist among users of shared water resources when upstream users (e.g. irrigation farmers) of the resource are (accused of) taking more of the water, and leaving none or insufficient quantity for those downstream.

It is realised that many of such small-scaled conflicts where local community residents fight over allocations and use of water, and sometimes violence over management decisions of the resource have always been recorded (USAID, 2014), and it is not peculiar to the current study. More importantly, Gleick and Palaniappan (2010) have observed that significant number of these conflicts are as a result of water scarcity and competition for a fixed resource that is reaching peak limits. These conflicts have been aggravated because, during the dry season, residents find it difficult to get enough water for their activities. Subsequently, Wolf et al (2005) claim that water-related tensions at any scale are triggered by three major reasons, the quantity, quality, and timing of the availability of water resources.

Conflicts among irrigation farmers within communities

Apart from the conflict which were reported between the two communities, others also occurred among some individual irrigation farmers from some of the communities studied. It occurred when a farmer's water source, usually, dug-outs, were taken by someone. As gathered from the study, verbal confrontations which ensue usually are resolved at the farm between the individuals involved, as evidenced in the expressions below:

> *It is at the garden that we normally quarrel seriously over the water. Seeing that your water has been used by another person is disgusting, and this always results in quarrel…*
>
> (Female FGD participant, Pialugu)

Conflicts of this nature are seen as common because irrigation water, whether in abundance or in scarce supply, has been identified as one important resource with great potentials of causing conflict among user groups, in several developing countries including Nepal, Nigeria, Democratic Republic of Congo, and several others (Folarin, 2015; Schweithelm, Kanaan, & Yonzon, 2006).

Conflict over domestic water sources

As already mentioned, another form of conflicts which emerged from the study were those which occurred particularly among women, and sometimes children, at community boreholes or wells. Women and children were parties in this conflicts because of their traditional roles as drawers of water. Women require water for their domestic activities, and so have to go to the borehole site to queue for water. Objecting to anyone who jumped the queue to fetch or draw water at the expense of others who have waited for long often ended up in quarrels and confrontations. Others also fought over those who made attempts to fetch more than the agreed quantity. The following statements capture some of the experiences at the borehole sites:

The women fetch water from the borehole on "first-come-first-serve" basis. Acting contrary to this term often leads to confusion.

(Opinion leader, Aniisi)

Most often confusion arises at the borehole whenever the women go to fetch water, but it normally does not escalate into a huge conflict.

(Male FGD participant, Gabuliga)

We do quarrel at the borehole, but they have never escalated into a conflict involving the community. Sometimes too it is our children who fight there. For instance, when they close from school and go to fetch water at the borehole, they tend to fight among themselves over queues. These fights and quarrels eventually becomes a fight for the parent or we the mothers, and this has been creating some kind of enmity between the parents.

(Female FGD participant, Gabuliga)

It is when the water became so scarce that we start to fight and quarrel among ourselves at the borehole.

(Female FGD participant, Yirigungu)

It was however similarly observed (as was the case of "conflict among irrigation farmers) that such quarrels were only verbal confrontations and residents rebuffed to classify them as conflict, and as such, were usually resolved at the borehole site, and rarely at the chief's palace. These views cannot be taken to make a conclusion that conflicts over water in the communities are non-existing. Indeed, the idea of water conflicts in these instances cannot be ignored when seen in the light what has been expressed in the conflict literature. For instance, Folarin (2015), Kloos et al. (2013), and USAID (2014) have expressed that conflict sometimes do not show itself in violent and hostile nature, but verbal confrontations, where each party fails to accept the views and directions of the other. Again, identified confrontations among residents in the communities does not in any way deviate from Goulden et al.'s (2009) definition of conflict as adopted for this study – "any range of negative interactions that encompass mild verbally-expressed discord and cold interstate relationships, as well as hostile military acts or declarations of war".

Lastly, such occurrences easily could lead to some form of violent or major conflict if not guarded against since according to Galtung (2009), every "conflict originates from somewhere and becomes articulated", thus, from a small beginning, to an immeasurable status. Also, minor conflicts of this nature could stir up latent ones into hostilities. As expressed by Shah (n.d.), "long before conflict erupts in hostile action; it has existed in latent form in social tension and dissatisfaction".

Conflict between livestock and irrigation farmers

Findings from this study also revealed another form of *conflict* between two major users of water in the study communities – livestock and dry season irrigation farmers. Such conflicts either occurred within same communities or between communities. It was rare to come across farmers sending their livestock to wander for water, on the grounds that such efforts were fruitless, and again, since most of them were not traditional nomads. Hence, livestock farmers left the cattle, goat and sheep to wonder off for water within their communities, and sometimes enter people's irrigation farms to graze and destroy food crops. Being aware of this, farmers build mud fence around their farms to prevent any entry by *stray* livestock (see Figure 47). In spite of this attempt, it occasionally occurs that some of the cattle, goats and sheep were able to break into some farms to destroy food crops, resulting in conflict between the livestock owners and farmers.

Figure 47: Mud fence built around farms at Gabuliga
Source: Field survey (2016)

Again, unsupervised livestock were reported to have caused some few minor conflicts or misunderstandings among some communities. In fact, because of their destructive nature, livestock were feared and anticipated to be the future cause of conflict within and among communities; thus, between communities with deficit water situation and those with surplus. The possibility of conflict emanating from this scenario is certain since cattle are left unsupervised to wander for water. The expressions below confirm the aforementioned issues.

You don't expect me to tie my cattle to a pole at all times. I must allow them to go and look for food and water. Situations like this can create a problem, but you don't also expect me to follow the cattle wherever they go.

(Male FGD participant, Yirigungu)

Sometimes when cattle destroy other people's crops, it can result in fights between the cattle owner and the crop farmer.

(A Police Officer, Bawku Municipal)

This finding is congruent with a study conducted by Ofuoku and Isife (2009) who concluded that the main reason why farmers and nomads engaged in conflict were because cattle were always causing destruction to farmers' crops in the Delta State of Nigeria. Similarly, Tonah (2006) had stated earlier that the most frequent cause of conflict between irrigation farmers and pastoralist in arid environments is the destruction of crops by cattle, while herdsmen stand unconcern, pretending not be noticing the destruction. Also, in the case of Mali, Jones-Casey and Knox (2011) report that about 42 percent of conflict are natural resource related, of which struggles over water resources between crop farmers and livestock herders are recorded in most cases.

The Climate Change-Conflict Pathways: Political Ecology and CLICO's Explanations

The findings from the study suggest that residents in the Bawku Area must have had these scuffles among themselves and sometimes with other neighbouring communities because access to water for their daily activities has been hampered. Reasons for the scarcity of water in the area are obvious. The Bawku Area, which lie in the Sudan Savanna belt is plagued with drought due to high variability in rainfall and temperature (Antwi-Agyei et al., 2013; Owusu & Weylen, 2009), with Aridity Index of 0.44 (FAO, 2007). This description makes the area, a "*hydro-insecured"* one, which according to Kloos et al.'s (2013) *Framework of Hydro-Climatic Change, Conflict and Human Security*, and Strategic Foresight Group (2014), exposes the vulnerability of residents in such areas to water-related stressors, and/or water vulnerability.

Apart from the fact that this study's findings have been supported by other empirical studies, explaining the cause of conflict in water stricken environments, between and among several user groups, can also be interpreted in the light of political ecology theory and CLICO's perspectives.

Political ecology theory's explanation

The approach explains how environmental and political forces interact to affect social and environmental changes through the actions of various social actors at different scales. The likelihood of conflict from this interaction results from mal-distribution and access to water between and among various user groups (Cole, 2012).

Evidence from the data collected from both primary and secondary sources indicate that water conflict identified in the study communities had been as a result of interactions between environmental and socio-political factors. The interaction has generally resulted that access to water by different user groups, at any point in time is unfairly done, with one group having some excessive advantage over the other, or the fact that distribution of the scarce water sources available are being skewed in favour of the other. From this study, the environmental factor to this political ecology's explanation to the water conflict situations emanates from the harsh or increasing temperature and erratic rainfall pattern of the area studied, whereas the socio-political factors were mainly as a result of constraints on the part of government to supply water sources for domestic and agricultural use.

As already mentioned, this study has revealed the inadequacy water for both domestic and agricultural purposes in the selected communities. Two major reasons accounted for this – harsh climatic condition and government's failure to provide water source points for residents. Thus, data gathered from the field showed that there is water scarcity situation in the selected communities mainly due to erratic rainfall pattern especially in the past five to ten year. in most cases, farmers can have just about three months of rain for their agriculutiral activities.

None of the communities visited had pipe-borne water, making residents relying greatly on mechanised boreholes and hand-dug wells for their domestic activities. Surely, the shortfall in the provision of adequate water sources for the communities has been the failure on the part governments. This confirmed the national statistics which reports that the Bawku Area fall within the 29.1 percent of households who rely on borehole or protected wells which had been largely provided by international donors, non-governmental and faith-based organisations. Out of this figure, 70.2 percent out of the national value (29.1 percent) is from the Upper East Region (GSS, 2012) which houses the Bawku Area.

Apart from the inadequate domestic water sources in the communities, water for agricultural activities were also insufficiently available. While the climatic condition in the area could be a factor in explaining the lack of water for agricultural activities, attempts by governments to construct or provide dams and/or irrigation facilities were not encouraging. Thus, with the exception of Kuka that had a dam, and an attempt to construct one at Zabugo (all in the Bawku Municipality), none of the other study districts had irrigation facilities. This, according to respondents, contributed to their inability to engage in any meaningful agricultural activities, hence, their low livelihood status. For example, a response by a 51-year old male respondent at Yaanatinga confims this assertion when he mentioned that: “we live next to nothing in this village. You can see even our tarted clothes that we are really suffering, and that we don’t have anything. But at least if we had a dam here, we could work in our farms all-year round to get some money for ourselves".

Though according to some respondents, several complaints have been to some government officials or representatives and stakeholders such as assembly members, Municipal or District Chief Executives to provide them with potable drinking water sources (pipe borne water or enough boreholes), as well as to construct for them irrigation facilities, none have been successful. Some blamed their unproductive efforts on their high illiteracy, as reported by an opinion leader at Gabuliga who said in an interview that "I am sure they are taking advantage of our illiteracy. I think if we had some educated people in our community, they would be able to advance our demands well, and it would put some fear or pressure on government to listen to us".

Due to the above reasons, residents had turned their anger against one another in the form of conflict, both within and between communities. Thus, women and children regularly fought among themselves when queuing for water while farmers also battled with each other over dug-outs. Fights also resulted when livestock from other owners, in their search for water and foliage, destroyed crops of other farmers. Between communities, downstream farmers of Lansa accused Kuka at the upstream of failing to open the dam in the community to supply them with water for their farming activities, especially in the prolonged dry season.

It is therefore appropriate to emphasise that political ecology as an approach, could be used to unravelled how particularly, the political and environmental forces in the Bawku Area have been a major reason why residents and communities engage in conflicts in their bid to access water resources for their daily activities. Daily and seasonal confrontations between domestic and agricultural users of water have resulted from long period of denial of the residents' access to water resources by array of government institutions (political factor), the areas' geographical locational disadvantage (environmental factor) and venting their anger among themselves instead of appropriate government institution (social factor).

CLICO's explanation

Conflictive and cooperative events in the Bawku Area are analysed using the CLICO framework. Conflict or cooperation, as earlier indicated, results as actors or entities attempt to adapt to water scarcity phenomenon which is exacerbated by climatic anomalies. These anomalies, are seen in the form of high variability in rainfall and increased temperature in the Bawku Area (Antwi-Agyei et al., 2013; Owusu & Weylen, 2009). When exposed to these extreme events, residents are rendered vulnerable especially in the area of access to water sources. This phenomenon of hydro-insecurity reveals itself in residents' inability to meet their water demands (for domestic and agricultural uses), especially during the dry season. However, as to whether this become a cause of conflict or cooperation is dependent on the environmental condition's interaction with the prevailing socio-economic environment (Kloos et al., 2013).

Generally, if institutions and behaviours are well laid, attempts to adapt to any severe climatic event will rather lessen or avoid conflict and ensure cooperation (Forsyth & Schomerus, 2013). The reverse is however true if poor governance, societal inequalities, bad neighbourliness, culture, perception, etc. interact with increasing temperature, erractic rainfall pattern and water scarcity phenomenon (Gleditsch, 2011; Kloos et al., 2013). The eventual outcome to this negative interaction instigate conflicts and/or opportunity to organise them due to its power to promotes political and economic instability, social fragmentation, migration, and inappropriate responses from governments (Buhaug et al., 2008; German Advisory Council on Global Change, 2007; Gleditsch, 2011; Kloos et al., 2013). While this study came across people with almost same cultures and social class, same could not be said of some basic social infrastructure (potable water sources, dams and irrigation facilities, schools, hospitals, etc.) provided by government to deal with water scarcity issues. Except for the ineffective WUA, there were no formal and documented arrangement to regulate the use and management of water resources in the communities. Furthermore, there were some difference in the way respondents' perceived the use and management of the scarce resource. While a section of them believed that their needs must be served before any other's, others saw the need to cooperate and share whatever resource that is left for them no matter what the situation may be. One other strong but silence social setup found was the latent Bawku Conflict which were known to every member in the communities.

In the mist of all these, respondents and residents of the communities studied were adapt to the scarcity situation which have been propelled by the changes in the climate. The adaptation took many forms, including relying on dams and dug-outs for dry season vegetable farming, leaving livestock to wander for water and grass, queuing for long hours for water for domestic activities, migration and several others. These forms of adaptations by both individuals and communities in one way or the other had impacts on others since by adapting, actors and entities crossed each other's paths, mainly for the negative reasons.

On community basis, some farmers fetched water from dug-outs of others to irrigate their crops, depriving the original owners of enough water for their own. Also, some livestock at some points managed or broke into people's farms to destroy their crops. In other instances, some women and/or children jumped queues to fetch water when it is not their turn to do so. On relatively large scale, Kuka's *use* or *consumption* of water from the community dam deprived other communities, such as Lansa, from having water for their dry season farming. These clear cases of *divergent adaptation* or *mal-adaptation* of 'win-lose' situation as described by Snorek, Renaud and Kloos (2014) and Barnett and O'Neill (2010) promoted social divisions, initate conflict, and even an opportunity to organise one.

Water Scarcity and Potentials of Violent Conflict

Among the issues that came up in most of the discussions was the re-echoing of the popular adage "water is life". Respondents agreed for the resources to be managed to benefit all. However, while some respondents in a male focus group discussion at Apotdabogo II were of the view that this "attribute" of water (as life) could be the reason for conflict when there is scarcity of it, others in the same discussion thought otherwise. In the said discussion, a respondent commented that:

Why should I give my life to someone if there is only one left? Yes, I understand that water is life, so I must always protect it when *someone wants to take it. It doesn't make sense for you to let someone take your life. But mind you, when there are plenty of it, I can share.*

(A 37-year-old male, FGD, Apotdabogo II).

On the other hand, another respondent rebutted by arguing that:

Will it not be wickedness to deny someone life (water) if you have one? If you fail to give it out, it only means that you want to kill that person, and that is wrong! I can't forgive someone whose action could mean he wants to kill me.

The above comments in one way or the other, fit into the natural resource scarcity debate between the Prophets of Doom and the Cornucopian. The former, which is inspired by Reverend Thomas Malthus' 'Limit to Growth' opines that any deficiency between food production and population pressure is most likely for spell doom for any society (Meadows, Meadows, Randers, & Behrens, 1972). The author's line of thought has subsequently been given further interpretations by other fields of study. For example, according to some social scientists, Malthus' debate points to the fact that increasing scarcity may lead to violent conflict (Buttel, Hawkins, & Power, 1990) in areas where these scarcities occur. Thus, concerns have been raised about the social consequences of scarcities and (human-induced) environmental degradation (Gleditsch, 2003; Hauge & Ellingsen, 1998). Water scarcity has been one of the major concerns among stakeholders and policy makers who believe such a phenomenon can result in a dire social consequence in several societies (Katz, 2011; Theisen et al., 2011; Ward, 2002). While this is considered a pessimistic view of looking into the future; there are some elements of truth since according to Carius et al. (2004, p. 60), "increasing scarcity of clean fresh water impedes development, undercuts human health, and plays critical roles along the conflict continuum between and within states".

This pessimistic view about water scarcity as a source of conflict was also admitted by a key informant who opined that it should be a matter of concern because in an area like Bawku, such a phenomenon could trigger violence. His view is captured below:

> *In terms of scarcity of water as a resource, everybody will be fighting to get a share of it particularly if it is between the herders and the community. Definitely there is a recipe for conflict if there is this tension Now you might see it as happening at a very low intensity, but is a recipe for violent conflict if nothing is done to provide water in times of scarcity.*

Again, comments such as those expressed by theses respondents are indications of potentials of violent conflict in years to come if: 1) the water scarcity situation lingers, and 2) no effective institutional arrangements for adaptation are put in place. As have already been noted, mild forms or levels of water conflicts were largely found by this study. Thus, mild conflicts which are normally realized in the early stage of the act (pre-conflict stage) would sets the tone for violent ones (the in-conflict stage) (Fisher et al., 2000) if the water-needs of the residents in the communities studied are not met. Thus, with the current water scarcity situation in the area, several evidences of hidden incompatibility or low level open conflict were found where individuals and communities without regard to the consequences, confronted the other whenever their attempt to adapt to the scarcity conditions are challenged. This view point, as supported by Wehrmann (2008), seemed obvious especially when the Kuka-Lansa conflict almost got to a crisis point had it not been the timely intervention of the agricultural extention office in the Bawku Municipality. Though resolved, it is also certain to reason that some levels of polarization have been created between these two communities, which when not dealt with may trigger violent conflict in a future hydro-stress phenomenon. While it may not be in the domain of stakeholders to prevent the climate from changing or any future extreme hydro-climatic event, it is within their capacity to ensure that structures are put in place to avert any form of divergent or maladaptation practices.

Also from the human needs theory point of view, the Bawku Area in general and the studied communities to be specific awaits some form of violence conflict associated with any further extreme water-related stress conditions. The theory states that violence bursts forth as individuals or groups tend to find possible ways of survival in event that the provision of their basic needs by the state are frustrated (Danielsen, 2005; Doucey, 2015; Rosenberg, 2001). This possibility is not in doubt considering the worth of water and the fact that the residents' livelihood in the area mainly revolve around the resource which is relied on for the region's main economic activity – agriculture. Similarly, FDI (2012) have upscaled this view and shares that potentials of (violent) conflicts are ripe between and within nations in cases where there is imbalance between water demand and provision.

Though the pessimistic view point may persist, the opportunities associated with resource scarcity, as found by the study (expressed by a respondent) and according to the Cornucopians, are worth promotinged. Thus, to the Cornucopian, scarcities in any society can be annulled by human ingenuity, technological progress, prudent use of market dynamics, or social and political institutions that promote cooperation (Kenny, 2011; Lomborg, 2001; Simon, 1989, 1998; Wolf, 1998). Specifically, Wolf has been of the view that resource competition is more likely to result in cooperation instead of conflict. Water scarcity has proven to be a productive conduit for confidence building, cooperation, and conflict prevention (Carius et al., 2004). Thus, cooperative incidents are more pronounced than conflictive ones in relation to water from 1945-1999 (Wolf, et al., 2003).

In all, it can be reasoned that the way in which a person perceives the environment largely determines the way he/she will react to it, and for that matter, as to whether one will engage in conflict over any environmental resource will be based on the degree of accuracy of the meanings obtained from an individual perceptual process (School of Arts and Social Sciences, n.d.).

Residents' Awareness of the Other Causes of Conflict

There is not a single cause of conflict. As rightly mentioned by Vasquez (2000), it is not a mono-causal phenomenon, rather, it could be made up of other multiple explanatory variables of social, historical, political, economic, underpinnings. As already indicated in Chapter Two, even where environmental factors are statistically significantly correlated with the outbreak of any conflict, the other remedial factors cannot be underestimated (Goldstone, 2001). Hence, the presence of conflicts emanating from these other sources were worth investigating.

In this case, data on past or current, latent or active conflicts were sought for from residents. It came out that, conflicts of this nature were rare among those communities investigated. However, there was only one of such conflicts that immediately came out for mentioning by respondents when ask – the decades old Bawku conflict. The Bawku 'Skin' conflict which is over 60 years old (Lund, 2003; Noagah, 2013) was not only mentioned in the Bawku municipality where the incidence had existed, rather, it was cited by respondents in all the other districts. This finding was not unexpected since the districts hitherto belonged to one Bawku District.

Infamously, ethnic or chieftaincy struggles between the Kusasis and the Mamprusis were mentioned by respondents as the cause of the Bawku conflict. It was also explained by some respondents that the ethnic struggles have some political underpinnings. Not only was this conflict well known among respondents, the historical account to it was also similar. Below are some narratives that explain the causes of conflict in the Bawku municipality:

> *We have Mamprusis and Kusasis living together. It was the Mamprusis who were ruling in some years back, but now rulership rests with Kusassis. But the Mamprusis do not want to concede for the Kusasis to rule, and that has brought about the conflict…*

(Opinion leader, Kuka)

Conflicts here have always been about chieftaincy between the Mamprusis and the Kusasis. And this has been a protracted conflict for a very long time. According to history, this land belongs to the Kusasis, and at a point when the Mamprusis came here from somewhere, they were received by the Kusasis, and eventually became more like kindred. So at one point the Maprusis were given a place to farm, and through time, had the chance to ascend the 'skin' to be overlords for some time. But when it was time for the Kusasis to take over as the real overlords, it resulted in conflict, and that has been the bone of contention till date. So from this history that we all know, it is clear that the 'skin' is for the Kusasis.

(A police officer, Bawku Municipal)

Bawku is polarized with several tribes. But majority of the tribe are the indigenous Kusasi people. According to the Kusasis, the land belongs to them, and that the Mamprusis cannot come from somewhere to rule over them. This has been the cause of conflict between the two groups…So this is our core problem - the chieftaincy issues, the ethnic Kusasi-Mamprusi thing! Nobody is willing to give away the land, and the power that goes with it. That is power, and everybody enjoys it…Politically, they are equally *divided in the same way. The Mamprusis are seen to be affiliated to NPP, and Kusasis, NDC. Because of this, even if there is political argument between these two groups, it is interpreted from ethnic background. And since these two are already not in agreement, you should expect violence.*

[NPP and NDC are political parties in Ghana]

(Public officer, Agric Office, Bawku)

The assertion on the main actors and the cause of the Bawku conflict is corroborated by extensive reports by several authors including Awedoba (2010), Bombande (2007), Kendie et al. (2014), Lund (2003) and Noagah (2013). It is also realised from the above expression by a Public officer at the Municipal Agricultural office at Bawku that the political interference in the Bawku conflict serve as a trigger, which is able to cause violence conflict at any slight political animosity, leading to deaths, destruction of properties and displacements. This account has extensively been study and chronicled by Lund. It has also been reported by Kendie et al. (p. 48), stating that:

"*The conflicts in Bawku relate to the chieftaincy problem, which has increasingly become political so that some of the conflicts reported in the past have been between the supporters of the NPP and the NDC…Political interference has become the immediate cause now of conflicts in the Bawku Area which then are waged along ethnic lines as the ethnic groups align themselves to political parties. While political undertones have been rife since the post-independence era,* *in recent decades these have intensified pitting the NPP (purportedly supported by the Mamprussi) against the NDC, which is said to support the Kusasi".*

Though these conflicts are fought in core towns of Bawku, it is reported that other near-by towns and districts in the Bawku Area felt the impacts. According to some respondents, some of their relatives working in Bawku have to move back to their villages, while others had to stop going to farm for fear of being killed by any of the fighters. Others also reported sharing their lands with the internally displaced victims of the Bawku conflict. This was a possibility since most residents in the study communities belonged to any of the two ethnic groups. Therefore, it was almost impossible for any of the communities not to feel the impact of the conflict in Bawku. These are some of the experiences of some respondents:

Yes, in this community we are only affected by what happens in Bawku…We are Kusassis, and if anything happens there, it affects us. If there is a conflict and your people are involved, then you have to also get yourself in readiness to fight back…When that happens people are so scared that they cannot even go out nor to their farms! Besides, you do not know your enemy so you may be at your farm and somebody might come and shoot you…So we barely go to farm and we are careful because we much watch out. Curfews are then imposed and the police go round the community.

(Opinion leader, Kuka)

We also experienced some problems of the conflict because when it happens like that, our children are deprived of their jobs at Bawku. Some of them left their work there and are now staying with us. They come and add up to our woes of water scarcity. Eventually you see us suffering together.

(Female FGD participant, Pialugu)

Finally, it was reported that there has been relative peace in the Bawku municipality as at the time of the data collection. The reported peace had been restored in the municipality five years earlier, and had been attributed to the strict security presence in the area. Others opined that it was as a result of the residents' own desire and efforts to work towards peace in their communities. Thus, the adverse effect of the protracted conflict has had a great toll on them, which makes them crave for the peace. This notion is carried in the following expressions:

The security services have stamped their authority in the areas. There's serious police and military presence everywhere to make sure that no one misbehaves. But another fact is this; the people themselves are tired of fighting. They have realised that the conflicts have brought them nothing good, and so they have realised that if they don't stop, they will gain nothing good. They know it is so frustrating. Just imagine during the conflict, there is always a curfew – men were not allowed to ride motorbikes. That meant that wherever you went, you had to ride bicycle or walk: how far can you go? So the people have realised that conflict will not help them. This *has contributed greatly to this peace, and that is why it has been successful because it has been peace from within.*

(A police officer, Bawku Municipality)

These changes [peace] have come about because of the huge security presence, and the fact that people here have come to realize that there is no gain in war. You only lose in war, so it is better to forget about it and live harmoniously with each other.

(Public officer, Agric Office, Bawku)

Yes, it [conflict] is no more. There is relative peace now, and I think it is because of the presents of the military and the police. Also, the people [warring factions] themselves have realized that it doesn't pay to fight…

(Opinion leader, Kuka)

In spite of these claims of peace in the Bawku Area, it cannot be interpreted to mean sustained resolution of the conflict. Such attempt can only be made when the resolution becomes a conduit for improved security, peaceful co-existence among factions, and improved living condition of the people (Noagah; UNDESA, 2001). Again, this study cannot be concluded now that there is resolution of the conflict because similar claims of presence of peace had been made on several platforms, yet the conflict keeps reigniting (Noagah). The reason is, as explained by Noagah (p. 5) using the Protracted Social Conflict theory, because of the "claim to values, identity, power and cultural contestation", making "the conflict defy any workable solution".

Water and Cooperation

Not only was this study interested in conflicts over water, it was also interested in cooperation among community members and between communities in moments of water stress conditions. Again, based on the result of the fieldwork, which is also in agreement with Facius' (2008) observation, cooperation among and between members of the study communities, were either visible (worked through an established institution, e.g. Water Users Associations [WUA]) or invisible character (rules and norms of behaviour), or both.

In fact, while most of the disagreements or minor conflicts were resolved at the community, household or individual levels, and very few or just one, as found by this study, went beyond the borders of the communities involved. It was the only conflict that went mere disagreement level to a near-violent one, that was between the Kuka and Lansa communities. The said conflict went as far as the office of the Municipal Agriculture Officer and the Ghana Irrigation Authority for settlement. The expressions below capture this fact:

> *Even though we went to Kuka to complain about what they were doing to us, their explanation was not convincing enough. They were not ready to listen to us in any way, and this whole thing was affecting us severely. We therefore went and reported the matter at*

the Agric office at Bawku. The office later called both of us to settle the matter.

(IDI with opinion leader, Lansa)

We tried to resolve the matter here with the Water Users Association, but they (people of Lansa) went and reported us to the Agric office at Bawku. That is where we realized that the matter has become serious, and that it could result in some serious conflict. So we also had to follow up at the Agric office to explain our side of the story. Then they called us together and we explained why we could not serve them the water. After that, we all came to an agreement…

(IDI with opinion leader, Kuka)

Yes, they were here to settle their dispute. They didn't pick arms; it was just exchange of words, and so it was not difficult so resolve. The MCE has also been there severally to see how we can resolve such issues permanently.

(IDI with an officer, Agricultural Office, Bawku Municipal)

The finding here is in accordance with Sokile, Mwaruvanda and van Koppen's (2005) six-tier levels of formal and informal conflict resolution. Their study found that several minor skirmishes over water were informally resolved at the lower levels, while serious ones were done at the levels of village authorities. For instance, the few disagreements which arose were resolved on one-to-one level between the victims (Level 1), at local elders' levels (Level 2), and at the WUA levels (Level 3). It only takes major issues (at Level 6) to be resolved at governmental levels due to the form it may take if not well handled.

Traditional authorities and conflict arbitration

Largely, internal or communal disagreements or conflicts were handled or resolved by traditional authorities in the various communities. These traditional authorities were especially resorted to for final adjudication when an issue went beyond the individual, household and family settlements. That is to say, attempts are first made to resolve conflicts at the aforementioned levels. Below are some comments indicating how minor disputes over water were resolved in the study communities:

> *…we don't normally extend the fight beyond the 'shores' of the borehole. We sort ourselves out at the borehole before we leave, and continue to live in peace among ourselves.*
>
> (Female FGD participant, Gabuliga)

> *There are informal institutions like the "Tendana"* [Chief priest, spiritual owner of the land]*, and the "Yirigungu-naaba"* [Chief of Yirigungu]. *If there is any conflict or fight between us, we report it to the "Tendana" and he will summon the parties involved and question them. When the case is beyond the "Tengdana" then he will refer it to the main chief of the community, the "Yarigung-naaba".*
>
> (Female FGD participant, Yirigungu)

Though there were government representatives (Assembly or Unit Committee members) in all the communities visited, yet no case of conflict was reported to them for settlement. It was in some rere cases that these group of people (Assembly or Unit Committee members) were invited by elders of the communities when settling disputes. Even in those instances, their representation and views were subsumed by those of the traditional leaders or authorities. Some of these views are summed below:

> *There is an order in resolving disputes here. Disputes within families are handled at the family level; issues between two families are taken care of by elders of the community. If the elders don't have the capacity, they refer it to the chiefs' palace. Although we have an Assemblyman, we don't report cases to him.*
>
> (A 29-year old male FGD participant, Yirigungu)

> *We do that at the chief's palace. The unit committee members are sometimes invited by the elders to take part in conflict resolution, but while they are there, they speak in line with traditional rules, and not as government spokespersons.*
>
> (A 38-year old male FGD participant, Pialugu)

In an interview, Kofi, a security expert provided some reasons why the traditional authorities are revered in conflict resolution in the communities. In all, the major reason is focused on the availability and effectiveness of the traditional institutions vis-à-vis the formal state structures. Kofi's explanations are indicated as follows:

> *Usually in such places, their first point of call when it comes to these matters is their traditional leaders because in some instances, you will see that the formal state institutions do not exist or not readily available. In most cases, those structures do not even exist for the people to access when in need. Sometimes too, they don't trust the state agencies, especially the police, to deal with some of these matters. Hence the traditional authority becomes the immediate institution they can access. It will interest you to note that in most cases people prefer to resort to the indigenous institutions or mechanisms because of these issues about trust and the cumbersome nature of the formal agencies. Secondly, some of them also don't see these conflicts as issues that should go to the formal institutions for settlements. They see it as communal matter which can be dealt with by themselves. Because, should the matter be taken up by the police, it will have to go to court and all those processes. And so, if they can use their own indigenous mechanisms to settle those problems, why not?*

As found by this study, the first point of call for any cooperative endeavour among local residence in rural environments have been to resort to local customary laws and institutions. This is perhaps due to the imposing nature of formal law (Nkonya, 2006) as an institution for conflict resolution "where decisions are based on ‘I loose-you-win’ or vice versa principles” (Sokile et al., 2005, p. 9). Customary laws are seen to be effective in terms of water conflict resolution in several circles (Nkonya). Again, Annan (2014) is of the view that because of the reverence they have earned probably due to their long-term existence and the perception that they are the symbol of wisdom and leadership within communities, chiefs and their elders in Ghana (and other African countries) are credited to settling diverse non-criminal issues ranging from land, chieftaincy and family disputes to petty quarrels.

Of course, this is not to rule-out people’s respect for the formal institutions, since at some point (when the magnitude of the disagreement is beyond them), it becomes the ‘lender-of-the-last-resort’ which has the capacity to deal with matters of those nature.

On the other hand, the CLICO framework can provide an explanation to why violent conflict over water were averted. One, according to the framework, the likelihood of conflict over water is high if any latent conflict exists among or between communities. Therefore, it is plausible to conclude that the absence of any ongoing conflict at the time of data collection, or histories of *violent past*, were enough incentive for cooperation or peaceful co-existence, in spite of the water challenges they were confronted with.

Secondly, the social milieu (culture, perception, etc.), political institutions, and economic interactions in the area interfered in ensuring cooperation in the areas studied. This explanation corroborates Kloos et al’s. (2013) study of water conflict in the Middle East. The authors expressed that water scarcity did not necessarily translate to conflict or even reduce the adaptation capacities of countries in the

Middle East due to the roles played by political, social and institutional contexts of these areas.

Ghana is recognised as a stable and peaceful country within the Sub-Saharan African sub-region (Boafo-Arthur, 2008; UNDP, 2013). According to the 2016 Global Peace Index, the country scored 1.809, and ranked as the 44th most peaceful nation in the world (Institute of Economics and Peace, 2016). Aside the relative peace the country is reported to be enjoying, Bawku and its environs which had been characterised by conflict, have also enjoyed relative peace in the past years (Noagah, 2013). The peace enjoyed, together with Ghana's stable democracy altogether determined how well the country's institutional and political set-up boosts its ability to confine any growing water conflicts. This observation is alluded to by Gizelis and Wooden (2010), Neumayer (2002), and Lake and Baum (2001).

This finding goes on to confirm Kloos et al.'s (2013) assertion that water-related conflict or cooperation at domestic levels may not be a direct influence of climate anomalies. Rather, economic, social institutional and political set-ups of an area play major roles. From this study, it is evident that these factors explain why most conflict tendencies were averted.

Summary

In sum, Carius et al. (2004) submit that, three major linkages exist between water and conflict – access to adequate water supply; water, livelihood loss and civil conflict; and water management and conflict. From the data collected for this study, two out of the three scenarios in one way or the other clearly manifested in the communities studied. That is, several instances of conflict over water owing to inadequate water supply, and the Kuka-Lansa conflict was mainly as a result of how the dam at Kuka was reportedly managed by the WUA at Kuka.

As there was no violent conflict found by this study, all the mild ones recorded were mainly intra-communal, involving residents of the same community, and an instance of inter-communal (in the case of Kuka and Lansa) which was curtailed earlier enough to avoid escalation. The intra-communal conflicts were among crop farmers who would fight over a common water for irrigation purposes, and crop farmers and livestock farmers whose reason for conflict emanated from the destruction cause to crops by stray livestock. Women and children also engaged in exchange of words among themselves while queuing and struggling for water for domestic use. It is however made clear that the phenomenon of water scarcity alone was not a direct cause of conflict. Rather, the absence of proper institutional arrangement put in place by government to ensure effective adaptation only interacted with the vulnerabilities created by the extreme climate events. The Political Ecology Theory and CLICO's conceptual framework helped to explain this claim. The analysis further revealed that though issues of violent conflict in the current study was absent, yet there is a possibility of such in the future if systems are not put in place to adapt to water scarcity challenges.

The mild water-related conflicts found by this study were resolved mainly at the levels of the traditional authority. That is to say in spite of the presence of government representatives in each of the communities studied, chiefs and elders were the main institutions for conflict resolution. Only one conflict (between Kuka and Lansa) went beyond the level of the traditional authorities, and even the WUA. It was eventually resolved at the Agricultural Extension office in the Bawku Municipality.

The decades old 'Bawku Conflict' between the Kusaasi and Mamprusi ethnic groups featured prominently in this chapter where respondents from all communities studied indicated their awareness the conflict. Another well-known fact concerning the Bawku Conflict was the political dimension of the conflict. The Kusaasi's were purported to belong to the National Democratic Congress, while the New Patriotic Party was popular among the Mamprusis. It was very possible for conflicts to ensue between these two ethnic groups along the NDC-NPP political lines.

CHAPTER EIGHT

HYDRO-CLIMATIC EVENTS, SOCIO-POLITICAL ENVIRONMENT AND HUMAN SECURITY

Introduction

Though the connections between climate change, violent conflict and human security are empirically hard to be proven (Barnett & Adger, 2007), some authors are able to show some level of relationship. According to Sen (1999), there is enough evidence to suggest that there are human insecurities that are exacerbated by lack of basic needs such as water, food, and shelter, and these in turn, limit people's capabilities and freedoms, with the resultant effect of limiting their human development. Wisner et al. (2007) on the other hand posits that there are at least seven ways through which climate change is likely to affect security in its narrow and wider meanings.

This chapter therefore sought to examine how hydro-climatic hazards, as well as the social and political events impacted on the human security within the study communities. The chapter looks into how climate change undermines human security of respondents by reducing their access to basic natural resources that are necessary for sustaining their livelihoods. Furthermore, residents' lack of access to social opportunities which helped them to adapt to climate change or variability were also investigated. Finally, residents' view on their human security situation were also assessed.

Residents' perception of human security

The findings from this study revealed that residents' notion on the concept of human security was similar to the traditional meaning of the word security – the absence of conflict. Thus, according to respondents, once they are free from attacks or aggressions which undermined their peaceful co-existence in their communities, their human security is assured. More specifically, some residents indicated they felt secured because they were able to go about their daily activities without any fear of attack from anywhere or by anyone. Some of such notions have been summed below:

We feel safe and secured. People in this community can walk in and out without any disturbance.

(Opinion Leader, Anisi)

We are much secured in this community. This community is a very peaceful community, and you can go to any part of this community without any fear.

(Female FGD participant, Gabuliga)

On the other hand, some respondents also interpreted the concept to mean the absence of theft cases. Put differently, human security of a community is marred if theft cases abound. Thus, residence of Zabugo and Gabuliga expressed worry that their human security is threatened because it was common to have their food items and livestock always stolen. The following narratives throw more light on this concern:

The theft cases are just too many here. They steal our livestock in the night. It is so serious that, even the food that we store are also stolen sometimes.

(Male FGD participant, Zabugo)

The challenge is theft cases. We don't sleep well in the night. We can't tell whether the perpetrators are from this community or elsewhere.

(Male FGD participant, Gabuliga)

All these forms of security as reported by respondents had not been so at all times. Thus, when asked whether there had always been peace in the communities, respondents reported that such an ambience had been so in the last five years. In the previous years, residents admitted that there were regular occurrences of the ethno-political Bawku conflicts. Such views are summed in the expressions below:

No, it has not always been easy. There were fights almost every time. Even 10 years ago there were these political conflicts here and there but I think the people involved are tired of fighting, and so they decided to put a stop to it.

(Opinion leader, Kuka)

It is quite recently that we started to experience this peaceful atmosphere. They were always fighting. I won't say the situation *now is the same as then; no now (5 years till now) is better than then (from 5 to 20 years ago).*

(Male FGD participant, Gabuliga)

Oh now, there is peace in Bawku. There is so much security, and people are just able to go about doing their day-to-day business. Twenty years ago, the situation was bad. You couldn't just walk on the street of Bawku like that. Am talking about during the Rawlings regime, and it was rough. But now, since the last conflict in the early 2000, things are ok now. Even now, Mamprusis and Kusasis are able to walk on Bawku streets engaging in sexual relationships.

(Security officer, Bawku)

These responses are to some extent, confirmation of the relevance and influential nature of the traditionally narrow, shallow and dominant worldview of the concept of human security. Thus, in the traditional sense of the concept, human security had focus on the state's responsibility of provision of free and secured environment for its citizens (Barnett, Matthew, & O'Brien, 2008; Owen, 2004). Often, this means of providing security gives pre-eminence to military solution as a policy means to ensuring security even in the context of a changing climate (Grove, 2010). On the other hand, the reported incidence of security affirms Noagah's (2013) position that, at least, since setting up of the Bawku Inter-Ethnic Peace Committee (BIEPC) in 2009, there has not been any major conflict in area.

While the respondents' views could be understandable, it may not necessarily be whole since their judgement or assertion clearly was skewed towards just one aspect of the definition of human security as carried by UNDP's Human Development Report (1994). The said report defined human security as a ''concern with human life and dignity'' (UNDP, p. 22), and it comes with consideration for human well-being manifested through the quality of life and individual or a community lives. This stance is agreed and accepted by Adger (2010) and Barnett et al. (2008). For instance, Barnett et al's. review of UNDP's definition opined that it "adopted a comprehensive approach by identifying economic, food, health, environmental, personal, community, and political components to human security (p. 8). In an interview with 'Kofi', a security analyst at KAIPTC during the data collection, a similar thought was shared. According to the respondent:

> *Human security goes beyond the traditional notion of security. It has to do with access to healthcare, education, security – freedom from fear, want, and anything that threatens the existence of human being. I think the conception of what human security is, is limited because it is not only about the environment you find yourself. Are they having good roads, access to good drinking water, quality education, and good healthcare? If all these are not existing in Bawku and its environs, then there is a problem in terms of their human security…So if the people of Bawku think that they are secure, they may be right to some extent. But surely, they are not aware of the other indicators.*

This view had earlier been shared by Kofi Annan he shared in a *Forward* that *"Today, we know that "security" means far more than the absence of conflict... We know that lasting peace requires a broad vision encompassing areas such as education and health, democracy and human rights, protection against environmental degradation, and the proliferation of deadly weapons"* (McRae, & Hubert, 2001).

Hydro-climatic events and human security

Though residents admitted enjoying greater security, when asked whether this reflected in their access to basic natural resources including water and clean environment, and food, responses were negative. Thus, all respondents found it difficult to access water resource for their various activities due to the insecurity of the environment. They indicated that, while it was not enough to rely on the erratic rainfall pattern for water for their agricultural activities, it was also difficult for them to access groundwater for domestic purposes. This situation eventually affected residents' ability to produce and provide food for households, and to ensure decent living standards. The statements below affirm these assertions made by respondents:

> *We don't feel secure when it comes to food…our water situation doesn't help us to work to generate income to cater for our needs, and this is a worry for us in this community.*
>
> (Female FGD participant, Anisi)

We manage to farm during the rainy season, but there is nothing to show for our efforts. We don't get anything! This makes us very insecure in terms of food. It is always difficult to get food to eat in this community.

(Female FGD participant, Yirigungu)

These forms of deprivation which undermine the human security situation of people fall within the domains of environmental, food and economic insecurities as specified by UNDP's Human Development Report of 1994 and the Human Security Unit of the United Nations (2009). These responses largely give weight to the material deprivation aspect of security which asserts that insecurities may result from threats to livelihoods and well-being, especially those which have links to land and/or water scarcity (Zografos, et al., 2014). Again, findings from this study attest to the conceptual framework adopted, which opines that insecurities will come about due to hydro-climatic stressors such as drought, gradual shifts such as changing average precipitation, increased water scarcity due to temperature rise, and several others (Kloos et al., 2013).

This finding reporting insecurity as aided by hydro-climatic events corroborates with an earlier report by the United Nations Development Programme and Ghana's Human Development Report (2007) which indicated that Ghana's reliance on erratic rainfall pattern for her agricultural productivity renders the country food insecure. Again, World Food Programme's Comprehensive Food Security and Vulnerability Analysis (WFP-CFSVA, 2009) has stressed that the poorest regions of the country which are also susceptible to adverse weather events such as flood and drought have had about 453, 000 of people suffering from limited access to sufficient and nutritious food, and for that matter are considered food insecured. Thus, they comprise 34 percent of the population in the Upper West Region, 15 percent in Upper East and 10 percent in the Northern Region.

Another study by Rademacher-Schulz and Mahama (2012) has further predicted that, around this same period (2016), the three northern regions of Ghana will have about 507,000 people becoming vulnerable to food insecurity. The underlying factors to this phenomenon in Ghana and several other countries, according to Brown and Crawford (2008), are as a result of the droughts experienced across the sub-regions, especially in Sub-Saharan Africa. This, the authors continued, is a major threat to the security of the region. In addition to the adverse weather events, Quaye (2008) has maintained that in an environment where food production is highly subsistence-oriented, food insecurity is seen as a normal phenomenon.

Socio-political dynamics and human security

CLICO's framework posits that human security issues caused by several factors, and that there is the need to investigate how, in addition to the hydro-climatic events, other social, political and economic dynamics interact with people's vulnerability to impact on their human security (Kloos et al., 2013). When asked how their human security was influenced by these factors, some respondents indicated that the respect for their cultural values help to calm any conflictive events. Thus, traditional authorities were trusted to resolve most issues which could have triggered any violent act capable of disrupting their human security. On the other hand, the military presence in the Bawku Municipality was also mentioned as one means of ensuring security in the area. The expressions below sum these thoughts:

> *Our leaders have always ensured peace in this community. When there is any issue, the "Tengdan" will do everything in the interest of both parties to ensure that there is peace; he is always fair and just in his judgment; he tries to unite us and stop the in-fighting and conflict between us.*
>
> (Female FGD participant, Yirigungu)

> *The incidences of conflict in Bawku have been reduced due to the vigilance of the security agencies in the municipality, and if this should continue, we will not hear of any conflict in the communities.*
>
> (Officer, Agricultural office, Bawku West)

This finding is in line with assertion made by Zografos et al. (2014) that decisions reached by institutions at any level can go a long way to reduce conflict, and thereby improving human security. In other words, Albizua and Zografos (2014) and Milman and Arsano (2014) conclude that where the decision making process fails to recognise either views, and goes ahead to give priority to the agenda of any other group for any reason, the resultant outcome are obvious – latent or manifest conflict. According to Snorek et al. (2014), such occurrences are common among pastoralists and agro-pastoralists in Niger, where in most cases, the former are marginalised. In essence, it is interpreted to mean that where decisions are reached fairly, conflicts are avoided, and by extension, human security situation is improved.

Again, the reported 'heavy' security presence in the Bawku municipality to boost the human security in the area is supported by Barnett and Adger (2007, p. 646) who argue that "human security cannot be separated from the operation of states" and so states are most likely to increase human security when it protects, provides and creates a stable economic and political environment for individuals to pursue their livelihoods with confidence. The authors' position, as shared by Sen (1999), explained that this environment must possess, among other things, freedom for people to seek employment, freedom of speech, freedom of the media, civil liberties, etc.

In this current study, though residents had opportunities to address any conflictive event by resorting to local traditional institutions, WUA, and district agricultural offices, it was observed that these avenues were not enough to curtail any violent threat that may erupt in all of the study communities, except Kuka and Zabugo which are quite closer to the main Bawku township with several police posts. State institutions such as police posts and court systems should be available to ''supplement'' and ''reinforce'' the local arbitration setup. In instances like this, Sen (1999) believes that conflict resolution mechanisms become effective, while people become less anxious about their security at the same time.

Although none of these institutions (police station or courts) existed in local environments, residents admitted that they were not worried since their traditional leaders wielded enough power and respect to settle disputes. Some rather accepted that in cases of violent conflict, the traditional authorities would be in a position mediate. These differing views have been captured in the statements below:

> *If the police come here, they will not get any work to do because I have not seen a case that the elders here have not been able to solve. This is what my sister said, whenever there is any fight, we quickly go to the 'Kamin-naab' to settle it, and we are ok.*
>
> (Female FGD participant, Apotdabogo II)

> *As you can see, we don't have one here. I am sure it would have been better to have at least one police station for all the villages around so that if there are any serious conflicts or disturbances, they can settle it for us…the chief or elders cannot arrest and put anybody behind bars for any serious offense.*
>
> (Male FGD participant, Yirigungu)

This finding is in agreement with several literatures on indigenous conflict resolution in African societies. For example, Ajayi and Buhari (2014), Muigua (2010) and Attah-Poku (1998) submit that the reliance on local authorities on conflict resolution in traditional African societies have existed in pre-colonial era where disputants often take their cases to a local tribunal for their disputes to be resolved using traditional familiar standards of behaviour (Attah-Poku). Often, the authors continue that disputants with their high level of confidence in the tribunal, are always ready to submit themselves to the terms of the ‘win-win’ resolutions. Where resolutions are achieved by taking the needs and the traditions of the local people into consideration, sustainable human security may be achieved with less or no efforts from the state (Global Partnership for the Prevention of Armed Conflict [GPPAC], The Civil Society Network for Human Security, & IKV Pax Christi, 2013).

Whereas the conceptual framework paid much attention to the direct effects of (violence) conflict on human security, it also recognizes the role of (violent) conflict, especially when severe and prolonged, in undermining the human security of a group by reducing their access to resources, and thereby increasing their exposure and vulnerability to climate change (Kloos et al., 2013; Zografos, et al., 2014). This occurs while local residents adapt whatever means possible to survive in the face of their insecurity. This current study could not verify this assertion due to two reasons – 1) the study could not record any history of violent conflict in the communities studied which may warrant this exposure to this vulnerability, and 2) there is no enough evidence to suggest that the residents’ lack of access to natural resources such as water, is as a result of persistent human insecurities.

Summary

Drawing from the conceptual framework adapted, the study sought to find how hydro-climatic hazards, and the socio-political environment in and around the study communities impacted on human security. From the data gathered, it was found that apart from the human insecurity resulting from hydro-climatic events, the socio-political situation, in one way or the other, was seen to be one key source of human insecurity in the Bawku Area. But first of all, when the residents' understanding of the concept of human was examined, it was clear that the traditional meaning of the concept (thus the absence of conflict or even the presence of peace) had widely been accepted. In spite of this, they also recognised their predicaments in the areas of the other forms of human security indicators including economic, food, health, environmental and other social amenities.

The basic resource of their wellbeing and development, water, was difficult to access. This situation was also said to affect the provision of food for residents. This deprivation of basic resources threatened their livelihoods and wellbeing while eventually impacting negatively on their human security, as shared by Zografos, et al. (2014). As well, the option of adaptation to water scarcity by the Kuka community resulted in insecurity for the people of Lansa who had to suffer from inadequate or no water supply for their dry season vegetable farming. This was a clear example of Snorek et al.'s (2014) divergent adaptation.

On the socio-political dynamics, the presence of military and police in the Bawku township, a hotspot of conflict, was interpreted to mean high sense of security as provided by the state. This provision by the state, as purported by Barnett and Adger (2007), provides opportunities for people to have confidence to pursue their livelihoods since they will have the protection to undertake their economic activities. Though, police post or stations were absent in all the study communities, it was not a source of worry to residents because of the regard they had for their traditional authorities to resolving all disputes as and when they emanated. Thus, the local institutions of dispute resolution were trusted in settling conflicts in a manner that ensures adequate security for residents.

CHAPTER NINE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The objective of this study was to investigate the relationships that exist between climate change, water-related conflicts, and human security in the Bawku Area of Ghana. Thus, by using the qualitative paradigm of research, the study sought to examine how water and climate-related hazards exacerbates conflicts or ensure cooperation, and under what conditions do the social, economic and political systems foster or mitigate conflict situations. Also, it sought to find out how the hydro-climatic hazards either impacted on any aspect of the human security of residents in the study communities.

Earlier chapters of this thesis have analysed and discussed findings which are related to the objectives of the study. This chapter highlights some of the key findings, conclusions, contributions to knowledge, recommendations, limitations and suggested areas for further research.

Summary of main findings

This study investigated the relationship between climate change, water conflict and human security in the Bawku Area of Ghana. Results from the study were geared towards responding to this objective. These motivated other specific objectives to be set, and the summary of the findings in relation to the objectives are presented below:

Findings from the data picked with Tremble GPS device and observations made indicated that the residents of the study communities were faced with inadequate water sources. Apart from rainfall which was mainly relied upon for their agricultural activities, other sources such as dams and dug-outs provided water for vegetable farming, especially in the dry season. Sometimes too, water from mechanised boreholes and hand-dug wells were used to irrigate vegetable farms, even though that was not the main use of those sources. Aside using water for crop cultivation and domestic duties, livestock also had to depend on dams and water troughs which were connected to mechanised boreholes. As already indicated, these water sources were inadequate to meet the demands of the residents as well as the livestock.

The analysis of the meteorological data from GMet indicated rainfall in the area have been increasing, despite some seasonal drops in the figures. Mean monthly and annual temperature figures were also on the increase. While residents' views on the rising temperature were in line with the analysis of the meteorological data, contrary notions were expressed regarding the rainfall trends. Thus, according to them, the communities were experiencing water scarcity conditions as a result of significant drop in rainfall or erratic nature of the rainfall pattern. In their views, the water available at any moment are unable to meet the demand for the resource for both domestic and agricultural need. According to residents, the rain did not fall in the required quantity needed for farming, especially during the planting season, and occasionally too, more than enough of it (rainfall) destroyed their farms or crops. This erratic patterns of rainfall and the increase in temperature experienced in the communities were perceived by residents to be the result of climate change, with a dire impact of water scarcity.

The incidence of water scarcity in the study communities required several adaptation strategies in order to ensure sustained livelihoods. Among the adaptation strategies were engaging in intensive irrigation or dry season vegetable farming, changing planting periods in accordance with the rainfall pattern, practicing mixed cropping, rearing of livestock with underground water sources, and rationing of water for domestic use. Others included migration to the southern cities of Ghana, including Kumasi and Accra in order to escape the unfavourable climatic conditions in their local communities. It was noticed from the study that these adaptation strategies were not new, yet the rate of relying on these forms for survival had been on the increase in recent times. This, residents attributed to climate change.

On the issue of water scarcity and conflict, the study found no evidence of violent conflicts. Instead, mild or minor forms of conflicts were found in all the communities studied, and water happened to be the casus belli. In several cases, these conflicts involved women and children who fought at borehole sites. Minor conflicts between crop farmers over water for irrigation, were as common as those between crop and livestock farmers. Particularly, livestock farmers were accused of leaving the flocks to stray to people's farms to destroy crops. The only conflict which nearly escalated to a crescendo was the water-related conflict between Kuka and Lansa communities over the use of a dam at Kuka. The intervention by the Municipal Agricultural Office ensured a cooperation between the two communities. Indeed, the analysis revealed that the conflicts emanating from residents' maladaptation practices were only possible because of lack of institutional arrangement for effective climate change adaptation.

Contrary to the minor conflicts experienced via adaptation to water scarcity conditions, the socio-economic and political situations in the study communities could not account for any form of conflict in the Bawku Area. Thus, residents could not recount any conflicts in their communities which had any of the mentioned factors as either proximate or remote causes. However, it was very common for respondents to mention the decades-old Bawku conflict as having both ethnic and political undertones as the root cause.

Commonly, conflict situations were directly and indirectly resolved at individual, household, and community levels. Thus, women and children who fought at the borehole resolved their differences at the same spot or immediately after the confrontation or skirmishes. However, traditional authorities were the main institutions which ensure cooperation among and between members of the communities in cases of conflict. For instance, the chief's words were the final authority to resolving any protracted conflict among residents. Resorting to the traditional authority for resolution was an option after attempt by other outfits such as the head of the women groups and Water Users Assocaitions or the Unit Committee had failed. The only conflict that went beyond the traditional authorities' jurisdiction for settlement was the one between Kuka and Lansa. In this instance, the conflict was resolved by the Municipal Agriculture Officer and the office of the Ghana Irrigation Development Authority.

Furthermore, it was found from this study that the traditional notion of human security was upheld in the sense that, in spite of their deprivation in terms of food, health, economic sustenance, and some basic resource (including water), respondents' initial responses indicated that their human security was guaranteed. Their responses stemmed from the fact that they were not experiencing any form of violent conflict or any aggression that would undermine their peaceful co-existence. Yet when inquired from them whether their 'so-called' secured human security resonates in their access to basic natural resources such as water and food, respondents indicated that it was difficult for them to get water to produce enough food for their households' existence.

Finally, the study investigated the socio-political dynamics of the study communities, and their relationship with the human security situations. It was revealed that the traditional authorities' exercise of power, and the military presence within the Bawku Area provide security for residents. Thus, residents specified that belief or cultural tenets gave their traditional authorities adequate influence to resolve any 'near-conflict' circumstances which would dent their human security. Again, the military presence which had been established in previous years due to the historical Bawku Conflict, had built some confidence in residents about the current and the future security of their communities.

Conclusions

Based on the key findings, the following conclusions were drawn:

As found by the study, residents were faced with challenges of accessing water for their activities, particularly agricultural. Thus, the water supply for their activities fell below the demand for the resource especially in the long dry season. Apart from this source, rivers, streams or dams which were supposed to compensate for the shortfall from the rain water was virtually absent in most of the study communities. It can therefore be concluded that the Bawku Area of Ghana suffers from water stress conditions.

Like several communities in most developing countries, rain water is the major source of water for agricultural activities. Farmers plant according to the dictates of the rainfall patterns for preparing the land, planting, and harvesting. Adaptation only surfaces at some points where this natural source either delays or is not forthcoming, hence forcing farmers to temporary adjust. In this study, adaptation is a standard or normal means of survival rather than a temporal adjustment strategy to earning a living. This inference is made from the understanding that the Bawku Area experience the harsh reality of climate change manifesting itself through high temperature and erratic rainfall pattern, which exposes residents to long period of drought which puts them in a perpertual challenge of living lives of adjustment in greater parts of the year.

It can be established based on the result of this study that the next conflict to be experienced in the Bawku Area may not necessary be ethno-political, rather a hydro-climatic one. This conclusion is borne out of the fact that water is becoming scarcer in the area due to climate change, and families and communities are ready to protect the limited quantities available to them. Also, the adaptation practices of one user or group are most likely to "step on toes" of others to trigger conflict. Another side of the story is that, the future water-related conflict in the area will be started from rural communities where livelihoods is dependent on one's access to water.

The enormous roles of the traditional authorities in resolving conflict were noted in the study, as they were last point of call when all other means of resolution – women's group, and WUA efforts especially had failed. Of course, there were instances when they (traditional authorities) step in from the onset to settle conflicts. It is however recognised that this exercise of power was recognised within the boundaries of particular communities, and not the other. It can therefore be mentioned that a chief's role or authority in resolving conflict bothering on water, could not be exercised outside of his jurisdiction, making it futile in matters of inter-community conflicts.

Recommendations

This study has indeed shown that the climate-water-security linkage is highly context-specific, and therefore requires certain specific policies to deal with the issues. Thus, specific policies will be required to improve residents' adaptive capacity in the face of climate change and its related hazards, while at the same time, addressing human security and preventing conflict in the midst of climate change. It is based on this that the following recommendations are made:

The erratic, together with the lack of or inadequate dams, irriagation facilities, and boreholes come with concomitant effect of water scarcity situation in the Bawku Area. Residents are therefore compelled to rely greatly on underground water sources for farming and other household chores. Hence, the Ghana Irrigation Development Authority, through the District Assemblies and the MoFA, should construct dams, and other irrigation facilities in the study communities or some advantageous locations which will supply water even in the dry season for farming activities. Thus, governments' promised policy of One-Village-One-Dam will be the exact panacea for communities such as those in the Bawku Area of Ghana.

In addition, the Community Water and Sanitation Agency particularly should extend the coverage water supply into the communities in order for residents to have alternative source of water supply for their domestic duties. NGOs such as World Vision, IRC Safe Water Network, etc. are also to increase their coverage of provision water to the rural communities studied. As well, assisting communities to repair or fix broken mechanised boreholes. Provision of such facilities will ensure peaceful co-existence among residents and communities. This logic flows from the backdrop that conflicts situations found in this study had to do with scarcity of water for farmers and other users in their daily activities. Furthermore, constant supply of water for farmers will get them engrossed in the farming activities, leaving them with less or no time and opportunity to involve in conflicts. Even though the Bawku conflict may have less or nothing to do with water scarcity situation in the area, there is high likelihood of achieving cooperation and relatively prolonged peace using this means of increasing water provision and access in the areas.

Residents of Bawku Area seem to be living "*lives of adaptation*" because of the erratic rainfall pattern and the associated water stress conditions. Hence, farmers sow their crops in accordance to the pattern of the rain. MoFA should therefore provide agricultural extension service to farmers, including the provision of drought-resistant seedlings in order for farmers to get yields even during the long dry season. In relation to occasional and seasonal flooding phenomenon associated with the opening of the Bagre Dam in Burkina Faso and excessive rainfall, residents should be given early warning signals or education by the Ghana Meteorological Agency and MoFA so as to inform farmers about the appropriate periods to prepare and plant their crops.

Lastly, provision of police posts by the Ministry of Interior and the Ghana Police Service at some convenient locations close to these water stressed communities would prevent or forestall any violent conflict situations that may arise among residents or between communities. This is because the Police Service would be able to respond quickly or be able to pick early conflict signals due to their close proximity to the communities. This is needful since the WUA and the chiefs or traditional authorities had the right to mediate in conflict situations, and not to cause arrest.

Contribution to knowledge

A number of lessons have been learnt from this study, especially when viewed from the conceptual framework used. Firstly, it emerges that while there may not be any violent conflict associated with water stress or scarcity situation emanating from climate change, minor ones are obvious. These minor conflicts emerged as a result of divergent adaptation to water scarcity situations, which more or less, may have been caused by the phenomenon of climate change. This study has therefore shown that even though there might not be any concrete evidence to associate, for instance, the decades old conflict at Bawku with water scarcity or stress conditions, future possibility of any violent conflict in this ‘conflict hotspot’ should not be overruled. This is because conflicts of higher magnitudes have had smaller begginings.

Again, this study has supported literature in the study of hydro-climatic change and conflict in the areas of the methodology used to arrive at the various conclusion. Though several studies with similar objective exist, yet most of them adopt quantitative approaches as opposed to this current study which solely employed a qualitative design to reveal the explanations behind the statistical figures as reported by several studies. Thus, the approach allowed respondents to construct and interprete their own meaning and happenings around them.

The latter part of the 20th century saw the massive expansion of literature on the discussion of population growth, resource scarcity and violence. The works of Homer-Dixon (1999, 1994, etc.) especially have been exemporary, and initialled a number of unending debate on resrouce scarcity and conflict. Findings from this study have added to this debate and has corroborated several other finding to pick stance that water as a causative factor of conflict cannot be ruled out in areas where the resource is scarce. The unique cases of Kuka-Lansa minor conflict, plus several other diputes at water fetching points are evident to this assertion. Hence, there is no doubt that this study has added to the literature on the climate change, water conflict and human security discussion.

Areas of further studies

After conducting this study, the researcher came across certain areas which could be explored in future studies. Such areas include the following:

- Though the study found the immense contributions of traditional authorities in conflict resolution in the various communities, yet the study failed to look into how these authorities specifically deal with situations to arrive at brokering peace and cooperation.
- Residents indicated that they were food insecured, yet this study did not go into the extent of their insecurity. Hence, future study should look into the quantification of their food insecurity exercebated by climate change, and its possible relation to conflict in the Bawku Area of Ghana.

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APPENDIX A

UNIVERSITY OF CAPE COAST

COLLEGE OF HUMANITIES AND LEGAL STUDIES

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

FOCUS GROUP DISCUSION GUIDE FOR WATER USER GROUPS – DOMESTIC/CROP/LIVESTOCK PRODUCTION

Introduction

There is inadequate understanding of how hydro-climatic stressor and/or system and socio-economic system interact; and when, where and under what conditions climate change may be associated with conflicts. This study therefore investigates the hydro-climatic security (how climate and water-related hazards influence human security) or the climate-water-security nexus (climate change, water conflicts and human security linkages) in the Bawku Area of Ghana. This exercise is strictly for academic purposed, hence your views on this subject matter within this locality will helpful. Your anonymity and confidentiality is confidently assured, and no part of your views will be used for any other exercise apart from what it is intended for.

Section A: Identification data

1) Date of interview
2) District
3) Community
4) Location/place of interview

5) Language used for the interview

6) Name of interviewer

7) Time of start of interview:

Section B: Demographic characteristics of respondents

8) Sex

9) Name (first name preferred/pseudonym)

10) Age

11) Ethnic background of respondent

12) Highest educational level attained

13) Occupation (main source of income)

14) Alternative source of income

15) Position in community

*****Number of years (name) has stayed in the community……..

Section C: Knowledge about climate (change) situation

16) How will you describe the climate situation in this community since the time you stayed in here?

Probe: How has there been changes in frequency, duration (timing) and intensity of extreme weather events, such as high temperature, storm surges, floods, and drought? Since when?

17) Specifically, how has changes in frequency, duration (timing), and intensity of rainfall in this community been? Since when?

18) How is this area/community likely to be affected by scarce rainfall or extreme rainfall/flood in the future?

Probe:

- What would be the impacts on water access and availability for the different user groups?

Section D: Climate change versus availability and access to water – Obj. 1 & 2

19) From where do you or different water user groups get water for their activities – well, pipe, river/stream/lake/irrigation facility?

Probe:

- How long have you and/or the community used this water source?
- Can you get enough water for all your activities?
- How has climate change affected your access to water from this water source?

20) (How) has changes in climate affected the availability of water for all use – domestic, crop and livestock use?

Probe:

- In what way has climate change affected the availability of water for these purposes?
- Since when has this/these been the case?
-

Section E: Impacts of water-related hazards – Obj. 1 & 2

21) How does water scarcity affect you and/or your community?

    Probe: Domestic use; crop production; livestock rearing;

22) Does water scarcity affect everyone equally in this community?

    Probe:

    - Are there some (group of) people it affects more than others?
    - Who and why?

23) Why do you think water scarcity is a major problem for all water user groups in this community?

    Probe: in terms of these users - domestic use; crop production; livestock rearing.

Section F: Adaptation to water-related hazards

24) What is the extent of the adaptive capacity of the different user groups to climate change?

    Probe:

25) What have you been doing to adapt to water-related hazards for these uses: domestic use; crop production; livestock rearing?

26) What financial and technical means do the different user groups have to adapt to climate change effects on their livelihoods in the areas of domestic and agricultural water supply?

27) How are government institutions reacting to climate change, e.g. are they supporting adaptation measures or educating or sensitising people as to what to do?

27) What will you do if there is less water for all activities in the future?

Section G: Water-related hazards and conflicts or corporation - Obj. 1 & 2

28) Who owns the land, and hence the water resources on the land? And who does not?

29) How often do conflict occur over water in this community?

    Probe: Seasonality of conflicts – excessive rainfall or scare rainfall season period?

30) What on-going water-related conflicts are there in the community? Is/are there history of any?

    Probe:

    - Who are/or were the conflict parties?
    - What are the grievances of the conflict parties?
    - When did it start, over what water resource (tap, well, river, irrigation)
    - How did it happen - e.g. tensions, protests, violence, etc.?
    - How do historical differences and unresolved conflicts manifest themselves in the (in any) current conflict over water?
    - How is the water-related conflict linked to other (current) conflicts – social, economic or political?

31) Are there any transboundary water bodies in this community?

Probe:

- Do the community share some water body/source with other or nearby community or communities?
- How do water users and managers from across those communities impact water availability and/or access in this community?
- Do you think there are or there have been other transboundary issues (socio-economic factors) influencing water conflict (potential)?

32) What is the possibility that scarcity of water resources could lead to corporation rather than conflict in a community?

Probe:

- Has there been any experience like that in this community? When? What happened? What was the outcome?

Section H: Social, economic and political factors to conflict or corporation – Obj. 3

33) Apart from the water-related conflicts, how has other factors (social, economic, and political) contributed to conflict in this area/community?

Probe:

- What on-going conflicts are there in this community that are related to these factors stated? Is/are there history of any?
- Seasonality of these conflicts – when does it normally occur?
- Who are or were the conflict parties?
- What are the grievances of the conflict parties?

- When did it start?
- How did it happen - e.g. tensions, protests, violence, etc.?
- How do historical differences and unresolved conflicts manifest themselves in the (in any) current conflict?
- How is this conflict depriving people of their livelihood – domestic and/or agricultural?
- What attempts have been made to resolve the said conflict?

Section I: Human Security situation – Obj. 4

34) How is your human security situation affected by risks associated with hydro-climatic hazards, social, economic and political factors?

Probe:

- How secured do you feel in this community?
- Do you feel as secure as five, ten or twenty years ago? What is the reason for your response?
- How has the human security situation in this community changed?
- What do you think might have cause the change in the human security situation in this community – hydro-climatic/social/economic/political?
- Are there areas in your life where you feel insecure? What areas are these – economic, food?

Section J: Policy and institutional framework for climate-related water conflict resolution – Obj. 6

35) In any given water conflict under consideration, have prior attempts already been made at reaching a solution?

Probe:

- If yes, have/has it been resolved?
- What were/are the main elements of the resolution? Are you and/or the community satisfied with the outcome?
- If in your opinion the conflict has not been resolved, what are the critical pending issues?
- What future awaits this conflict? What would be a satisfactory outcome from your point of view?

36) Has there been **OR** are there formal or informal institutions, rules or mediators for water-conflict resolution in this community?

Probe:

- What steps are taken by the institutions in resolving conflicts?
- Are those institutions and conflict-resolution mechanisms regarded by all groups as legitimate and fair?
- If not, how are all user groups who perceive they are not being treated well by these institutions marginalized in other socio-political matters – good roads, national health insurance, hospital, schools, market centers, etc?
- Do the institutions for conflict resolution intervene in a timely manner and achieve a reconciliation of interests?

37) If institution or resolution mechanisms are weak or non-existent, how could they be improved and/or created?

38) How can conflict factors be turned into cooperation potential?

Probe:

- Are there cooperative approaches possible which can decrease some or all conflict factors?

- What are possible solutions to water access and availability problems?

- What are possible ways to prevent or resolve the water conflict?

Last word

Is there anything you want to add which we have not mentioned yet? If yes, kindly share with me.

APPENDIX B

UNIVERSITY OF CAPE COAST

COLLEGE OF HUMANITIES AND LEGAL STUDIES

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

IN-DEPTH INTERVIEW GUIDE FOR KEY INFORMANTS

Introduction

There is inadequate understanding of how hydro-climatic stressor and/or system and socio-economic system interact; and when, where and under what conditions climate change may be associated with conflicts. This study therefore investigates the hydro-climatic security (how climate and water-related hazards influence human security) or the climate-water-security nexus (climate change, water conflicts and human security linkages) in the Bawku Area of Ghana. This exercise is strictly for academic purposed, hence your views on this subject matter within this locality will helpful. Your anonymity and confidentiality is confidently assured, and no part of your views will be used for any other exercise apart from what it is intended for.

Section A: Identification data

39) Date of interview

40) District

41) Community

42) Location/place of interview

43) Language used for the interview

44) Name of interviewer

45) Time of start of interview:

Section B: Demographic characteristics of respondents

46) Sex

47) Name (first name preferred/pseudonym)

48) Age

49) Ethnic background of respondent

50) Highest educational level attained

51) Occupation (main source of income)

52) Alternative source of income

53) Position in community

*****Number of years (name) has stayed in the community……..

Section C: Knowledge about climate (change) situation

54) How will you describe the climate situation in this community since the time you stayed in here?

Probe: How has there been changes in frequency, duration (timing) and intensity of extreme weather events, such as high temperature, storm surges, floods, and drought? Since when?

55) Specifically, how has changes in frequency, duration (timing), and intensity of rainfall in this community been? Since when?

56) How is this area/community likely to be affected by scarce rainfall or extreme rainfall/flood in the future?

Probe:

- What would be the impacts on water access and availability for the different user groups?

Section D: Climate change versus availability and access to water – Obj. 1 & 2

57) From where do you or different water user groups get water for their activities – well, pipe, river/stream/lake/irrigation facility?

Probe:

- How long have you and/or the community used this water source?
- Can you get enough water for all your activities?
- How has climate change affected your access to water from this water source?

58) (How) has changes in climate affected the availability of water for all use – domestic, crop and livestock use?

Probe:

- In what way has climate change affected the availability of water for these purposes?
- Since when has this/these been the case?

Section E: Impacts of water-related hazards – Obj. 1 & 2

59) How does water scarcity affect you and/or your community?

Probe: Domestic use; crop production; livestock rearing;

60) Does water scarcity affect everyone equally in this community?

Probe:

- Are there some (group of) people it affects more than others?
- Who and why?

61) Why do you think water scarcity is a major problem for all water user groups in this community?

Probe: in terms of these users - domestic use; crop production; livestock rearing.

Section F: Adaptation to water-related hazards

62) What is the extent of the adaptive capacity of the different user groups to climate change?

Probe:

63) What have you been doing to adapt to water-related hazards for these uses: domestic use; crop production; livestock rearing?

64) What financial and technical means do the different user groups have to adapt to climate change effects on their livelihoods in the areas of domestic and agricultural water supply?

65) How are government institutions reacting to climate change, e.g. are they supporting adaptation measures or educating or sensitising people as to what to do?

27) What will you do if there is less water for all activities in the future?

Section G: Water-related hazards and conflicts or corporation - Obj. 1 & 2

66) Who owns the land, and hence the water resources on the land? And who does not?

67) How often do conflict occur over water in this community?

   Probe: Seasonality of conflicts – excessive rainfall or scare rainfall season period?

68) What on-going water-related conflicts are there in the community? Is/are there history of any?

   Probe:

   - Who are/or were the conflict parties?
   - What are the grievances of the conflict parties?
   - When did it start, over what water resource (tap, well, river, irrigation)
   - How did it happen - e.g. tensions, protests, violence, etc.?
   - How do historical differences and unresolved conflicts manifest themselves in the (in any) current conflict over water?
   - How is the water-related conflict linked to other (current) conflicts – social, economic or political?

69) Are there any transboundary water bodies in this community?

   Probe:

   - Do the community share some water body/source with other or nearby community or communities?

- How do water users and managers from across those communities impact water availability and/or access in this community?
- Do you think there are or there have been other transboundary issues (socio-economic factors) influencing water conflict (potential)?

70) What is the possibility that scarcity of water resources could lead to corporation rather than conflict in a community?

Probe:

- Has there been any experience like that in this community? When? What happened? What was the outcome?

Section H: Social, economic and political factors to conflict or corporation – Obj. 3

71) Apart from the water-related conflicts, how has other factors (social, economic, and political) contributed to conflict in this area/community?

Probe:

- What on-going conflicts are there in this community that are related to these factors stated? Is/are there history of any?
- Seasonality of these conflicts – when does it normally occur?
- Who are or were the conflict parties?
- What are the grievances of the conflict parties?
- When did it start?
- How did it happen - e.g. tensions, protests, violence, etc.?

- How do historical differences and unresolved conflicts manifest themselves in the (in any) current conflict?
- How is this conflict depriving people of their livelihood – domestic and/or agricultural?
- What attempts have been made to resolve the said conflict?

Section I: Human Security situation – Obj. 4

72) How is your human security situation affected by risks associated with hydro-climatic hazards, social, economic and political factors?

Probe:

- How secured do you feel in this community?
- Do you feel as secure as five, ten or twenty years ago? What is the reason for your response?
- How has the human security situation in this community changed?
- What do you think might have cause the change in the human security situation in this community – hydro-climatic/social/economic/political?
- Are there areas in your life where you feel insecure? What areas are these – economic, food?

Section J: Policy and institutional framework for climate-related water conflict resolution – Obj. 6

73) In any given water conflict under consideration, have prior attempts already been made at reaching a solution?

Probe:

- If yes, have/has it been resolved?
- What were/are the main elements of the resolution? Are you and/or the community satisfied with the outcome?
- If in your opinion the conflict has not been resolved, what are the critical pending issues?
- What future awaits this conflict? What would be a satisfactory outcome from your point of view?

74) Has there been **OR** are there formal or informal institutions, rules or mediators for water-conflict resolution in this community?

Probe:

- What steps are taken by the institutions in resolving conflicts?
- Are those institutions and conflict-resolution mechanisms regarded by all groups as legitimate and fair?
- If not, how are all user groups who perceive they are not being treated well by these institutions marginalized in other socio-political matters – good roads, national health insurance, hospital, schools, market centers, etc?
- Do the institutions for conflict resolution intervene in a timely manner and achieve a reconciliation of interests?

75) If institution or resolution mechanisms are weak or non-existent, how could they be improved and/or created?

76) How can conflict factors be turned into cooperation potential?

Probe:

- Are there cooperative approaches possible which can decrease some or all conflict factors?

- What are possible solutions to water access and availability problems?

- What are possible ways to prevent or resolve the water conflict?

Last word

Is there anything you want to add which we have not mentioned yet? If yes, kindly share with me.

APPENDIX C

UNIVERSITY OF CAPE COAST

COLLEGE OF HUMANITIES AND LEGAL STUDIES

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

IN-DEPTH INTERVIEW GUIDE FOR PUBLIC AND/OR PRIVATE AGENCY

Introduction

There is inadequate understanding of how hydro-climatic stressor and/or system and socio-economic system interact; and when, where and under what conditions climate change may be associated with conflicts. This study therefore investigates the hydro-climatic security (how climate and water-related hazards influence human security) or the climate-water-security nexus (climate change, water conflicts and human security linkages) in the Bawku Area of Ghana. This exercise is strictly for academic purposed, hence your views on this subject matter within this locality will helpful. Your anonymity and confidentiality is confidently assured, and no part of your views will be used for any other exercise apart from what it is intended for.

Section A: Identification data

77) Date of interview:

78) District:

79) Name of Community:

80) Location/place of interview:

81) Language used for the interview:

82) Name of interviewer:

83) Time of start of interview:

Section B: demographic data

84) Sex:

85) Name (first name preferred/pseudonym)

86) Age

87) Ethnic background of respondent

88) Highest educational level attained/completed

89) Occupation (main source of income)

90) Alternative source of income

91) Position in community/organisation:

*****Number of years (name) has stayed in the community……..

Section C: Knowledge about climate (change) situation

92) How will you describe the climate situation in (this community) the Bawku Area of Ghana?

Probe: How has there been changes in terms of frequency, duration (timing) and intensity of extreme weather events, such as high temperature, storm surges, floods, and drought? Since when?

93) Specifically, how has changes in frequency, duration (timing), and intensity of rainfall in this community been? Since when?

94) How is this area/community (or Bawku Area) likely to be affected by scarce rainfall or extreme rainfall/flood in the future?

Probe:

- What would be the impacts on water access and availability for the different user groups?

Section D: Climate change versus availability and access to water – Obj. 1 & 2

95) From where do the community get water for their activities – well, pipe, river/stream/lake/irrigation facility?

Probe:

- How long has the community used this water source?
- Are they able to get enough water for all your activities?
- How has climate change affected their access to water from this water source?

96) (How) has changes in climate affected the availability of water for all use – domestic, crop and livestock use?

Probe:

- In what way has climate change affected the availability of water for various purposes?
- Since when has this/these been the case?

Section E: Impacts of water-related hazards – Obj. 1 & 2

97) How would water scarcity affect the communities in the Bawku Area?

Probe: Domestic use; crop production; livestock rearing;

98) Will water scarcity affect everyone equally in these communities?

Probe:

- Are there some (group of) people who will be affects more than others?
- Who and why?

99) Why do you think water scarcity would be a major problem for all water user groups in these areas?

Probe: in terms of these users - domestic use; crop production; livestock rearing.

Section F: Adaptation to water-related hazards

100) What adaptive capacity do the different user groups need to respond to climate change?

Probe:

- What have the communities been doing (or should be done) to adapt to water-related hazards for these uses: domestic use; crop production; livestock rearing?

101) What financial and technical means do the different user groups have to adapt to climate change effects on their livelihoods in the areas of domestic and agricultural water supply?

102) How are government institutions reacting to climate change?

Probe: is government supporting adaptation measures or sensitising people as to what to do?

Section G: Water-related hazards and conflicts or corporation - Obj. 1 & 2

103) Who owns the land, and hence the water resources on the land in the Bawku Area? And who does not?

104) How often do conflict occur over water in these area?

Probe: Seasonality of conflicts – excessive rainfall or scare rainfall season period?

105) What on-going water-related conflicts are there in the community? Is/are there history of any?

Probe:

- Who are/or were the conflict parties?
- What are the grievances of the conflict parties?
- When did it start, over what water resource (tap, well, river, irrigation)
- How did it happen - e.g. tensions, protests, violence, etc.?
- How do historical differences and unresolved conflicts manifest themselves in the (in any) current conflict over water?
- How is the water-related conflict linked to other (current) conflicts – social, economic or political?

106) Are there any transboundary water bodies in these communities in the Bawku Area?

Probe:

- Do communities share some water body/source?

- How do water users and managers from across these communities impact water availability and/or access among themselves?
- Do you think there are or there have been other transboundary issues (socio-economic factors) influencing water conflict (potential)?

107) What is the possibility that scarcity of water resources could lead to corporation rather than conflict in Bawku Area?

Probe:

- Has there been any experience like that? When? What happened? What was the outcome?

Section H: Social, economic and political factors to conflict or corporation – Obj. 3

108) Apart from the water-related conflicts, how has other factors (social, economic, and political) contributed to conflict in Bawku Area?

Probe:

- What on-going conflicts are there in the area that are related to these factors stated? Is/are there history of any?
- Seasonality of these conflicts – when does it normally occur?
- Who are or were the conflict parties?
- What are the grievances of the conflict parties?
- When did it start?
- How did it happen - e.g. tensions, protests, violence, etc.?

- How do historical differences and unresolved conflicts manifest themselves in the (in any) current conflict?
- How is this conflict depriving people of their livelihood – domestic and/or agricultural?
- What attempts have been made to resolve the said conflict?

Section I: Human Security situation – Obj. 4

109) How is human security situation in this area affected by risks associated with hydro-climatic hazards, social, economic and political factors?

Probe:

- How secured do people feel in the Bawku Area?
- Do they feel as secure as five, ten or twenty years ago? What is the reason for your response?
- How has the human security situation in the area changed?
- What do you think might have cause the change in the human security situation in the area – hydro-climatic/social/economic/political?
- Are there areas in the people's life where they feel insecure? What areas are these – economic, food?

Section J: Policy and institutional framework for climate-related water conflict resolution – Obj. 6

110) Scenarios forecasted by the climate change experts indicate that this area/region will experience significant changes in the water regime, with

sudden increase in intensive water precipitations followed by serious periods of water scarcity and drought.

Probe:

- What is your view and that of your organization of these expected changes?

- What potential risks will the change in water regimes have in this area?

- What is the state of the discussion and preparedness of your organization with respect to these expected changes?

111) In any given water conflict under consideration, have prior attempts already been made at reaching a solution?

Probe:

- If yes, have/has it been resolved?
- What were/are the main elements of the resolution? Is **your outfit** and/or **the area/communities** satisfied with the outcome?
- If in your opinion the conflict has not been resolved, what are the critical pending issues?
- What future awaits this conflict? What would be a satisfactory outcome from your point of view?

112) Has there been **OR** are there formal or informal institutions, rules or mediators for water-conflict resolution in this community?

Probe:

- What steps are taken by your outfit or other institutions in resolving conflicts?

- Are those institutions or yours and conflict-resolution mechanisms regarded by all groups as legitimate and fair?
- If not, how are all user groups who perceive they are not being treated well by these institutions marginalized in other socio-political matters – good roads, national health insurance, hospital, schools, market centers, etc?
- Do the institutions for conflict resolution intervene in a timely manner and achieve a reconciliation of interests?

113) If institution or resolution mechanisms are weak or non-existent, how could they be improved and/or created?

114) How can conflict factors be turned into cooperation potential?

Probe:

- Are there cooperative approaches possible which can decrease some or all conflict factors?
- What are possible solutions to water access and availability problems?
- What are possible ways to prevent or resolve the water conflict?

Last word

Is there anything you want to add which we have not mentioned yet? If yes, kindly share with me.

APPENDIX D

UNIVERSITY OF CAPE COAST

COLLEGE OF HUMANITIES AND LEGAL STUDIES

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

OBSERVATION CHECKLIST

ITEM	DISTRICT	COMMUNITY	YES	QTY	NO
Water source and facility					
Standpipe					
Mechanised borehole					
Hand-dug well					
Dam					
Dug-out					
Irrigation system/facility					
Crops cultivated/animals reared					
Grains/cereals					
Vegetables					
Security					
Livestock					
Bird/fowls					

Police post/station					

APPENDIX E
INFORMED CONSENT FORM

This is a research project intended to solicit information on your demographic characteristics, knowledge on climate change, source and use of water resources in this community, and how the scarcity or abundance of it have/may cause conflict or cooperation in this community in the wake of climate change. The information collected will help the researcher to understand climate change, water conflict and human security are connected in this district, and to recommend ways to ameliorate any adverse effect, and improve on existing cooperative measures.

I will ask you questions in relation to the above issues and record your responses or answers using a digital recorder. The interview or discussion will take approximately 45 to 90 minutes. During the interview or discussion, I will ask for your phone contact in case the need arises to contact you later for further clarification on any of the issues at stake. However, you may still participate if you do not have phone contact or you do not want to give it. There are no known risks associated with your participation in this study. I appreciate that this is a busy period for you, but I will crave your indulgence to bear and cooperate with me. If you need to take a break for rest or to take care of something, please inform me and I will stop when you wish.

I am unable to tell at this point, any intended benefit that you or the community may derive from this discussion. Theirs is no financial incentive for taking part in the study since this is a purely academic work. However, the finding that would eventually come out of this study or discussion would inform future policy on the issues that would be raise to make our live meaningful.

I will like to assure you all that any information you provide will be strictly treated as private and confidential and will be used only for purposes of this study. Your identity will not be disclosed. Therefore, pseudonyms or codes will be used to identify participants so that no personal identifiers would be available to link you to the information you will provide.

This research has been reviewed and approved by the Institutional Review Board of University of Cape Coast (UCCIRB). If you have any questions about your rights as a research participant you can contact the Administrator at the IRB Office between the hours of 8:00 am and 4:30 p.m. through the phones lines 0240109209, 0244207814 and 0332133172 or email address: irb@ucc.edu.gh.

Please, do you [NAME………………………………………………………]

agree to participate in this study? Yes [ ] No [ ]

I agree to be digitally recorded during the interview

Yes [ ] No [ ]

Respondent's signature/thumbprint..

Community………………………………………… Hse identification…………………………………………

District……………………………………………...

Date…………………………………………….......

APPENDIX F

The District Commander

Ghana Police Service

Bawku Municipal

Upper East Region

Dear Sir/Madam,

PERMISSION TO CONDUCT A RESEARCH IN YOUR DISTRICT

Mr. Yaw Asamoah, the bearer of this letter is a doctoral candidate from the Department of Geography and Regional Planning, (DGRP) of the University of Cape Coast (UCC), is undertaking a research project on the topic "Climate Change, Water Conflict, and Human Security in the Bawku Areas of Ghana".

The main intent of his research project is to investigate the interconnectedness that exists between climate change, water conflict and human security ("Climate-Water-Security nexus") in the Bawku Area of Ghana.

We will like to assure you that this research project will not in any way disturb the peace, security and stability of your area. Within our period of data collection, we will abide by all the ethical guidelines that govern research of this nature.

We are, by this letter, informing you of the data collection exercise which is scheduled for 08thFebruary - 29th February, 2016.

Please, do not hesitate to contact DGRP-UCC on 0332130681, 0332130680, or my supervisors Prof. K.B. Antwi (0246143986) and Dr. S. Mariwah (0204417444) or georegplg@ucc.edu.gh

Yours faithfully,

CC:

The District Commander

Ghana Police Service

Bawku West District

Upper East Region

The District Commander

Ghana Police Service

Garu - Tempane District

Upper East Region

The District Commander

Ghana Police Service

Binduri District

Upper East Region

APPENDIX G

INTRODUCTORY LETTER

UNIVERSITY OF CAPE COAST
COLLEGE OF HUMANITIES AND LEGAL STUDIES
FACULTY OF SOCIAL SCIENCES
DEPARTMENT OF GEOGRAPHY & REGIONAL PLANNING

Our Ref: GRP/G.4^A/16/Vol.1/141

Your Ref:

UNIVERSITY POST OFFICE
CAPE COAST, GHANA
WEST AFRICA

18th August, 2016

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....
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Dear Sir/Madam,

LETTER OF INTRODUCTION
TO WHOM IT MAY CONCERN

Mr. Yaw Asamoah, the bearer of this letter is a Doctoral candidate at the Department of Geography and Regional Planning, (DGRP) of the University of Cape Coast (UCC). He is undertaking a research project on the topic "Climate Change, Water Conflict, and Human Security in the Bawku Areas of Ghana".

The main intent of his research project is to investigate the interconnectedness that exists between climate change, water conflict and human security ("Climate-Water-Security nexus") in the Bawku area of Ghana.

Hence, we will appreciate it a lot if you give audience to the researcher.

Please, do not hesitate to contact DGRP-UCC on 0332130681, 0332130680, or my supervisors Prof. K.B. Antwi (0246143986) and Dr. S. Mariwah (0204417444) or geography@ucc.edu.gh

We count on your cooperation.

Yours faithfully,

Dr. Simon Mariwah.
HEAD