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HOUSEHOLD VULNERABILITY AND ADAPTATION TO FLOODS: A COMPARATIVE STUDY OF RURAL AND URBAN GHANA

By

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DECLARATION

I hereby declare that this PhD thesis is my own production under the supervision of my academic advisors. To the best of my knowledge, except for the references cited which have been duly acknowledged, no section of the work is a reproduction or submitted wholly or in part, for the award of any degree in any university elsewhere.

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DEDICATION

To my wife Mrs Esther Abass and my children Iran Shola, Dickson, Adeline and Desmond, I dedicate this thesis.

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ABSTRACT

The study examined household vulnerability and adaptation to floods involving a comparative study of rural Central Gonja and Kumasi Metropolis using an adapted MOVE (Methods for the Improvement of Vulnerability Assessment in Europe) analytical framework. It employed a concurrent triangulation mixed method design of quantitative and qualitative methods, using both primary and secondary sources of data. A survey of eight communities each from Kumasi Metropolis and rural Central Gonja involving 367 and 400 households respectively were undertaken. Different methods involving one-on-one in-depth interview, focus group discussions and direct observation, were used to collect primary data from households and key informants. Data from household survey was analysed using appropriate statistical tools in IBM SPSS (Version 21) and Microsoft Excel 2010 for household quantitative data and NVivo 9 qualitative data analysis software for the qualitative data. Both descriptive and inferential statistics, including percentages, Pearson's Chi-square and logistic regression were used for analysing the quantitative data while the qualitative data has been presented mainly as direct quotations. Satellite images were analysed using ERDAS imagine 13 remote sensing and ArcGIS 10.2 geo-information software. Digital Elevation Models (DEMs) of the study districts were used to show the relief of the study areas from which the stream networks were derived. The MAKESENS and time series plots were used to detect the monotonic trend of the rainfall data with data analysed using the Mann-Kendall test (Z) and Sen's slope (Q) tests. The study found that anthropogenic factors rather than physical-environmental factors are responsible for the past cases of floods in both rural Central Gonja and Kumasi Metropolis [urban]. The rural households were more vulnerable to floods than the urban households in respect of all the indicators and criteria used for vulnerability assessment. From economic and health effects point of view, a higher proportion of the rural populations suffered negatively than their urban counterparts. The non-structural measures of adapting to floods were limited. Over-reliance on the structural defence mechanisms has not helped to mitigate the sufferings of the rural and urban flood-prone communities. Institutional interventions in flood risk mitigation have not been effective due to mainly financial constraints. It is recommended that there should be sustained public education, institutional strengthening and enforcement of land use regulations as enshrined in the Land use and Spatial Planning Act (Act 925).

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LIST OF ACRONYMS AND ABBREVIATIONS

CCA	Climate Change Adaptation Programme
CERGISS	Centre for Remote Sensing and Geographic Information Services
CGDA	Central Gonja District Assembly
CRED	Centre for Research on the Epidemiology of Disasters
CREW	Community Resilience through Early Warning
DEM	Digital Elevation Model
DFID	Department of International Development
DOS	Dark Object Subtraction
DP&G	Department of Parks and Gardens
DPSEA	Driving-Force-Pressure-State-Effect-Action
DRR	Disaster Risk Reductions
DVG	Disaster Volunteer Group
ECG	Electricity Company of Ghana
EPA	Environmental Protection Agency
ETM+	Enhanced Thematic Mapper Plus
FC	Forestry Commission
FEMA	Federal Emergency Management Agency
FGD	Focus Group Discussion
GLOF	Glacial Lake Outburst Floods
GLSS	Ghana Living Standards Survey
Gmet	Ghana Meteorological Services Agency
GNAT	Ghana National Association of Teachers
GPS	Global Positioning System
GSS	Ghana Statistical Service
HV	High Vulnerability
HSD	Hydrological Services Department
ICE	Institute of Civil Engineers
ICSU	International Council for Science
IDI	In-depth Interviews
IFI	International Flood Initiative
IFRC	International Federation of Red Cross and Red Crescent Societies

ILGS	Institute of Local Government Studies
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
	Electrotechnical Commission
ITC	International Institute for Geo-Information Science and Earth Observation
IWMI	International Water Management Institute
KATH	Komfo Anokye Teaching Hospital
KMA	Kumasi Metropolitan Assembly
LRD	Land Registration Division
LV	Low Vulnerability
LVD	Land Valuation Division
LULC	Land Use Land Cover
MESTI	Ministry of Environment, Science, Technology and Innovation
MLGRD	Ministry of Local Government and Rural Development
MMDA	Metropolitan, Municipal and District Assemblies
MOVE	Methods for the Improvement of Vulnerability Assessment in Europe
MWRWH	Ministry of Water Resources, Works and Housing
NADMO	National Disaster Management Organization
NGOs	Non-Governmental Organizations
NHIS	National Health Insurance Scheme
OLI/TRS	Operationalised Landsat Imager/ Thermal Infrared Sensor
PAR	Pressure and Release
PTSD	Post Traumatic Stress Disorder
PVLD	Public and Vested Land Division
SLC	Scan Line Corrector
SMD	Survey and Mapping Division
SPSS	Statistical Package for the Social Sciences
SRTM	Shuttle Radar Topography Mission
T&CPD	Town and Country Planning Department
ToA	Top of Atmosphere
TM	Thematic Mapper
UNEP	United Nations Environment Programme

UN	United Nations
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Management
UNU-EHS	United Nations University Institute for Environment and Human Security
USGS	United States Geological Survey
UTM	Universal Traverse Mercator
VHV	Highly Vulnerable
WDR	World Disaster Report
WHO	World Health Organization
WMO-UNESCO	World Meteorological Organization-United Nations Educational, Scientific and Cultural Organization
WRC	Water Resources Commission

CHAPTER ONE

INTRODUCTION

1.1 Background

Flood refers to the accumulation of too much water which rises to overflow land which is not normally submerged (Mukhopadhyay, 2010). Floods are the most common natural hazard at the world scale and are caused by both natural and human factors. Floods result from overflow of rivers produced by prolonged seasonal rainfall, rainstorms, snowmelt and dam-breaks, accumulation of rainwater in low-lying areas with high water tables or inadequate storm drainage, and intrusion of seawater onto land during cyclonic/tidal surges (Handmer et al., 1999; Stoltman et al., 2004). The most common cause of floods, however, is heavy rainfall (Handmer *et al*., 1999). Some human-induced factors of floods include non-existent or poorly maintained drainage systems, clogged drainage channels, deforestation, increased urbanisation, building in waterways and landscape modification (Karley, 2009; Gyekye, 2011).

Floods may manifest in different forms, ranging from regular water logging of ground after rainfall through more severe but relatively predictable seasonal flooding to catastrophic flood events that overwhelm coping capacities of local communities and authorities and constitute disasters (Few, 2003). Wisner *et al.* (2004) however noted that the distinction between mild and severe forms of flooding is a blurred one as the same event can have differential effects on neighbourhoods and even households depending on their vulnerability.

Floods occur in both rural and urban settings. While this may be the result of combination of human and natural events, urban floods is particularly distinct. Urban floods is usually the result of inadequate drainage, worsened by urbanisation that reduces the permeability of ground surfaces and increasing runoff rates (Parker, 1999). As there is little open soil that can be used for water storage, nearly all the precipitation needs to be transported to surface water or the sewage system. When the city's sewage and drainage systems lack the necessary capacity to drain away the amounts of runoffs that are generated, floods are inevitable (Jha et al., 2012). Aside climate change effects, urban floods are a result of other environmental processes such as constrain of floodplains by dwellings, indiscriminate waste disposal, earthworks, embankments, concrete and other infrastructure which may alter floodplains (Smith, 2004). Urban areas are thus not disaster prone by nature but that the structural process that speeds up rapid urbanisation, population movement and population concentrations greatly increase the vulnerability of low-income urban dwellers to disasters (Hamza and Zetter, 1998).

The term vulnerability can be viewed from two main perspectives. Viewed as an outcome, vulnerability is seen as the degree of loss resulting from a potentially damaging phenomenon such as floods (Downing at al., 1999). In a similar sense, Adger (1999: 5) views vulnerability as 'the exposure of groups or individuals to stress as a result of social and environmental change, where stress refers to unexpected changes and disruption to livelihoods'. To Turner et al. (2003: 8074), "vulnerability is the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard, either a perturbation or stress/stressor". A more conventional and distinct way is to view vulnerability as the set of attributes that condition outcomes (Lewis, 1999, cited in Few, 2003). The characteristics of the individuals and the physical environment for instance can influence how much damage one suffers in the event of a disaster. In vulnerable systems, even the smallest disturbances can cause dramatic social, economic and environmental consequences

(Adger, 2006). Vulnerability according to Philip and Rayhan, (2004) is a product of many factors including but not limited to poverty, gender inequality, poor health status, low levels of education, lack of access to information and knowledge, fragile and hazardous location, as well as limited access to political power and representation. These factors operate to undermine individuals' capacity for self-protection, block or reduce access to social protection, delay recovery, or expose some groups to greater or more frequent hazards than other groups. (Aysan, 1993; Philip and Rayhan, 2004).

Floods constitute one of the most endangering sources of disaster risk (Sharma and Priya, 2001; Smith, 2004; Wisner *et al.*, 2004; Jonkman and Vrijling, 2008) both at global and local levels. The danger however is not only the result of the process per se (natural vulnerability) but the result of the human systems and their vulnerability to natural disasters (human vulnerability). When both types of vulnerability have the same coordinates in space and time, natural disasters can occur (Alcantara-Ayala, 2002). Floods affect approximately 520 million people and their livelihoods, claiming about 25000 lives worldwide annually (WMO-UNESCO, 2007). Floods are often associated with widespread contamination that results in immediate, short-term and long-term threats to human health and the environment. A clear understanding of the causes and effects of flood impacts and taking appropriate measures to minimise them must become part of mainstream development thinking and be embedded in wider development goals.

Globally, immediate loss of life from floods has been decreasing over time, indicating successes in the implementation of flood risk management measures. While this this welcoming, it is a different story in underdeveloped countries where fatalities remain high with flood events having a disproportionate impact on the most vulnerable, mostly the poor, women and children (Jha et al., 2012). In these less developed countries, flood disasters are becoming increasingly unpredictable. With the changing frequency of flood events due to urbanisation, rapid urban population growth and potential climate change (IPCC, 2001; WDR, 2010), the number of people vulnerable to devastating floods worldwide is expected to rise. The picture becomes gloomy if we consider the fact that predominantly the poor and the most vulnerable persons settle on marginal or potentially dangerous areas, due to their inability to afford safe locations (Parkinson, 2003)· Although these sites are vulnerable to the impacts of flooding, the benefits of living nearer sources of employment and urban services generally outweigh the disadvantages associated with flooding, which is generally perceived as a natural and seasonal event (Parkinson, 2002).

In Ghana, it is common to read news headline on how one community or the other is hit by floods. Prolonged heavy rainfall coupled with human factors is often blamed for the perennial floods. Haphazard development of buildings, building in waterways and poor environmental practices are observable. In the study of Gbawe-Mallam in Accra for example, Gyekye (2011) identified relief, geomorphic factors, urbanisation of stream basins, drying up of wetlands, removal of vegetative cover as well as deficient drainage networks and waste disposal problems as flood aggravating factors. Karley (2009) notes that the cause of the problem of floods in Accra is the lack of drainage facilities to collect the stormwater for safe disposal. Annual floods often result in serious socio-economic, environmental and health consequences.

Despite increasing mitigation efforts human vulnerability to floods continues to increase. The floods of July 3, 1995 for example destroyed major roads, thousands of homes and took 13 lives in Accra (Aboagye, 2012). In June 28, 2001, floods in Accra caused the death of 20 people, displaced thousands of households, and destroyed property worth millions of dollars (Aboagye, 2012). Between 1995 and 2007, more than ten incidents of floods were recorded in Accra. The horrific scenes of the 3rd June, 2015 floods and gas explosion disaster in Accra are still fresh in the minds of many (Obour, 2015). The Tolon/Kumbungu District of the Northern Region of Ghana was hit by floods between July and September in 1995, 1997, 2004, 2007, 2008, 2009 and 2010 with the August 2007 flood reported as the worst (Musah et al., 2013). In the 2007 flood disaster, six lives were lost with more than 1,300 households rendered homeless as many buildings were destroyed. At the same time, many farmers suffered heavy losses owing to the destruction of over 3,000 hectares of farmlands. Besides, floods caused outbreak of water-borne diseases including diarrhoea, cholera particularly among children (Musah et al., 2013). The number of people affected in the Upper East, Upper West and Northern Regions in 2007 was put at 307,127 people (Graphic Online, 2015) and about 15,000 houses, mostly mud ones, destroyed in Upper East and Northern Regions alone (Ghanaian Times, 2008). The July 25 2017 floods in the Tamale Metropolis affected hundreds of residents in different parts of the Metropolis. The floods resulted in several residents being displaced, claimed four lives, several livestock were drowned and a lot of property destroyed in the hardest hit communities like Shishegu, Bilpela, Rice City (Gumani), Gumbihini, Kalariga, Kanvili-Tunayili and Gurugu (Duodu, 2017; Myjoyonline, 2017). A worrying trend in Ghana is that each successive flood event has a rather more severe impact than the previous one (GoG, 2001; 2003). The high level of vulnerability in flood-risk communities would probably demonstrate their low coping and adaptive capacities. Responses to such flood events by state institutions have always been reactive rather than being proactive. During flood events, individual volunteers, government agencies, metropolitan, municipal and district assemblies respond by providing relief items to victims. This, sometimes, is followed by selective demolition of buildings in waterways. Such approaches have only provided temporary relief to flood victims and not a lasting solution to the perennial floods in the country.

Adaptation and mitigation strategies are necessary to increase the communities' preparedness and resilience in the face of disaster impacts on humankind and its created environment. These would include among other measures better early-warning systems and rescue services, sustained behavioural change, a change in housing design and improvement of sanitation infrastructure as well as sustained public education and public health surveillance. Milly et al. (2008) advocate a ‘‘predictable uncertainty’’ of floods as a step towards adaptations to flood disasters. The prediction of this uncertainty, however, can be done only after specific local conditions are assessed to determine future hydrological conditions based on past climate records.

Conventional approaches often provide conventional engineering solutions (e.g. delineation of floodlines, assigning infiltration zones and building of dams, levées and attenuation structures) that focus mainly on the physical event through engineered processes (Cardona, 2003; Varis, 2005; Zevenbergen et al., 2008). These interventions are more often than not costly and require space to be allocated. It has become imperative to understand the human behaviour, new technologies, indigenous knowledge and social livelihoods to be able to put effective adaptation and mitigation strategies in place (Campion and Venzke, 2013).

Events show that floods in Ghana have become annual ritual, increasing in both scale and frequency as well as human vulnerability (Ahadzie and Proverbs, 2011). While attributions have been made in many instances to anthropogenic factors when flood disasters occur, research to unravel the complex set of factors at play in flood dynamics has been given little attention. With human vulnerability to floods reported to be on the increase, research to examine how and why households become vulnerable is of essence. Implicit in household vulnerability is their coping and adaptation. Again, these are grey areas in flood disaster literature in Ghana. The choice of Central Gonja in the Northern Region for the rural flood perspective and Kumasi Metropolis in the Ashanti Region for the urban flood studies is apt as this afforded the researcher the opportunity to do the comparative study of the physical and human contexts of floods and household response and adaptive mechanisms from the rural and urban prefectures.

1.2 Problem Statement

Flooding is an inevitable natural phenomenon but in recent years, flooding of major Ghanaian cities and riparian communities has become a recurring issue causing disasters on an unprecedented scale (Afriyie et al., 2017; Ahadzie and Proverbs, 2011; Musah et al., 2013). It is contended that, with an increasing population and growth in human settlements, the worst effects of floods might be ahead (Ahadzie and Proverbs, 2011). Studies on flood vulnerability in Ghana, show varied attributions to their frequent occurrences. One of these factors is 'climate variability' and 'change', with increasing flood incidence explained in terms of changes in rainfall and temperature patterns (Rain et al., 2011; Addo et al., 2011). Other reported factors are poor physical planning, poor and inadequate drainage network, rapid growth and expansion of the city, poor waste management practices, informal housing development practices and poor physical development control (Amoako and Boamah, 2015; Gyekye, 2011; Karley, 2009).

In Kumasi Metropolis, the fastest growing urban area in Ghana, perennial floods continue to be a threat to human life and property (Campion and Venzke, 2013; GSS, 2014a). These floods have always resulted in displacement of people, needless loss of human lives and property and disruption of economic activities, with each successive flood having a severer impact than the previous one (GoG, 2001; 2003). Commonly, newspaper reports and city authorities have blamed the floods on obstruction of waterways through human activities (Campion and Venzke, 2013).

Many rural communities in the Central Gonja district of the Northern Region of Ghana have suffered losses in terms of property and human life. For instance, the event of October 2010 is just one of the many flood disasters that had devastated the Central Gonja District. The October 2010 floods saw about 55 communities in Central Gonja, including part of the District capital Buipe, submerged by flood waters following the overflow of the Volta Lake (Graphic Online, 2015). Newspaper reports indicated that the Central Gonja floods were the results of increased rainfall, coupled with the opening of the Bagre Dam in neighbouring Burkina Faso (Ghana Web, 2010).

The widening spatial extent of floods, their increasing regularity and level of human vulnerability to floods in rural and urban Ghana tend to suggest a rather complex mix of factors at play. Unravelling these underlying factors is key for managing the flood menace in an integrated manner. Yet, holistic scientific studies that unravel the extent to which meteorological, hydrological and anthropogenic factors underpin flood events in rural and urban Ghana are limited.

Besides, comparative studies of exposure, sensitivity, resilience and adaptive capacities of rural and urban households in Ghana and how these potentially make them vulnerable to future floods is lacking. Importantly, the question regarding the differential effects of floods on people with differing demographic, social and economic characteristics remains inadequately answered in the Ghanaian context. In particular, research on the medium- and long-term health effects of floods in Ghana has not been adequately explored.

Literature search suggests that flood vulnerability and adaptation studies in Ghana are largely urban focused (e.g. Campion and Venzke, 2013). The study by Afriyie et al. (2017) on asset vulnerability which set out to investigate rural communities rather studied two urban communities. However, the work of Musah et al. (2013) on household livelihoods and food security effects of floods was rural-focused.

One would expect that people who have long experience with floods would have developed methods to mitigate their impacts. If flood victims however continue to suffer heavy losses during floods, then it raises serious questions about the effectiveness of flood disaster mitigation measures. The exercise of removing buildings in waterways, with the view of solving the problems of floods, often have not worked as expected. While comparative studies of rural and urban households' flood coping and adaptation strategies are under-researched, existing works on households' floods coping and adaptive strategies (e.g. Dari et al., 2013; Dayour et al., 2014) have failed to draw a clarity on coping with and adapting to floods. These works have treated coping and adaptation as though they are the same. Being an emerging phenomena, vulnerability and adaptation studies in the Ghanaian context have in the main focused on climate change/variability and livelihood adaptation (e.g. Antwi-Agyei et al., 2013; Dasgupta and Baschieri, 2010; Dumenu, and Obeng, 2016). The current research, therefore sought to contribute to filling the existing gap. The research addressed the following questions:

1. What different physical and human contexts does flood occur in rural and urban Ghana?
2. Do rural flood-prone households show higher levels of vulnerability to floods than urban flood-prone households?
3. Does flood affect rural and urban households differently?

4. Are there any differences in the ways rural and urban Ghanaian households cope with floods?
5. Are there any differences in the ways rural and urban Ghanaian households adapt to floods?
6. How have the institutional and legal regimes affect household vulnerability to floods?

1.3 Aim and Objectives

Generally, the research sought to examine how rural and urban households are vulnerable and adapt to floods in Ghana. Specifically, the study sought to:

1. describe the different physical and human contexts within which floods occur in rural and urban Ghana.
2. analyse the relative vulnerability of rural and urban flood-prone households to floods.
3. assess how rural and urban households have been affected by floods.
4. examine the coping strategies of rural and urban Ghanaian households to floods.
5. examine the adaptation strategies of rural and urban Ghanaian households to floods.
6. evaluate how the institutional and legal context affects vulnerability of households to floods.

1.4 Hypotheses and propositions

1.4.1 Hypotheses

The following hypotheses were tested in the field:

1. $H_{O:}$ There is no statistically significant relationship between age of respondents and their perceived flood-induced psychological health problem.

$H_{1:}$ There is a significant relationship between age of respondents and their perceived flood-induced psychological health problem.

2. $H_{O:}$ There is no statistically significant relationship between length of stay in flood-prone community and households' ability to cope with floods.

$H_{1:}$ There is a significant relationship between length of stay in flood-prone community and ability to cope with floods.

Decision rule: Reject the null hypothesis if the p-value is less than the level of significance, 0.05 (Reject H_o if p-value < 0.05). You will fail to reject the null hypothesis if the p-value is greater than or equal to the level of significance.

1.4.2 Propositions

1. Anthropogenic rather than physical factors account for increasing incidence of floods in both rural and urban Ghana.
2. Rural households are potentially more vulnerability to floods than the urban households.
3. Urban households are more vulnerable to flood-induced economic losses than rural households.
4. Rural households show a higher level of vulnerability to flood-related physical health problems.
5. Rural households show a higher level of vulnerability to flood-related psychological health problems.

1.5 Significance of the study

This study is relevant for a plethora of reasons. The increasing incidences of floods and associated high levels of fatalities and property damage demonstrate increasing number of vulnerable groups with low capacity to adapt. The publications and policy briefs that will emanate from this research are expected to influence policy direction. A study on how vulnerable groups adapt to and cope with floods would be very important for future flood management and adaptation strategies.

The study also has tremendous contributions to make in the area of methodology. The combined qualitative and quantitative approaches and the varied techniques make this work particularly useful.

This work reviews and synthesises different theoretical perspectives and conceptual issues on vulnerability. This undoubtedly will offer students, researchers and readers alike with rich assemblage of information within which to analyse vulnerability issues and also to develop their own. The adapted MOVE analytical framework is particularly novel.

The research ended by identifying areas for further research. Thus, the current work provides the basis for future research in the areas of flood hazard studies. Besides, this adds to the valuable literature on vulnerability and adaptation to natural disasters.

CHAPTER TWO

EMPIRICAL AND CONCEPTUAL PERSPECTIVES OF VULNERABILITY AND ADAPTATION TO FLOODS

2.1 Introduction

The preceding chapter presents the study background and the problem statement highlighting the lacunae or the knowledge gap that the current research tries to fill. It addresses the general and specific objectives of the study, formulates the hypotheses and propositions upon which the study is hinged and highlights the significance of the study.

This chapter sought to situate the study within a scholarly context. It is thus made up of two key sections. The first part is an empirical review of floods, its impact and human response. It makes empirical reviews of the nature, types and causes of floods. It further reviewed direct and indirect as well as immediate, medium- and long-term effects of floods among different social entities within a spatio-temporal context. Finally, the chapter addresses conceptual issues relating to flood vulnerability including the analytical framework for the study.

2.2 Definition of terms and concepts

2.2.1 Floods defined

A flood has been defined as a mass of water, which produces runoff on land that is not normally covered by water or alternatively a flood is a fairly high flow, which overburdens the natural channel, provided for the runoff (Ramlal and Baban, 2008). Viewed in another way, floods refer to temporary covering of land by water as a result of surface waters (still or flowing) escaping from their normal confines or due to heavy precipitation (Munich Re, 1997). This definition however appears limited in scope as it is specific for precipitation. Floods are defined as “the condition that occurs when water overflows the natural or artificial confines of a stream, river, or other body of water, or accumulates by drainage over low-lying areas” (Du et al., 2010 p. 265). Floods are caused by rainfall, melting snow or ice, or by structural failure of water containing structures, including subterranean structures (Du et al., 2010). Following broad definition by FLOODsite-Consortium (2005), this work operationally defines flood as a temporary covering of land by water outside its normal confines.

2.2.2 Vulnerability

According to Kelly and Adger (2000:300), vulnerability is “...the ability or inability of individuals or social groups to cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being.” Their approach focuses on existing “wounds” (or prior damage), which might limit capacity to respond to stresses and are independent of future threats. A very short one is the degree of loss (from 0 to 100%) resulting from a potentially damaging phenomenon” (United Nations, 1992). A more common definition was formulated by Kasperson et al. (2010) “the degree to which a system or unit (such as a human group or a place) is likely to experience harm due to exposure to perturbations or stresses”. These authors identified three components of vulnerability: 1. the exposure to stresses or perturbations, 2. the sensitivity to the stress or perturbation including to anticipate and cope with the stress and 3. the resilience, the ability to recover from the stress, to protect themselves against and to adapt to future stresses and perturbations.

For a social system, vulnerability can be viewed a set of conditions and processes emanating from physical, social, economic and environmental factors, which make the community more susceptible to the impact of hazards (UNISDR, 2002). Similarly, Zakour and Swager (2018) define vulnerability as the susceptibility to harm and the process that creates and maintains that susceptibility. The current work embraces the definitions of UN, 1992 and that of Kasperson et al. (2010) to define vulnerability as the potential to be harmed because of the inherent characteristics of the system and the degree of loss or harm a system (e.g. household) suffered due to floods. In this respect, vulnerability is seen as a set of attributes or processes that increase human susceptibility to floods and an outcome (impact) of a flood event.

2.2.3 Flood hazards

Hazards usually refer to physical agents (such as floods), in the natural or artificial environment that pose threats (Hewitt, 1997). Hewitt (1997) extends this view by noting that something is a hazard to the extent that it threatens losses we wish to avoid. Hazards can also be viewed as the probability of occurrence of a potentially damaging phenomenon or events as for example floods (ITC 2004; Schanze, 2006). Potentially damaging means that there are elements exposed to floods which could, but need not necessarily, be harmed.

The recognition of the fact that hazards can stem from a multitude of sources and that the occurrence of a hazard does not always or necessarily lead to harm led FLOODsite-Consortium (2005) to define it as a physical event, phenomenon or human activity with the potential to result in harm. Similarly, UNISDR (2009), defines hazard as a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

2.2.4 Flood disaster

A disaster is occasioned when a hazard results in losses exceeding the capacity of the human system to support or resist them or when the effects undermine easy recovery. According to UNISDR, (2009), disaster is a serious disruption of the functioning of a society involving widespread human, material, economic or environmental losses and impacts beyond the ability of the affected society to cope using its own resources. Disasters are often described as a result of the interplay of: the exposure to a hazard; the vulnerability conditions; and inadequate capacity to cope with the potential negative consequences (UNISDR, 2009). Disasters often come with loss of life, physical injury, increased morbidity, psychological health problems, destruction of property and disruption of social services (UNISDR, 2009). The Mozambican floods of 2000 is a classic example where about 700 lives were claimed, 500,000 people were displaced and more than $400 million of property was damaged by the floodwaters (Christie and Hanlon, 2001).

2.2.5 Coping with floods

Coping is understood as a short-term, often reactive, response to deal with the impacts of a hazard during or after the hazards strike and, by doing so, to minimise the effects of a disaster (Birkmann et al. 2012). It is an immediate response and reaction to hazard events that impact societies or communities as in the case of a specific flood event (Birkmann et al. 2009, 2010; Birkmann, 2011a). Thus, coping mainly encompasses strategies, measures, and actions that are related directly to specific hazard impacts during or after a crisis or disaster strikes and refer primarily to capacities within existing institutional frameworks (Birkmann, 2011b).

2.2.6 Adaptation to floods

Adaptation connotes an adjustment of system components, processes and structures in response to experienced or anticipated hazards in order to moderate harm or even exploit beneficial opportunities (Birkmann et al., 2012). It implies a longer time frame and a notion of planned, strategic, target-oriented and coordinated action. It is characterised by medium and long-term strategies that imply or lead to change and often require changes in institutional frameworks and framework conditions (Birkmann, 2011b).

2.3 Nature and types of floods

The general belief is that floods are associated with harm and damage and considered an undesirable occurrence, hence the notion of the water being normally confined as reflected in the various definitions above. Every flood event can be characterised by features such as water depth, flow velocity, matter fluxes, and spatio-temporal dynamics (Schanze, 2006). Floods can occur in small and large river basins, in coastal locations, in estuaries, and locally. Floods can be systematised according to their causes as for example snow-melt floods, dam break floods, winter rainfall floods, tidal floods and urban sewer floods (Penning-Rowsell and Peerbolte, 1994; Schanze, 2006). A special type of flood is the highly dynamic flash floods.

Floods vary greatly in their character and in the size and vulnerability of the populations they affect. The nature and extent of the flood is determined by the physical location and topography, and by the built environment (Du et al., 2010). Some floods are catastrophic and affect thousands of people who may have little capacity to protect themselves, as was the case in China in 1959, Mozambique in 2000, Bangladesh in 1974, 1988, 1998 and 2004 and the tsunami in Southeast Asia in

December 2004 (Ahern et al., 2005; CRED, 2005; Kunii et al., 2002). At the other end of the spectrum is the small-scale flood in a high-income country where emergency and support services are better able to cope with the immediate and longer-term effects (Ahern et al., 2005).

Based on combination of sources, causes and impacts, floods can generally be categorised into pluvial (or overland) floods, river (or fluvial) floods, coastal floods, groundwater floods. When the speed of onset of flooding is used as the basis, floods can be characterised as flash floods, urban floods, slow rise floods, and semi-permanent floods (Jha et al., 2012). Understanding of the cause and speed of onset of each flood type is key for understanding their effects as well as mitigating their impacts. The types and causes of floods are summarised in Table 2.1.

Table 2.1: Types and causes of floods

Types of floods	Causes		Onset time	Duration
	Naturally occurring	Human induced		
Urban flood	Fluvial, Coastal, Flash, Pluvial, Groundwater	Saturation of drainage and sewage capacity Lack of permeability due to increased concretisation Faulty drainage system and lack of management	Varies depending on the cause	From few hours to days
Rural floods	River/Fluvial	Rise in water level, dam opening	Varies	Varies
Pluvial and overland flood	Convective thunderstorms, severe rainfall, breakage of ice jam, glacial lake burst, earthquakes resulting in landslides	Land use changes, Urbanisation, Increase in surface runoff	Varies	Varies depending upon prior conditions
Coastal (Tsunami, storm surge)	Earthquakes, Submarine volcanic eruptions, Subsidence, Coastal erosion	Development of coastal Zones, Destruction of coastal natural flora (e.g., mangrove)	Varies but usually fairly rapid	Usually a short time; however sometimes takes a long time to recede
Groundwater	High water table level combined with heavy rainfall, Embedded effect	Development in low-lying areas; interference with natural aquifers	Usually slow	Longer duration
Flash flood	Can be caused by river, pluvial or coastal systems; convective thunderstorms; Glacial Lake outburst floods (GLOFs)	Catastrophic failure of water retaining structures, Inadequate drainage infrastructure	Rapid	Usually short often just a few hours

Semi-permanent flooding	Sea level rise, land subsidence	Drainage overload, failure of systems, inappropriate urban development, Poor groundwater management	Usually slow	Long duration or permanent

Source: Jha et al., 2012 (adapted)

2.4 Physical and Human triggers of floods

2.4.1 Human triggers of floods

Floods usually the result of meteorological and hydrological extremes, such as extreme precipitation and flows. However, they can be triggered by anthropogenic factors such as unplanned growth and development (Jha et al., 2012). Urbanisation has implications for flood incidence through land use land cover changes. For instance, urban development that reduces the permeability of soils increases surface runoff and overloading drainage systems that were not designed to cope with augmented flows (Jha et al., 2012). In many parts of the world, new city entrants often settle in flood-prone areas where absence of flood defence mechanisms expose them a high level of vulnerability. Urban floods in the view of Douglas et al. (2008) are simply not related to heavy rainfall and extreme climatic events but more importantly to changes in the built-up areas themselves. As people crowd into the city, their impact on land surfaces and drainage systems tend to increase. Even just moderate storms are enough to generate quite high flows in rivers because of surface runoff from concrete surfaces and drains (Douglas et al., 2008). Water flowing through a series of culverts and concrete channels cannot adjust to changes in the frequency of heavy rain, as natural streams do. The problem is exacerbated when drains are obstructed by solid waste, silt and urban debris (McGranahan et al., 2007).

Changes in land use can increase the risks associated with floods. Such changes have the tendency to affect hydrological regime thereby promoting the risk of flooding (Ouellet et al, 2012). Studies have demonstrated that the progressive clearing of forest cover in favour of the growth of urban areas or the expansion of farmland has led to an increase in surface runoff and river flow, resulting in greater flood risk (Tao *et al*., 2011).

2.4.2 Climate change, floods and human vulnerability

Over the last thirty years, climate change has become one of the most widely discussed global development challenges (Prowse and Scott, 2008). Intergovernmental Panel on Climate Change (IPCC) Fifth Report (2014) highlights the importance of climate change in contemporary global development. Climate change is implicated in the changing frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events (IPCC, 2012), with floods being one of the projected adverse impacts (IPCC, 2014; Kundzewicz et al., 2014). Climate change is altering rainfall patterns, tending to increase storm frequency and intensity, thus increasing the potential for floods (Douglas et al., 2008). A warmer climate would increase the risk of floods (IPCC, 2012). These changes may have serious impacts on society, as in for example on river deltas as a result of both sea level rise and an increased occurrence of flood events (Jacobs et al., 2000). Flood events may cause huge economic, social and environmental damage and even loss of lives (Booij, 2005).

Reports show that this climate change will have not only a major impact on the environment, but also considerable economic impacts worldwide (Alcamo *et al*. 2007; IPCC 2011). Climate change has many elements, affecting biological and human systems in different ways (Thornton et al., 2014). Its environmental and human impacts have become the source of considerable concern over the past few years, not only for the scientific community, but also for governments and the general public (Ouellet et al, 2012). There is evidence to suggest that flood damage and flood occurrence have strong links with climate variability, especially in southern and eastern Europe (Nobre et al., 2017). Furthermore, climate change may cause extreme climatic events as for example heat waves and floods, that may occur more frequently in some parts of the world (IPCC 2007a, 2007b). Cases such as the 2003 European heat wave, Hurricane Katrina in 2005 and numerous floods in Asia in 2007 proved to be unusual events that marked the collective consciousness of the communities affected (IFI 2010; Kundzewicz *et al*. 2008).

While no single country is immune to changes in climate and instability in weather patterns, the poorest countries are most vulnerable. Not only are they most exposed, they also have the least means to adapt (Douglas et al., 2008). It is projected that the severity of climate change impact and extreme weather events would be felt more in the global south, particularly in rural Africa (FitzRoy and Papyrakis, 2010; IPCC, 2014). Climate change appears to be altering flood patterns in Africa with indications that the pattern of rare large floods changing much more than long-term average river flows. The prediction is that prolonged heavy rains will increase in volume and frequency of occurrence (Douglas et al., 2008). Poor communities often live in the most hazardous and unhealthy environments. Many build their homes and grow their food on river floodplains in towns and cities. Others construct their shelters on steep, unstable hillsides, or along the foreshore on former mangrove swamps or tidal flats. Climate change may compound the suffering of these class of people (Douglas et al., 2008).

A number studies have suggested a decrease in precipitation in Ghana for the period 1980–2000 (as compared to 1950–1970) (Owusu and Waylen 2009, 2013).

Manzanas et al. (2014) also analysed precipitation variability trends in Ghana and found decreasing and increasing precipitation trends respectively for the first (1961–1985) and second (1986–2010) half of the period of study. These variations in precipitation and temperature have been associated with extreme weather events, such as floods (Stanturf et al., 2011).

2.5 Effects of Floods

2.5.1 Direct and Indirect effects of floods

The effects of flood damage can be categorised into direct and indirect effects (Messner and Meyer, 2006). Direct flood damage includes all forms of harm which relate to the immediate physical contact of flood water to humans, property and the environment including loss of human life, destruction caused to buildings, and other household property, destruction of crops, livestock and other livelihood assets.

Indirect effects cover damage, which occurs as a further consequence of the flood and the disruptions of economic and social activities. Examples include loss of economic production due to destroyed facilities, loss of time and profits as a result of traffic disruptions, disturbance of markets after floods, among others (Smith and Ward, 1998; Green et al., 1994).

Floods are the most common and frequent natural disaster in both developed and developing countries (Milojevic et al., 2012) and indeed one of the most threatening natural hazards for human societies (Jonkman and Vrijling, 2008). They have affected over 2.8 billion people during the past 30years and killed over 200,000 (Milojevic et al., 2012). Not only is the incidence of floods increasing, but rapid urbanisation is leaving more people exposed to floods. This is evident from the increase in flood-induced damage in the last 50 years due to a series of extreme floods (Schanze, 2006). In addition, it is projected that global warming will have an impact on the frequency of floods worldwide (Du et al., 2010; Haines and Patz, 2004). In the past twenty years in particular, the number of reported flood events has been increasing significantly. The numbers of people affected by floods and the financial, economic and insured damage have all increased too (Schanze, 2006). Every year floods cause enormous damage all over the world. In the last decade of the 20th century, floods killed about 100,000 persons and affected over 1.4 billion people (Jonkman, 2005). The statistics show that floods have a large impact on human well-being on a global scale. As a direct consequence, floods may lead to economic damage and damage to eco-systems and historical and cultural values (Jonkman, 2005). Indirectly, floods can cause the loss of economic and agricultural production and a decrease of socio-economic welfare (Appleton, 2002). Their impacts on health vary between populations for reasons relating to population vulnerability and type of flood event (Hajat et al., 2003).

The tsunami and the associated floods that hit South-East Asia caused 220,000 deaths which makes it probably one of the most disastrous floods (Schanze, 2006). In 2010 alone, 178 million people were affected by floods. The total losses in exceptional years such as 1998 and 2010 exceeded $40 billion (Jha et al., 2012). Over the past eighteen months, destructive floods occurred along the Indus River basin in Pakistan in August 2010; in Queensland, Australia, South Africa, Sri Lanka and the Philippines in late 2010 and early 2011 (Jha et al., 2012). Bangladesh’s 1988 floods, described as the worst in history caused 5338 deaths with 32 million people affected. However, the disaster that occurred in 1998 was described as worse than that of 1988 in terms of extension and duration. It inundated two thirds of the country with a peak flood level exceeding 20 meters at some places, breaking several historic record water levels (Kunii et al., 2002). The disaster affected more than 30 million people in 5 million houses, among whom 1 million people were evacuated (Kunii et al., 2002). The floods of 2007 described as the worst ever recorded in the UK had a wide range of direct and indirect impact on health. A total of 350,000 people near Gloucester were left without access to the main water supply for over two weeks, 42,000 were left without power for up to 24 hours, access to telephone and internet services was interrupted while a significant number of schools were closed in flood affected areas resulting in loss of 400,000 pupil school days. The total economic cost of the floods was estimated to have been £3.2 billion (Murray et al., 2011).

The negative effects of floods are obvious. Episodic catastrophic floods can drown people and livestock, destroy crops, sweep away bridges, vehicles and buildings, and force the survivors to abandon their homes. Disruption of infrastructure can occur, business activities can be suspended while access to essential critical services by the population may be cut off during floods. Besides, health risks in the home and local environment can be exacerbated during floods (Parker, 1999). Most low-income residents of developing countries do not have a realistic option of moving elsewhere while waters recede (Ahmed and Ahmed, 1999). A study of the devastating flood in Mozambique in 2000 shows that in many areas displaced people were accommodated in local schools (Christie and Hanlon, 2001).

The United Nations Regional Coordinator in Dakar indicates that the 2007 July floods in West Africa was the most awful one in thirty years (Asumadu-Sarkodie et al., 2015). More than 210 deaths were recorded and more than 785,000 people were affected. It was revealed that the rains affected almost a half of African countries bringing the total death to more than 350 with hundreds of thousands of inhabitants displaced. Nigeria, Ghana, Burkina Faso and Togo were reported as the most affected countries (Asumadu-Sarkodie et al., 2015). Nigeria for example registered 68 deaths with 50,000 people affected. In Ghana, 332,000 people were affected with 56 deaths registered. Burkina Faso lost 46 people while 92,979 people were affected. In Togo, 23 deaths were recorded, 120,000 people affected, out of which 11,483 were displaced (Asumadu-Sarkodie et al., 2015). In general, flood losses have greatly increased over the years as a result of land use amendment, urbanisation of flood-prone areas, sub-customary construction, and high population density. Cities are more prone to floods than rural areas because of high population densities and concentration of economic activities (Asumadu-Sarkodie et al., 2015).

Available literature shows that floods are not always associated with negative consequences. As Pelling (1999) notes, there are cases where individuals make economic gains from otherwise damaging floods. From Agricultural perspective, floods can be a source of irrigation and fertilisation of fields. While floods flush out salts and toxins from soils and watercourses, they can help in the recharge of reservoirs. This two-faced nature of flood impact helps explain why many residents of developing countries demonstrate an ambivalent attitude toward flood events, and partly underpins the logic of policies of 'living with floods' rather than attempting to prevent them through large- scale engineering interventions (Few, 2003).

2.5.2 Health effects of floods

One of the most significant, but difficult to quantify effects of flooding is the impact on health (Kolsky, 1999). Floods have been associated with extensive morbidity and mortality throughout the world. Available world statistics show that between 2000–2009, floods (not including tsunamis) accounted for 38.7% of all incidents, 6.2% of the deaths, and 43.0% of people affected by all disasters triggered by natural hazards (Du et al., 2010). One study found a four-fold increase in illnesses among people whose homes had been flooded compared with those whose homes were not flooded (Du et al., 2010; Waring et al., 2002). The dominant reported health effects of floods are diarrheal diseases and acute respiratory infections especially among children in low-income countries (Milojevic et al., 2012).

Floods can lead to enduring health consequences, including the stress, trauma and other psychological health problems. That is, the effects of floods on the health and general well-being of people can linger for many months after the actual flood event and can be severe (Tapsell et al., 2002). Loss of treasured or valuable possessions in floods can be traumatising and heart-breaking (Penning-Rowsell and Green, 2000). Research shows that the health status of people before floods can be a determining factor of the extent of health impacts experienced by flood victims (Tapsell et al., 2002).

Two broad categories of health consequences of floods have been identified as direct or indirect. Direct consequences result from direct exposure to the water and the flooded environment. These include, drowning, injuries from debris, chemical contamination, and hypothermia. Indirect effects are associated with risks related to damage caused to the natural and human-built environment floodwater and include infectious diseases, poverty-related diseases, malnutrition and diseases associated with displaced populations (Ahern and Kovat, 2005; Du et al., 2010; Tapsell and Tunstall, 2008). In terms of time, the health effects of floods may be described as immediate, medium-term, and long-term (Du et al., 2010). Immediate is considered as the period when the flood is present, medium describes the immediate recovery phase (days to weeks), and long-term is the reconstruction phase (months to years) after the flood (Du et al., 2010). It is important however to note that a clear definition of these terms is lacking with these periods overlapping in many respects, *2.5.2.1 Immediate health effects of floods*

Flood-related mortality has been studied in both high-income (Staes et al., 1994) and low-income (Kunii et al., 2002) countries. The most readily identified flood deaths are those acutely occurring ones from drowning or trauma, as in for instance being hit by objects in fast-flowing waters or flash flooding rather than the slower riverine flooding. The number of such deaths is determined by the characteristics of the flood, such as the speed of onset, depth, and extent (Ahern et al., 2005). Flash floods for instance are more hazardous than slow-onset ones and in many instances, drowning occurs when floodwaters sweet away vehicles (Ahern et al., 2005). Evidence of flash floods in developed countries indicates that most deaths are due to drowning (Jonkman and Kelman, 2005). While limited information on risk factors for deaths related to floods exists, men appear more at risk than women (Jonkman and Kelman, 2005). Those who get drowned in their own homes are largely older people. Generally, people get drowned when they under-estimate the power of the current or depth of the water in the process of evacuation or in an attempt to salvage their valuables. This may also happen while individuals try to cross a bridge, during sailing, or during rescue operations (Du et al., 2010).

Most flood water is well below human core body temperature (Du et al., 2010). Hypothermia with or without submersion comes with some floods and irrespective of the season (Poole and Hogan, 2007). Ice dam breakage can increase the risk, but ice-cold water is not a necessary condition for hypothermia to occur. During floods, access to primary health care is limited affecting demand for services (Schatz, 2008). Floods also can lead to destruction of medical records, medication, medical devices, and disrupt health resources provision, consumables, and critical infrastructure needed for maintenance of services. Difficulty of patents in accessing health services can worsen health problems of families affected by floods (Curry et al., 2001).

Flood-related injuries may occur as a result of buildings or other structures collapsing when households try to get out of danger during floods. Injuries in the form of sprains, strains, and wounds can also be sustained when people return to their homes or job places and start the clean-up operation. Stagnant water close to electrical lines, circuits, or equipment represents a potential electrical hazard (Du et al., 2010).

2.5.2.2 Medium term health effects of floods

Aside the physical threat from flowing water, flood events can increase risk from water-borne pathogens (Few, 2003). Although it is difficult to prove conclusively because of the complexities of disease transmission routes, there is abundant empirical evidence to show that illness prevalence can be linked to flooding and poor drainage and that large-scale flooding can lead to disruption of water supply and sanitation systems and result in disease epidemics (UN–HABITAT, 2003). In areas with poor drainage and inadequate sanitation, urban runoff mixes with excreta, which may spread pathogens around communities and increase risks to health from various waterborne diseases (Parkinson, 2003). The outbreak of diseases may be associated with the spreading of pathogenic wastes carried by floodwaters and disruption of safe water supplies (Kolsky, 1999). Floodwaters may damage the sewage system resulting in contamination of local water and food supply and thus increase the potential for communicable diseases (Du et al., 2010). In flood conditions, there is potential for increased faecal-oral transmission of disease, especially in areas where the population does not have access to clean water and sanitation (Du et al., 2010). Contaminated water leads to transmission of waterborne diseases such as Escherichia coli, Shigella, Salmonella, and hepatitis A virus. Faecal contamination can be a potential health threat to man, livestock, crops and the larger environment (Casteel et al., 2006).

Elevated risk of communicable diseases can be a concern when disaster occurs (Du et al., 2010). Several reasons may explain the increased risk of communicable diseases during flooding. First, overcrowding and unsanitary conditions in temporary shelters when flood victims are kept may increase the incidence and spread of infectious diseases. Second, floods can lead to a decrease in basic hygiene due to inaccessible toilet and clean water. These, coupled with nutritional deficiency account for the spread of diarrheal diseases during flood disasters (Sur et al., 2000).

Published studies have reported post-flood increases in cholera (Sur et al., 2000), nonspecific diarrhoea (Heller et al., 2003) and typhoid and paratyphoid (Vollaard et al., 2004). In Indonesia, for example, Vollaard et al. (2004) found flooding of the home to increase paratyphoid fever. In high-income countries, the risk of diarrheal illness appears to be low, as shown by studies from the former Czechoslovakia, Norway and the United States (Ahern et al., 2005). However, Wade et al. (2004) documented a measurable increase in gastrointestinal symptoms during a severe flood in the Midwest in 2001. They found that flooding of the house or yard was associated with elevated gastrointestinal illness. The floods in Mozambique in 2000, for example, disrupted water and sanitation systems in the capital, Maputo, causing dysentery and cholera outbreaks (Sanderson, 2000). In the United Kingdom, Reacher et al. (2004) reported an increase in self-reported gastroenteritis following the Lewes floods of 2001. Tapsell et al. (2002) reported cases of diarrhoea, upset stomachs and other types of infection following the 2000 floods in northeast England. The study by Kunii et al. (2002) shows that the 1998 flood in Bangladesh had a substantial impact on the health of the communities affected and caused a particularly high incidence of diarrhoea and respiratory problems.

As regards flood-induced deaths from diarrhoea, reports of several studies in low-income countries have shown inconclusive evidence. An increase in diarrhoeal related mortality is evident in surveillance data following the 1988 Khartoum (Sudan) floods, but a similar rise was also recorded in the same period (May–July) of the preceding year (Woodruff et al., 1990). Routine surveillance data and hospital admissions records similarly presented diarrhoea as the most frequent cause of mortality after the 1988 Bangladesh floods, but again the effect of the flood was not isolated from seasonal influences (Yusof et al., 1991).

Vector-borne diseases may increase during periods of flooding. Stagnant water provides a breeding ground for many vectors, such as mosquitoes, resulting in diseases such as malaria and dengue. The relation between flooding and vector-borne disease is however convoluted. Many important infections are transmitted by mosquitoes, which breed in, or close to, stagnant or slow-moving water (puddles, ponds) (Ahern et al., 2005). Floodwaters can wash away breeding sites and, hence, lower mosquito-borne transmission (Sidley, 2000). On the other hand, the stagnant water due to the blocking of drains, especially in urban settings or persistence of water in low-lying areas may provide breeding grounds for mosquitoes which, can lead to increases in transmission as shown by numerous reports from Africa, Asia and Latin America (El-Sayed et al., 2000; Saenz et al., 1995). The Mozambique floods of 2000 also appeared to have increased the number of malaria cases by a factor of 1.5–2 by comparison with 1999 and 2001 (Kondo et al., 2002).

Diseases transmitted by rodents may also increase during heavy rainfall and flooding because of altered patterns of contact (Ahern et al., 2005; Diaz, 2007). There have been reports of flood-associated outbreaks of leptospirosis from a wide range of countries, including countries like Argentina, Brazil, India, Mexico and Nicaragua (Ahern et al., 2005). In Salvador, Brazil, risk factors for leptospirosis included flooding of open sewers and streets during the rainy season (Sarkar et al., 2002). Displaced domesticated animals, rats, insects, snakes, and reptiles during periods of flooding often result in an increased incidence of bites (Du et al., 2010). Flooding can lead to widespread chemical contamination of the environment. This may happen when industrial sites become flooded, releasing chemicals and other contaminants into the floodwaters (Du et al., 2010; Joyce, 2000).

2.5.2.3 Long-Term Health effects of floods

Major life stressors, such as disasters, increase susceptibility not only to physical illness, but also mental health (Stimpson, 2004; Chae et al., 2005). Flooding can pose substantial mental health problems that may continue over extended periods of time (Stanke et al., 2012). Flood disasters take a heavy toll on the mental health of the people involved, most of whom live in developing countries, where there is extremely limited capacity to handle these problems (WHO, 2001).

Studies have shown that people with flood experiences have a fourfold higher risk of psychological distress than those without such experiences (Reacher et al., 2004) and a post-disaster suicide rate of 13.8% higher than pre-disaster rates (Du et al., 2010). Disability from traumatic experiences suffered during floods can be a cause of morbidity particularly if complications from infections arise. Disability may be linked to exacerbation of chronic diseases (Reacher et al., 2004; Du et al., 2010). Flood-induced physical health problems, loss of livelihood assets, economic hardship, social disruption, among others can trigger mental health problems (Ahern et al., 2005).

The expectation is that people who experience a traumatic flood event will react severely to it in the first few days after the event (Tapsell et al., 2002). When symptoms are displayed beyond this period, three possible diagnoses are possible: adjustment disorder, acute-stress disorder, and post-traumatic-stress disorder (Ahern et al., 2005). The differences among these three can be made in terms of the type of stressor, and the range and duration of symptoms (Rick et al., 1998). These symptoms may include quietness, always thinking about the flood event, depression, flashbacks, and sleep disorders (Tapsell et al., 2002). The main evidence of mental health relates to common mental disorder, posttraumatic stress syndrome, and suicide (Ahern et al., 2005). Most studies on the effects of flooding on common mental disorders (anxiety, depression) are from high-income or middle-income countries, including Australia, Poland, the United Kingdom and the United States (Ahern et al., 2005; Bokszczanin, 2002; Ginexi et al., 2000).

Bennet's analysis of the 1968 Bristol floods found a significant increase in the number of new psychiatric symptoms (considered to comprise anxiety, depression, irritability, and sleeplessness) reported by women from flooded compared with non-flooded areas, although there was no significant difference for men (Ahern et al., 2005). Flood exposure was associated with significant increases in depression, anxiety as well as physical symptoms, especially in those with higher levels of pre-flood depressive symptoms and in those from lower socioeconomic groups. A case-control study from the United Kingdom (Reacher et al., 2004) found a fourfold increase in psychological distress among adults whose homes were flooded compared with those whose homes were not.

Posttraumatic stress disorder (PTSD) arises after a stressful event of an exceptionally threatening or catastrophic nature and is characterised among other things by intrusive memories, avoidance of circumstances associated with the stressor, sleep disturbances, irritability and anger, lack of concentration and excessive vigilance (WHO, 2001). Nonetheless, studies showing increases in PTSD following floods come from Europe (Norris et al., 2002) and North America (McMillen et al., 2002; Waelde et al., 2001). The nature of the trauma may impinge upon the severity of symptoms (Tapsell et al., 2002). Research suggests a complex relationship between the experience of a traumatic event and subsequent mental disorders. Tapsell et al. (2002) report of trauma from flooding following the June 2000 floods in northeast England. Evidence from northeast England floods suggests that the greater the damage, losses and inconvenience from a flood event, the greater the stresses suffered by flood victims are likely to be (Tapsell et al., 2002). Studies of the 1996 flooding in the Saguenay/Lac St. Jean region of Quebec, Canada, also suggest substantial increases in emotional distress and PTSD among flooded respondents (Ahern et al., 2005). In relation to flood-induced suicides, there is very limited evidence (Ahern et al., 2005). Evidence from the United States that initially interpreted increased suicides following natural disasters was initially interpreted as showing evidence for increased suicides after natural disasters was subsequently retracted, with the conclusion that it could no longer be supported in the face of new results after error corrections (Krug et al., 1999). A paper from China (He, 1998) reported a higher suicide rates in the Yangtze Basin (an area affected by periodic flooding) than in the rest of the country. However, no direct epidemiologic evidence was found to suggest that the difference was due to flooding.

Following a flood, subsequent rainfall can act as a trigger for repeated stress and trauma among those who were flooded, being a factor directly related to the initial flood event. There is a lack of studies which have investigated the impact of flooding on the mental health of children, young people and older people (Stanke et al., 2012).

There are, however, indications that both children and older people suffer PTSD after flooding and that the prevalence figures may well be greater than those that are found for adults of working age. Children, young people and older people may be more vulnerable than are adults of working age because they are dependent on adults' responses to the floods that affect families (Stanke et al., 2012).

2.6 Conceptual issues

2.6.1 The origin and basic components of flood vulnerability

Vulnerability, a concept that evolved out of the social sciences, was introduced in response to the purely hazard-oriented perception of disaster risk in the 1970s (Schneiderbauer and Ehrlich, 2004). This dominant hazard-oriented approach has since the 1980s been increasingly challenged by alternative paradigm where vulnerability is used as the starting point for risk reduction. This approach combines the susceptibility of people and communities exposed with their socio-economic and cultural abilities to cope with the damage that could suffer (Hilhorst and Bankoff, 2004).

A system is susceptible to floods due to its exposure in addition to its incapacity to be resilient, to cope, recover or adapt (Balica et al., 2012). Flood vulnerability is viewed as a condition determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards (UNISDR, 2004). It is the inherent characteristics of a system that create the potential for harm but are independent of the probability of any particular hazard or extreme event (Sarewitz et al., 2003). To Jones and Boer (2003), it is the amount of potential damage caused to a system by a particular-related event or hazard. Flood vulnerability can be defined by the attributes of a system that describe its potential to be harmed. It can be expressed in terms of functional relationships between expected damage regarding all elements at risk and the susceptibility and exposure characteristics of the affected system (Messner and Meyer, 2006). With regard to floods, Merz et al. (2010a) characterised the vulnerability (V) by a combination of exposure (E), susceptibility (S) and response capacity (RC). The exposure (E) is specified by social, economic, ecologic and cultural consequences that may be affected by floods. The susceptibility (S) is the degree to which the system is damaged by floods. The response capacity (RC) describes the ability to respond to and to recover from a flood.

Varied as these views may be, it is important that any defining criteria should include the elements such as people, property, and the environment that have the potential to be harmed by a hazard such as flood and their adaptive and coping capacity. Thus, flood vulnerability study that fails to explore the population's capacity to anticipate, absorb, cope, adapt and recover from the impact of floods would be problematic. On the other hand, a study of vulnerability from solely narrow perspective of natural/environmental conditions may be a failure. Flood vulnerability could therefore not be seen as a mere proximity to flood-prone areas but a product of the flood as a physical, political and socio-economic phenomenon (Messner and Meyer, 2006).

Three basic areas of flood vulnerability thus can be distinguished according to the principle of sustainability: socio-cultural, economic and ecological vulnerability. Socio-cultural vulnerability embraces for example loss of life, health impacts, stress, social impacts, and loss of cultural heritage. Economic vulnerability includes direct and indirect financial losses resulting from damage to assets, goods, and reduced productivity. Ecological vulnerability covers anthropogenic pollution of waters, soils and ecological systems with their biota (Messner and Meyer, 2006).

The subject matter of any flood vulnerability analysis is the group of elements which are at risk of being harmed by flood events. Element-at-risk indicators specify the amount of socio-economic or ecological units or systems which are at risk of being affected flood hazards in a specific area. These will include for example human population (individuals or households), firms, economic production, private and public buildings, public infrastructure, cultural assets, ecological species and landscapes located in a hazardous area or connected to it (Messner and Meyer, 2006).

Isolating the components of vulnerability has been the subject of vigorous academic debate. This notwithstanding, there is a simple and widely endorsed approach that captures the different concepts of vulnerability detailed in the literature. The framework defines vulnerability as a function of exposure, sensitivity, and adaptive or coping capacity (Figure 2.1). According to Balica et al. (2009), societies are vulnerable to floods due to three main factors: exposure, susceptibility and resilience. Similarly, Smit and Wandel (2006) indicate that the vulnerability of any system (at any scale) is a function of the exposure and susceptibility of that system to hazardous conditions and the resilience of the system to adapt and/or recover from the effects of those conditions. Many other scholars have conceptualized vulnerability as a function of exposure, susceptibility and resilience (Fuchs et al., 2011; Hufschmidt, 2011; Willroth et al., 2011).

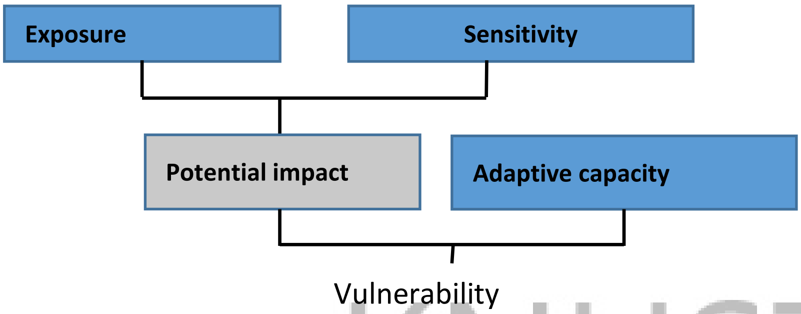

Figure 2.1: Measurable components of vulnerability

Source: Marshall et al., 2009, Fay and Ebinger, 2010

Exposure refers to the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014). Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest (UNISDR 2009). Exposure indicators according to (Messner and Meyer, 2006), are of two categories. The first one supplies information about the location of the various elements at risk, their elevation, their proximity to the river, their closeness to inundation areas, about return periods of different types of floods in the floodplain and the like. Collectively, these indicators give an idea of the frequency of floods and of the threat they pose to the different elements at risk of being affected by flooding. The second category of indicators relates to the general characteristics of floods including duration, velocity, inundation depth and sedimentation load. Considered in concert, they indicate the severity of inundation as well as its distribution in space and time. Exposure indicators give specific information regarding hazardous threats to varied elements at risk of flooding (Alexander, 1993; Heyman et al., 1991).

The concept of susceptibility, or sensitivity, has developed through the years. For example, Penning-Rowsell and Chatterton defined susceptibility in 1977 as the relative damageability of property and materials during floods or other hazardous events (Balica et al., 2012). Susceptibility relates to the characteristics of a system, such as the social context of flood damage, especially the awareness and preparedness of households as regards the risk they live with before the flood, the institutions that are involved in floods mitigation and reduction, among others (Balica et al., 2012). The susceptibility indicators embrace general information on social relations, institutional development and population with special needs such as children, elderly and the disabled (e.g. Blaikie et al., 1994; Watts and Bohle, 1993). These indicators measure how sensitively an element at risk behaves when it is confronted with some kind of hazard. Susceptibility indicators are related to the affected social, economic and ecological systems or to individual units of these systems (Messner and Meyer, 2006). Together, exposure and sensitivity will determine the potential impacts of flood hazards on a community or a system. However, vulnerability also depends on how capable a system is of adapting and coping. The ability to adapt is a function of organisational skills, access to and ability to use information, and access to finance (Marshall et al., 2009).

Resilience means the ability to “resile from” or “spring back from” a shock. Defined from its initial ecological viewpoint, it is “a measure of the ability of the systems to absorb changes …and still persist’’ (Holling, 1973, p.17). As a property of the system, resilience determines the persistence of relationships within a system. Resilience is the capacity of any kind of system, community, society or environment, potentially exposed to hazards to adapt to a change, by resisting or modifying itself, in order to maintain or achieve an acceptable level of functioning and structure (Pelling, 2003). It is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions (UNISDR, 2009). This presupposes that a system's or community's resilience to flood hazards would be determined by the degree to which it has the necessary resources and the capacity to organise itself both prior to and during times of disaster. A system at risk is more vulnerable when it is more exposed to a hazard and it is more susceptible to its forces and impacts. However, the system will be less vulnerable when it is more resilient and less exposed (Balica et al., 2012). Poor households for example will be more sensitive to shocks compared to wealthy households. They will also usually have less adaptive capacity due to their lack of resources to finance relocation or protective infrastructure such as dykes, stilts, or irrigation systems (Marshall et al., 2009).

2.6.2 Causes of Vulnerability

Many factors contribute to vulnerability. These factors act to undermine capacity for self-protection, block or diminish access to social protection, delay or complicate recovery, or expose some groups to greater or more frequent hazards than other groups. Some of these factors include rapid population growth, poverty and hunger, poor health, low levels of education, gender inequality, fragile and hazardous location, and lack of access to resources and services, disintegration of social patterns (social vulnerability) (Philip and Rayhan, 2004). It also includes lack of access to information and knowledge, lack of public awareness, limited access to political power and representation (political vulnerability), (Aysan,1993 cited in Philip and Rayhan, 2004). When people are socially disadvantaged or lack political voice, their vulnerability is exacerbated. The economic vulnerability is related to a number of interacting elements, including its importance in the overall national economy, trade and foreign-exchange earnings, aid and investments, international prices of commodities and inputs, and production and consumption patterns. Environmental vulnerability among other things concerns flood, land degradation, hurricane, drought, storms, and the other threats to biodiversity (Philip and Rayhan, 2004).

2.6.2.1 Poverty and vulnerability to floods

The poor tend to be more vulnerable for a number of reasons. First, they tend to live in areas that are more prone to natural calamities and therefore more exposed. Second, they tend to have less access to assets with which to manage risks. Third, they tend to have less time to invest in social capital and fourth, they have less political capital and thus receive fewer social services after a disaster or during periods of crisis (Alwang and Siegel, 2000). The most vulnerable are low-income peoples, migrants, those living in flimsy houses, those without insurance or financial reserves, the elderly and the infirm (Correia, 2002).

In the less developed countries, it appears that poverty and vulnerability to environmental hazards go hand in hand (Few, 2003). Though the two are by no means always associated, generally the poor suffer more from hazards than the wealthy (Correia, 2002). In simple terms, the poor tend to occupy the more flood-prone environments. Poverty can drive people toward to settle and work in precarious locations such as unstable riverbanks in farming communities.

In urban areas, exposure to flood hazard tends to be concentrated in marginal areas such as low-lying sites along rivers, floodplains and coastal marshes. These sites are historically avoided by the rich but often settled by the poorest communities not only because of their availability but also because of the proximity of these places to sources of economic livelihood. It is often poor rural-urban migrants who occupy squatter settlements in urban flood-prone areas (Correia, 2002) since they may not have the needed financial resources to secure accommodation in high-class or medium-class residential areas. Correia (2002) notes that squatters tend to find that there is less danger of eviction by city authorities if they locate in areas deemed undesirable for private or public development. Consequently, the unsustainable settlement of such areas can accentuate flooding levels, causing a cyclical increase in hazard exposure (Correia, 2002).

But the geography of vulnerability is not the same as the geography of hazard. It is not just that the poor may be more exposed to flooding: crucially they are also more likely than the wealthy to suffer when flooding strikes (Correia, 2002). At the household level, the poor have fewer resources upon which to draw to counteract or ameliorate the impacts of flooding (Chan and Parker, 1996). Blaikie et al. (1994) indicate that susceptibility is often cyclical with regard to flood hazards, because disruption to assets and livelihoods by one event often make households yet more vulnerable to future flood hazards. That downward spiral effect is highlighted in a report on flood recovery in Vietnam (International Federation of Red Cross and Red Crescent Societies (IFRC), 2001), which confirms how, after each flood, the same families tend to lose their homes, possessions and livelihoods, increasing their vulnerability to the next disaster event.

At a community level, the poor are also likely to occupy an environment in which the consequences of flooding are more serious. This is especially evident in urban areas. Urban flooding becomes a problem as soon as it reaches areas with inadequate storm drains, waste management and water supply (Correia, 2002). In such areas, squatter and other informal settlements with high population density, poor shelter, little or no access to resources such as safe water and public health services, and low adaptive capacity are highly vulnerable (Correia, 2002). Cairncross and Ouano (1990) suggest that many of the poorest consider insufficient storm/flood drainage as their worst problem. However, some studies suggest people do not rate flood problems as highly as might be expected – they are simply part of the trade-off for occupying urban locations or are given low priority in comparison with daily economic concerns (Davis and Hall, 1999; Correia, 2002). In this sense the urban poor may be trading off poverty and vulnerability, accepting increases in the latter to enhance their daily struggle against the former (Pelling, 1999; Correia, 2002).

2.6.2.2 Education and vulnerability to floods

Education not only increases labour market returns, but it also allows individuals to adapt more efficiently and effectively to crisis and uncertainty (Correia, 2002). Those who are better educated tend to make use of assets more efficiently; have greater capacity to obtain information, credit, and other productive resources; and are better able to exploit new income opportunities (Correia, 2002). Thus, differences in educational attainment and literacy are important in determining the vulnerability of men and women and that of the households to which they belong.

2.6.2.3 Household characteristics and flood vulnerability outcomes

Household characteristics affect vulnerability and the capacity to cope with external shocks and uncertainty. For example, the ability to mobilise and transform labour into income and well-being often depends on household structure, composition, and decision making (Cunningham, 2001). By taking on additional family members and by assigning members to the workforce, households act as insurance mechanisms and reduce vulnerability. But if household members are not employable for any reason—for example, because of age or gender, they can increase dependency and, in turn, intensify vulnerability (Correia, 2002).

Children and other dependants can reduce household financial security (Schiller, 1995) and thus increase vulnerability. The effects of more children include an increased need for household income, constraints to women entering the labour force, and increases in childcare and other domestic work (Correia, 2002). In terms of the gender-differentiated effects for women, a large number of children means fewer opportunities to participate in economic activities and generate income, with corollary implications for their negotiating power in the household. The presence of young children also affects the type of work that mothers can take on (Cunningham, 2001).

2.6.2.4 Health status and vulnerability to floods

Health status affects human capital, productivity, income-earning capacity, and thus vulnerability (Correia, 2002). Studies have shown that the health of people before flooding can be a major determinant of the health impact outcome of floods (Tapsell et al., 2002). A flood victim with flood-related condition may have a worsened or aggravated situation due to floods.

2.6.2.5 Demographic/socioeconomic characteristics/gender and flood vulnerability

The demographic or socioeconomic characteristics of population may place its members at greater risk of harm before, during, and after a disaster (Donner and Rodríguez, 2011). Vulnerability is formally defined as the attributes or characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard (Wisner et al., 2004). Implicit here is s the idea that different populations face different levels of risk and vulnerability. Consequently, policies aimed at addressing risk and vulnerability must also take into account these differential impacts and outcomes of disasters.

Population growth and distribution, especially increased population density and urbanisation, increases vulnerability to disasters (Perrow, 2007). Congestion, limited escape routes, dense infrastructure, and poverty add to the vulnerability (Donner and Rodríguez, 2011). The growth of coastal populations, for instance, raises important concerns about increased human exposure to coastal flooding, hurricanes, and tsunamis (Donner and Rodríguez, 2008).

While population growth and distribution are important factors in producing vulnerability, who is being affected by the disaster is equally important. The social and economic characteristics of a group may limit its members' abilities to protect themselves from harm. Poverty is a primary factor that affects how individuals perceive risk and how well they understand and respond to warnings (Donner and Rodríguez, 2011). Widespread poverty has played a critical role in increasing population vulnerability to many recent disasters (Donner and Rodríguez, 2011).

Women also confront unique challenges when facing disasters. Women tend to be poorer relative to men and may not have the necessary resources to respond to and recover from disasters (Donner and Rodríguez, 2011). This problem is particularly evident among single mothers, whose poverty rates exceed that of single or married women, and who must not only protect themselves but must also safeguard the lives of their children when threats emerge (Donner and Rodríguez, 2011). Women's vulnerability to disasters is also shaped by traditional gender roles, power and privilege, low wages, and secondary responsibilities such as child care (Donner and Rodríguez, 2011).

2.6.3 Coping with and adapting to Floods

The concepts of coping and adaptation have gained substantial prominence in scientific and political discourses revolving around natural hazards and climate change. The terms are often mixed or used interchangeably with their specific notions and implications not clearly differentiated.

Coping is an immediate response and reaction to hazard events that impact societies or communities as in the case of a specific flood event (Birkmann et al. 2009, 2010; Birkmann, 2011a). Coping strategies are mainly undertaken within the existing frame of processes and structures in a system and are generally not aimed at changing or altering the principles of operation of that system (Birkmann et al., 2012).

Ability of individuals and social systems to cope with the impact of floods is often correlated to general socio-economic indicators. Coping indicators entail among other things general information on gender, age, poverty, race, education, social relations, institutional development, proportion of population with special needs (children, elderly) and the like (Blaikie et al., 1994; Watts and Bohle, 1993; Hewitt, 1997; Smith, 2001). Coping indicators deal with the strength of actors to cope with flood events (Parker et al., 1987; Green et al., 1994).

Adaptation implies an adjustment of system components, processes and structures in response hazards in order to limit or reduce the negative impacts (Birkmann et al., 2012). Adaptation occurs in both natural and socio-economic systems (Burton et al., 1998). People generally adopt measures in order to adapt to extreme weather events like floods. Such interventions modify the threat of natural variability. Burton et al. (1993) however noted that human activities are not always as well adapted to extreme weather events as they might be. The mounting losses from great natural disasters are substantially associated with extreme weather events. Therefore, in a situation where natural climate and hydrologic systems have been modified by human intervention, even efficiently designed corrective measures might be proven to be either partially effective or ineffective.

Adaptation can be anticipatory or reactive, private or public, autonomous or planned (Mirza, 2004). Anticipatory Adaptation is adaptation that takes place before impacts or any intervention has been observed. It is also referred to as proactive adaptation. Adaptation that occurs after an event or impact is reactive. Adaptation that does not constitute a conscious response to any stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems is termed autonomous or spontaneous adaptation. However, adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state is a planned adaptation. An adaptation that is initiated and implemented by individuals, households or private companies is described as private adaptation. On the other hand, when adaptation is initiated and implemented by governments at all levels it is called public adaptation. Public adaptation is usually directed at collective needs.

Adaptive capacity depends on a number of determinants that include: socio-economic wealth, governance, technology, information and skills, infrastructure, institutions and equity. Among these determinants, socio-economic factors are the most important determinants that help develop adaptive capacity (Mirza, 2004). Socio-economic factors affect the ability of a system to absorb (robustness) or respond to changes that occur to a natural system due to natural causes or human interventions (Smith et al., 1998). There are many potential adaptation measures that may be adopted in response to extreme events. Burton et al. (1993) divided them into the following eight categories as follows: bear losses, share losses, modify threat, prevent effects, change use of the system, change location, research and educate, inform, and encourage behavioural change.

Thus, coping with and adaptation to floods are not solely differentiated in terms of timescale but also in terms of the actions and strategies that are possible within current institutional settings and those that are linked to change and require changes in framing institutions. While this change might be gradual, it is, however, different from a more short-term oriented response (coping) to flood hazard impacts (Birkmann 2011a; Birkmann et al., 2009, 2010). Coping compared to adaptation is closely related to impacts, while adaptation relates to change (Birkmann, 2011b).

2.6.4 Conceptual/analytical frameworks of vulnerability

2.6.4.1 An overview of theoretical/conceptual frameworks

Vulnerability of human populations to floods has been studied from different conceptual and theoretical perspectives. Vulnerability is said to have a double structure. The double structure perspective thus holds that vulnerability is the outcome of interaction between exposure to external stressors and the coping capacity of the affected household, group or society (see Bohle, 2001).

Davidson's (1997) conceptual framework which was later adopted by Bollin et al. (2003), views vulnerability as one of four components of disaster risk with the other components being hazard, exposure, and capacity measures (physical planning, social capacity, economic capacity and management). This conceptual framework views risk as the sum of hazard, exposure, vulnerability and capacity measures. Unlike the framework of the double structure of vulnerability, this approach defines vulnerability as one component of disaster risk and differentiates between exposure, vulnerability and coping capacity (Bollin et al., 2003).

In the UN/ISDR framework, vulnerability is divided into social, economic, physical and environmental components. It views vulnerability as a key factor determining risk and vulnerability assessment is seen as an instrument and a pre-condition for any effective risk assessment (UN/ISDR, 2004). One of the weaknesses is that it does not indicate how vulnerability reduction can also reduce risk. In addition, vulnerability in the framework lies outside the risk response and preparedness framework making it difficult to understand the necessity of also reducing risk through vulnerability reduction and hazard mitigation (Birkmann, 2006).

Turner et al. (2003) framework defined the basic elements of vulnerability as exposure, sensitivity and resilience. Their framework places the human-environmental system in the centre of its analysis while vulnerability is viewed in the context of coupled human-environmental system. However, the appropriateness of the distinction made between drivers and consequences in the feedback-loop system remains to be answered.

The pressure and release model (PAR model) presents an explanatory model of vulnerability that involves global root causes, regional pressures, and local vulnerable conditions (Füssel, 2007). It however fails to adequately address the coupled human-environment. Besides, it is hard to differentiate between the causal links of different dynamic pressures on unsafe conditions and the impact of root causes on dynamic pressures in multi-causal situations and a dynamic environment (Wisner et al., 2004).

In the holistic conceptual framework, vulnerability conditions depend on the exposure and susceptibility of physical elements (hard risk) in hazard-prone areas on the one hand, and on the other, on socio-economic fragility as well as on a lack of social resilience and abilities to cope (soft risk) (Cardona and Barbat, 2000). These factors provide a measure of the direct as well as indirect and intangible impacts of hazard events. While the categorisation of vulnerability conditions into ‘‘hard’’ and ‘‘soft’’ risk is a bit controversial, the conceptual framework presents a broader picture of vulnerability, which include exposure, susceptibility and lack of resilience. The revised version of the holistic model by Carreño et al. (2005) views risk as a function of the potential physical damage and the impact factor which depends on the socio-economic context. Based on the theory of control and complex system dynamics, a feedback loop encompassing corrective and prospective interventions, was introduced to underscore the need to reduce both the vulnerabilities and the hazards.

The Onion framework defines vulnerability with regard to different hazard impacts related to the economic sphere and the social sphere. Analytically, the framework distinguishes a reality axis and an opportunity axis. The reality axis shows that a flood event could affect the economic sphere and cause flood damage, while if the impact of the flood caused huge additional disruption in the social sphere, a disaster would occur. As a weakness, the framework fails to account for environmental vulnerability. The aspect of exposure is also not specifically incorporated (Birkmann, 2006).

Bogardi, Birkmann and Cardona (BBC) conceptual framework combines different elements of the frameworks discussed earlier and linked to conceptual work done by Bogardi and Birkmann (2004) and Cardona (1999). The framework underlines the need to view vulnerability within a process (dynamic), which means focusing simultaneously on vulnerabilities, coping capacities and potential intervention tools to reduce vulnerabilities (a feedback-loop system). The analytical frameworks for this study is the MOVE framework (Birkmann et al., 2013).

2.6.4.2. Analytical frameworks for the study of household vulnerability

The MOVE framework has been developed within the context of the research project called MOVE (Methods for the Improvement of Vulnerability Assessment in Europe) sponsored by the European Commission within the framework of the FP 7 programme. The framework is based on work dealing with the development of a holistic approach to vulnerability assessment linked to a system-science perspective, including reference to the concept of feedback loops (Birkmann et al. 2012; 2013) [See Figure 2.2]. At its core, the framework differentiates key factors of vulnerability and shows various thematic dimensions such as social, economic, environmental and institutional vulnerability. These key factors include exposure, susceptibility, lack of resilience or societal response capacity and flood hazard. In this framework exposure describes the extent to which a unit of assessment falls within the geographical range of a hazard event (Birkmann et al., 2012). Exposure extends to fixed physical attributes of social systems (infrastructure) but also human systems (livelihoods, economies, cultures) that are spatially bound to specific resources and practices, which may also be exposed. Exposure then is qualified in terms of spatial and temporal patterns.

The second key factor of vulnerability in the framework is susceptibility. That means even if a system or object is exposed, it does not necessarily mean that the system is vulnerable, since it might have a very low susceptibility and a high coping or adaptive capacity. Susceptibility (or fragility) describes the predisposition of exposed elements (social and ecological) to suffer harm.

The third key component of the MOVE framework is the societal response capacity and adaptation. This response capacity can include pre-event risk reduction, in-time coping and post-event response measures. Adaptation and adaptive capacities refer techniques, assets and strategies applied or available for use in changing the institutional and structural (balance and distribution of assets and information) frameworks that limit human intervention in managing exposure, susceptibility and resilience at any given point in time (Birkmann, 2013). The aim of such interventions is to reduce human vulnerability. As such, resilience building and improvement is seen as a component of adaptation. Compared to capacities to cope or to recover, classified as 'lack of resilience' in the framework, resilience in the adaptation box refers to learning and reorganisation processes in the light of potential future changes and hazards, as well as potential changes in vulnerability (Birkmann, 2013). Consequently, the concept of resilience is differentiated into (1) a more reactive part that refers to the lack of resilience, while (2) the ability to learn and to reorganize in anticipation of future changes (proactive actions) is linked to the notion of adaptation. While coping capacities and resilience are primarily linked to capacities that help in maintaining the current status of the systems under stress, adaptation as a concept implies actions aimed at making more profound change in socio-ecological relations (Birkmann 2011a; Birkmann, 2013). Flood hazards in the framework describe the potential occurrence flood events that may have physical, social, economic and environmental impact in a given area and over a period of time. It is therefore defined by the potentiality of hydro-meteorological processes to cause effects upon exposed elements.

The MOVE framework also emphasises coupling relations between environmental and societal dimensions. Coupling emphasises the framework's assertion that any defined hazard such as flood is given form and meaning by interaction with social systems, and similarly, social systems are influenced by their actual and perceived hazard context and environmental conditions. The framework also underscores that risk governance (see e.g. Renn, 2008) is a process that could span the whole diagram, but that was placed on the intersection between risk and adaptation in order to underline that risk management is linked to decisions and actions performed by both formal governmental stakeholders or institutions and non-governmental actors as well as informal stakeholders such as individual households (Birkmann et al., 2012; 2013). Risk management undertaken by these stakeholders includes tasks on risk reduction, through prevention, mitigation, preparedness or transfer.

The framework stresses the fact that hazards might not only be of natural origin. Many hazards that reveal societal vulnerability such as floods can be classified as socio-natural since they are influenced by anthropogenic factors. As a heuristic, the framework is a thinking tool to guide systematic assessments of vulnerability and to provide a basis for comparative indicators and criteria development to assess key factors and various dimensions of vulnerability (Birkmann et al. 2013).

In terms of the underlying systematisation of different components, the framework refers in a theoretical context to general systems theory, cybernetics and interlinked systems theory (Birkmann, 2013). It highlights the fact that vulnerability and risk are not static but dynamic in nature. Compared with the linear understanding of feedback and response processes held by cybernetic theory and the idea that systems can be steered more or less easily, the MOVE framework emphasizes that nonlinearity, complexity and emergence are key characteristics of disaster risk systems and their various processes.

As a limitation, the framework does not provide a specific assessment method (qualitative or quantitative) or a pre-defined list of indicators. Rather, it outlines key factors and different dimensions of vulnerability that can serve as a basis for a systematic operationalisation of vulnerability. Besides, the framework looks too general and does not address the flood-specific objectives of the current research.

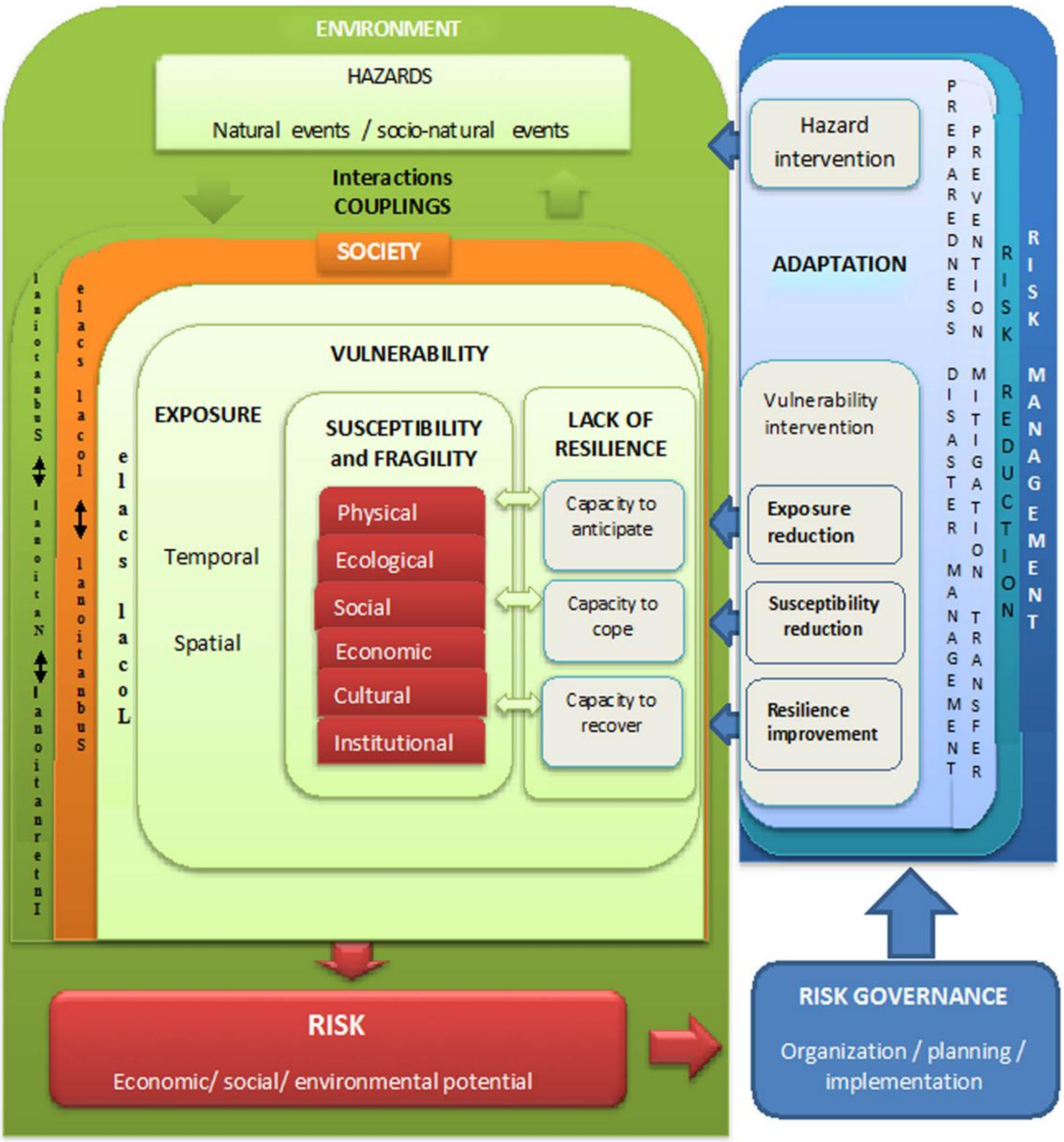

Figure 2.2: MOVE Conceptual Framework

Source: Birkmann et al. (2013)

2.6.4.3 Adapted framework for household vulnerability study

Due to the limitations associated with the original framework, a slightly adapted MOVE analytical framework has been developed (see Figure 2.3). This encapsulates all the critical elements for analysing household vulnerability as shown in the original framework and addresses the observed limitations. Unlike the original framework, Figure 2.3 addresses itself specifically to floods and highlights the characteristics and components of exposure. The defined indicators of the components of the framework have been presented and further elaborated in section 3.3.2.

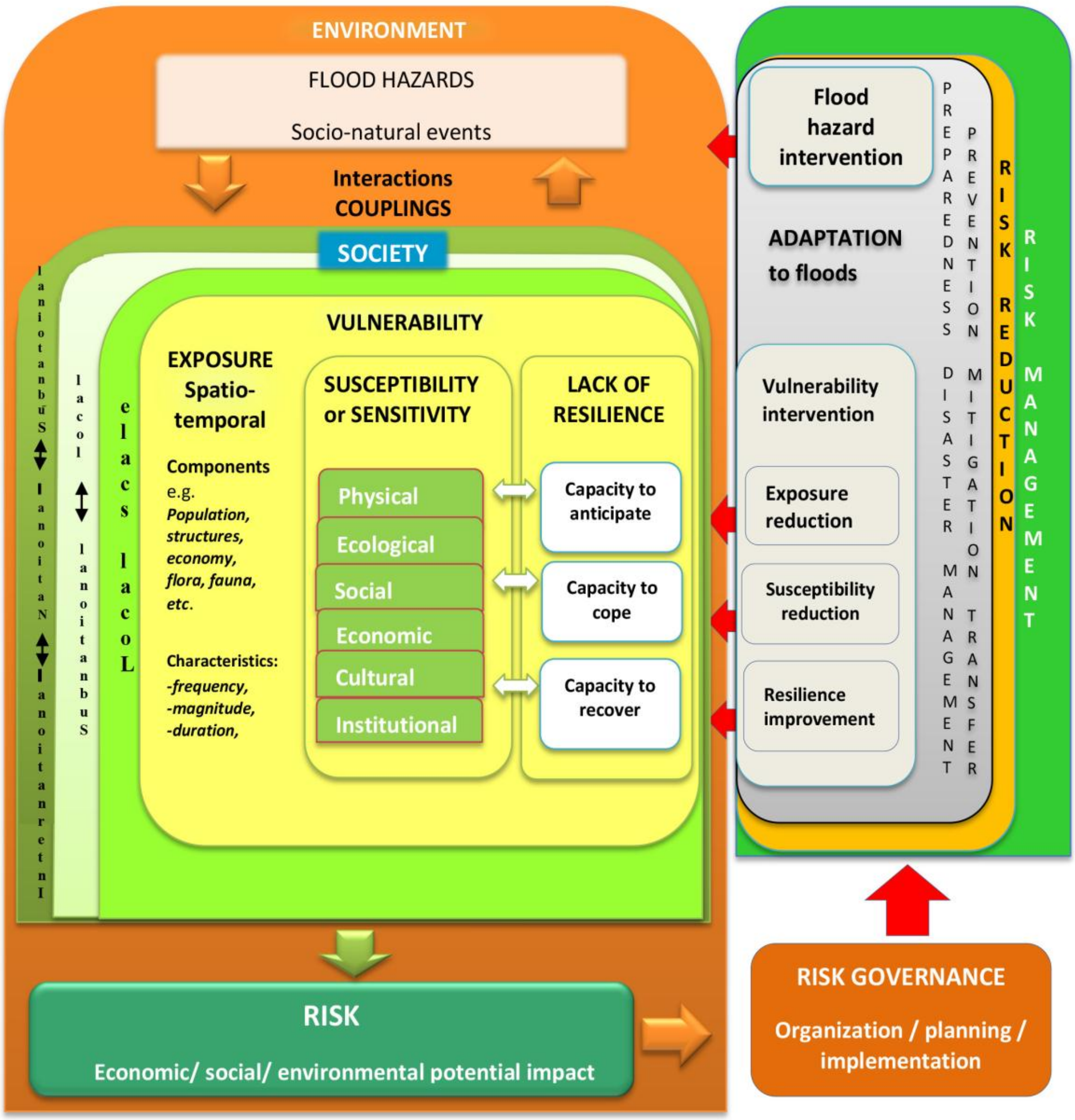

Figure 2.3: A modified framework for analysing flood vulnerability

Source: Adapted from Birkmann et al. (2013)

Like the original framework, the adapted analytical framework views vulnerability as a function of exposure, sensitivity, lack of resilience and hazard. The framework shows that flood hazards are results of the interaction between human society and the environment. When floods occur, different elements are at risk. Different elements of the system including the population or individual households, economic investments as well as social and physical infrastructure may be affected depending on the degree to which they are exposed, their susceptibility (sensitivity or fragility) and their capacity to adapt.

Following Penning-Rowsell et al. (2005), exposure in the framework refers to the likelihood that humans and/or physical items such as goods, infrastructure, cultural heritage and agricultural fields and other economic assets will be impacted by flooding. In other words, it is the extent to which population including their physical, social, economic, cultural and the natural environment fall within the geographical range of flood hazard. Exposure of any element in any given system to floods depends on the characteristics of the element as well as the magnitude, frequency, duration and spatial extent of the flood event (Turner et al., 2003), site of building, proximity of settlements to a major river, stormwater outlet and wetlands.

In community system, the level of exposure can be a condition that makes households and communities susceptible to the adverse impacts of floods hence, increasing their vulnerability. In a given system, some elements would be more exposed to flood risks than others due to a number of factors. Relating this to human settlement, some people may be more exposed to the risks of floods than others due to for example their location, type of buildings and resources at their disposal. Poor people may be more exposed than the rich. Poverty for instance could make people settle in a flood prone area, exposing them to flood risks. Settlements sited close to major streams, rivers or stormwater outlet will suffer more flood damage than those located far away because of their greater exposure.

Another important element in vulnerability analysis as shown in the framework is sensitivity (often used interchangeably with susceptibility or fragility) of elements or systems at risk of floods. The fact that an element or a system is exposed does not automatically translate into vulnerability if the element or system in question is less fragile or has low susceptibility or is less sensitive. Defined susceptibility/sensitivity indicators in the framework could be determined by the following household characteristics: age and sex composition of a household; health status; level of education; employment status and average monthly income accruing; length of stay in the community; quality of building; presence and number of people with special needs (children, elderly and the disabled).

While one may argue for instance that disastrous floods may not discriminate between the rich and the poor, young or the old, male or female, able and people with disability, these categories will exhibit different degrees of sensitivity to flood disaster. The poor will be more susceptible or more sensitive to floods than the rich. Similarly, children and people with disability will be more susceptible to floods than older people and people without any form of physical disability respectively. Poorly constructed house or a bridge would show high level of fragility in the face of destructive floods than those based on sound structural engineering work. Population living in mud or flimsy houses will be more exposed and therefore more vulnerable to floods. Sensitivity depends on how stressed the current system is. A system or a population already close to its limits will suffer great damage even from small shocks. Examples include poor individuals without any savings or populations in poor health (Marshall et al., 2009). The sensitivity of social systems according to Fenton et al. (2007) depends on economic, political, cultural and institutional factors. While the exposure-sensitivity determines the potential impact of floods, exposure-sensitivity-adaptation will determine the actual impact. A measure of households' level of sensitivity is how much socio-economic and human losses they incurred and how much physical and psychological health burdens they have had to bear as a result of floods.

Lack of resilience or societal response capacity, a third critical element in the framework, is determined by limitations in terms of access to and mobilisation of the resources of a community or a social-ecological system in responding to an identified hazard. Resilience indicators will also include among others membership of social network group, access to critical livelihood assets, flood insurance cover, access to credit facilities, existence of flood preparedness and response plans, existence of special measures to ensure the protection of children, women, the elderly and the disabled. As communities are exposed and become sensitive to the hazards such as floods, it is imperative that some adaptive responses occur to minimise the adverse impacts. Thus, systems must be able to demonstrate the capacity to respond accordingly.

Adaptive capacity describes the ability to respond to challenges through learning, managing risk and impacts, developing new knowledge and devising effective approaches. It requires amongst many other things, the flexibility to experiment and adopt novel solutions (Gunderson, 2000). In social systems, adaptive capacity can be a conscious or inadvertent characteristic, enhanced by the existence of institutions and networks that learn and store knowledge and experience, create flexibility in problem solving, without compromising the ability to cope and adapt to future change (Nelson et al., 2007) Adaptive capacity greatly influences the vulnerability of communities and regions by reducing exposure and susceptibility to floods and improving resilience.

When systems are unable to stand strong through their actions to reduce the impacts of flooding, it tends to increase their level of vulnerability. Vulnerability is experienced when the interactions and actions of the members of the system, such as the households, community members, local or central government among others fail to or are not directed at mitigating the potential impacts of the flood incidents (ILGS and IWMI, 2012).

Resilience strategies should imply communities not only being able to cope and recover but also changing to reflect different priorities arising from the disaster. This can be in the form of building hazard-resistant structures, changing negative social behaviours, and dissemination of early warnings in addition to other strategies. Moreover, the social support systems should be provided. When a system is redundant and incapacitated to respond adequately either before, during or after a flooding incident, there is the possibility of an increase in the vulnerability of the system and that will have a vicious impact on people's wellbeing and livelihoods. From the framework, it can be deduced that the stronger the adaptive capacity of the social system, the less vulnerable the system becomes. Adaptive capacity greatly influences socio-economic vulnerability of households and communities, hence, enhancing adaptive capacity is necessary for reducing vulnerability, particularly for those in the vulnerable socio-economic groups (McCarthy et al, 2001) that frequently experience flooding incidents.

The MOVE framework provides an improved conceptualization of the multi-faceted nature of vulnerability, accounting for key causal factors such as exposure, susceptibility, lack of resilience (lack of societal response capacities) as well as for the different thematic dimensions of vulnerability: physical, social, ecological, economic, cultural and institutional. Given the specific objectives of the current work, this framework is particularly useful. The examination of the physical and human contexts of floods and household vulnerability and adaptation to floods can well be examined within this framework.

2.7 Summary

Floods have been associated with extensive morbidity and mortality throughout the world. The most readily identified flood deaths are those that occur acutely from drowning or trauma. Among the health effects often associated with floods are diarrheal diseases (especially among children in low-income countries), and acute respiratory infections in children (particularly less than 5 years of age) - a major cause of illness and death in populations displaced by natural disasters. Vector-borne diseases may increase during periods of flooding. Stagnant water provides a breeding ground for many vectors, such as mosquitoes, resulting in diseases such as malaria and dengue. Major life stressors, such as flood disasters, increase susceptibility not only to physical illness, but also mental health. Available literature however shows that flooding is not always associated with negative consequences. There are even some who make financial gains from otherwise damaging floods.

Vulnerability refers to the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard. A very short one is the degree of loss resulting from a potentially damaging phenomenon and thus views vulnerability as an outcome rather than a condition that gives rise to vulnerability. The argument for the use of a political economy framework has been made by different scholars, often using the “entitlements approach” which begins at a household level in the analysis of vulnerability. From this perspective, vulnerability is understood as being determined by access to resources specifically, by individuals’ “entitlement” to call on these resources. This study adapts the MOVE framework as a conceptual or analytical framework where exposure, susceptibility and resilience are key elements of vulnerability and also emphasising coupling relations between environmental and societal dimensions. The next chapter addresses methodological issues of the study.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

Chapter two presented Empirical and conceptual perspectives of vulnerability and adaptation to floods. This chapter presents the study design and the philosophical basis of the research. It also delineates and defines the study variables and explains how these variables were measured including sampling design and outlines the various data sources, data gathering methods as well as methods of data analysis.

3.2 Study Design and Philosophical Underpinning

3.2.1 Study design

The ultimate goal of any research project is to answer the questions set forth in the beginning of the study. This study examines households' vulnerability and adaptation to floods and analyses the potential explanatory variables in the rural and urban context of Ghana. The study adopts a comparative, cross-sectional survey of rural and urban flood-prone areas in Ghana. A cross-sectional study approach is 'designed to study some phenomenon by taking a cross-section of it at one time' (Babbie, 1989: 89). Such studies are cross-sectional with regard to both the study population and the time of investigation (Kumar, 2011). Cross-sectional studies are sometimes carried out to investigate associations between risk factors and the outcome of interest (Levin, 2006).

There are many methodological approaches in social science research, largely reflecting basically the qualitative-quantitative divisions. In this research a mixed method approach was used, employing both quantitative and qualitative techniques. Mixed method may be defined as "the collection or analysis of both quantitative and qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research" (Creswell et al., 2003, p. 212). The combined use of qualitative and quantitative methods helps to produce results in ways that may not be possible with one approach (Brewer and Hunter, 1989; Tashakkori and Teddlie, 1998). This further allows for simultaneous generalisation of results from a sample to a population and to gain a deeper understanding of the phenomenon of interest (Hanson et al., 2005). The specific mixed method design used is the concurrent triangulation. It is concurrent triangulation design because both quantitative and qualitative data were collected and analysed at the same time even though they were analysed separately but both were integrated to explain the specific problems investigated (Hanson et al., 2005). The methodological rationale for adopting this concurrent triangulation is thus to ensure triangulation. Interpretation typically involves discussing the extent to which the data triangulate or converge and are useful for attempting to confirm, cross-validate, and corroborate study findings (Hanson et al., 2005). Different methods have different strengths and so using both qualitative and quantitative approaches combines the strengths of these two. Besides, the combined method can simultaneously address a range of confirmatory and exploratory questions, provides better (stronger) inferences and the opportunity for a greater assortment of divergent views (Teddlie and Tashakkori, 2009). The combined use of in-depth interview and questionnaire in primary data collection for example, will give both depth and breadth from which better and accurate inferences can be made. While complementarity and triangulations are common justifications for a combined approach (e.g. Greene et al, 1989), Morgan (2013) cautioned that its choice should be balanced against the complexity and challenges of research projects that this combined approach brings. Since flood vulnerability studies and adaptation are typically complex and dynamic social realities, a mix of quantitative and qualitative approaches becomes useful (Greene and Caracelli, 1997). This argument is further strengthened by the fact that quantitative research method alone may fail to fully capture the dynamics of households' flood risk perception and, in particular, may ignore local people's perspectives and understanding of risk perceptions and vulnerability (Grewal and Ritchie, 2006).

3.2.2. Philosophical underpinning of the research

Researchers base their work on certain philosophical perspectives and this may be based on a single or multiple paradigm(s), often depending on the kind of questions to which answers are being sought. The ontological, epistemological and methodological dimensions of social research are "packaged" in paradigms which guide everyday research. There is a widespread view within mixed methods research that the appropriate philosophical partner for quantitative research is positivist empiricism and that for qualitative research is constructivism (Johnson and Gray, 2010). In other words, positivist paradigm, which contains a realist/objectivist ontology and an empiricist epistemology guides the strategy of quantitative methodology and prescribe fixed designs and quantitative methods (Sarantakos, 2013). Paradigm of symbolic interactionism, phenomenology and so forth which are based on relativist/constructionist ontology and an interpretivist epistemology guide the strategies of qualitative methodology. This prescribes mostly flexible designs and qualitative methods (Sarantakos, 2013).

The positivist paradigm asserts that real events can be observed empirically and explained with logical analysis. The criterion for evaluating the validity of a scientific theory is whether our knowledge claims (i.e., theory-based predictions) are consistent with the information we are able to obtain using our senses. Positivist research methodology emphasises micro-level experimentation in an environment like laboratory that eliminates the complexity of the external world (Kaboub, 2008).

Post-positivism and constructivism disagree on major issues concerning the nature of the objects of research and our knowledge of these (Guba and Lincoln, 1989). But as methodological pragmatists (e.g. Patton, 2002; Tashakkori and Teddie, 1998) indicated, these disagreements are not fundamental and that research methods are not intrinsically linked to specific philosophical positions. Methods can be combined on the basis of their practical utility and that paradigmatic conflicts can be ignored (Maxwell and Mittapalli, 2010). This view has gained substantial acceptance within the mixed methods research community and pragmatism has been promoted as the appropriate philosophical stance for mixed method research (Biesta, 2010; Johnson and Gray, 2010). A research strategy or method is not necessarily linked to a single philosophical stance and any approach may be informed by one or more of a number of paradigms (Greene, 2000). The current study, being a mixed research approach carries with it some ontological and epistemological assumptions of post-positivism and phenomenology while upholding pragmatism as a guiding philosophical principle.

Pragmatism emphasises that all aspects of research inherently involve decisions about which goals are most meaningful and which methods are most appropriate (Morgan, 2014). One of the widely shared elements of pragmatism is that actions cannot be separated from the situations and contexts in which they occur. Instead of universal truths, pragmatists emphasise warranted beliefs. Besides, actions are linked to consequences in ways that are open to change implying that the meaning of acts can change over time, whenever the consequences of those acts change. Lastly, actions depend on worldviews that are socially shared set of beliefs (Morgan, 2013). Morgan

(2007) proposed an organisational framework for understanding his pragmatic approach to social sciences methodology. This framework refers to key pragmatic concepts such as abduction, intersubjectivity and transferability, which supersede the qualitative-quantitative dichotomies of induction/deduction, subjectivity/objectivity and context/generality.

As a paradigm, pragmatism gives mixed methods researchers a flexible view of how to conduct research (Morgan, 2013:8). Pragmatism implies a conceptual agreement about research in terms of both the purposes it pursues and the procedures it uses to pursue those purposes. Pragmatism can thus be considered "a paradigm of choice", a description that is particularly appropriate for mixed methods research because of the complexity of choices involved in integrating qualitative and quantitative methods (Morgan, 2013).

3.3 Variables, definitions and measurements

3.3.1 Predictor and outcome variables

Vulnerability is the outcome or dependent variable in this study. Definitions of and approaches to the study of vulnerability are varied. These different definitions and approaches show it is just not clear what vulnerability stands for as a scientific concept (See Chapter 2). Paradoxically, one is attempting to measure something whose definition is not precise. According to Balica et al. (2009) societies are vulnerable to floods due to three main factors: exposure, susceptibility and resilience. Similarly, Smit and Wandel (2006) maintained that vulnerability of any system (at any scale) is a function of the *exposure* and *susceptibility* of that system to hazardous conditions and the *resilience* of the system to adapt and/or recover from the effects of those conditions. An operational definition of vulnerability at this point is key. In this work, flood vulnerability is defined to mean not only the attributes of the physical and human systems that put individual elements at risk of loss, damage or being hurt (physically or emotionally) by floods but also the degree of loss or damage, including physical and psychological malaise associated with floods. In this respect, vulnerability is defined as a set of conditions and an outcome. Adger (2006, p. 269) puts it eloquently this way: ‘In all formulations, the key parameters of vulnerability are the stress to which a system is exposed, its sensitivity, and its adaptive capacity.

3.3.2 Determining vulnerability as a set of attributes that condition outcomes

Following the works of Birkmann (2006), Messner and Meyer (2006) and Pyle (2006), the following indicators of vulnerability are identified. These reflect a set of attributes that could make one vulnerable to floods.

3.3.2.1 Exposure indicators

1. Frequency, duration and magnitude of floods;
2. Site of building - valley, steep/gentle slope, high ground, flat surface etc.; and
3. Location of building – proximity to a major river or stream, wetland, stormwater outlet.

3.3.2.2. Susceptibility/sensitivity indicators

1. Age of head of household;
2. Sex of head of household;
3. Health of head of household;
4. Level of education of head of household;
5. The size of the household;

6. Employment status of head of household;
7. Average income accruing to the household from economic activities;
8. Income from remittances;
9. Length of stay in the community;
10. Quality of Building – built on foundation, principal material used for main building, floor and roof; and
11. Presence and number of people within household with special needs (children, elderly and the disabled).

3.3.2.3. Resilience (lack of)

1. Membership of social network group, community-based organisations/institution, or a registered party member;
2. Lack of critical livelihood assets;
3. Legislation or community rules to regulate behaviour/conduct of people to reduce flood risk;
4. Awareness of legislation which enjoins government to protect households against risks of floods;
5. Flood preparedness plan;
6. Credit facilities;
7. Flood insurance cover;
8. Existence of flood response plan; and
9. Existence of special measures to ensure the protection of children, women, the elderly and the disabled.

For the purpose of analysis, 19 indicators were used as shown in Table 3.1. The selection of these indicators was based on their relevance to the study communities.

Table 3.1: Selected vulnerability indicators

1.Material used for the building	11. Possession of Television (TV)/ radio
2. Material used for the floor	12. Level of education of household head
3. Roofing Material	13. Employment status of household head and other members
4. Building having foundation or not	14. Household mean monthly income (or per capita household monthly income)
5. Proximity to river/stream/stormwater channel	15. Access to credit facilities
6. Location in wetland and waterlogged areas	16. Insurance coverage
7. Site of dwelling	17. Social capital/security
8. Accessibility	18. Existence of Household flood preparedness and response plans
9. Electricity supply	19. Length of stay in the community
10. Possession of/access to telephone	

Source: Author's construct (2017)

To determine quantitatively household and rural-urban flood vulnerability level, a scoring scheme based on the work of Mogammad (2008) was developed to grade these indicators. Each indicator was scored on a scale of zero to ten (0-10) on the basis of their importance or significance in accentuating or attenuating vulnerability (see Appendix 7). Zero (0) is considered the least vulnerable and ten (10) most vulnerable. In other words, the closer the score is to the zero, the less vulnerable or more resilient one is and the closer the score is to ten, the higher the vulnerability. The maximum score per respondent using the 19 selected indicators is 190 while the minimum score is zero (0). This gives a score range of between 0-190, which in percentage terms is (0-100%). For analytical purpose, three different levels of vulnerability were distinguished. Score from 0%-30% were considered Low Vulnerability (LV) class, scores from 31%-69% were considered High Vulnerability (HV) class, and 70% and above were highly vulnerable (VHV) class. While the assignment of values to the selected indicators may appear subjective, the overall scores give one a fair idea of the level of vulnerability of the populations studied.

3.3.3 Determining vulnerability as an outcome

To determine the vulnerability of study communities to floods, where vulnerability is viewed as an outcome, the study collected household data on socio-economic and health impact of health using both qualitative and quantitative data collection methods. The study used the Kessler *et al*. (2002) Psychological Distress Scale (KPDS-K10), a 10-item screening questions for assessing individuals' level of psychological stress. The KPDS-K10 scale evaluates how often respondents experienced each symptom during and after the previous floods on a 5-point response scale: 1= "none of the time", 2= "a little of the time", 3= "some of the time", 4= "most of the time", and 5= "all of the time. Respondents were asked, to indicate *about how often they felt or thought of* (1) "tired out for no good reason", (2) "killing oneself", (3) "so nervous that nothing could calm them down", (4) "hopeless", (5) "restless or fidget", (6) "get upset by little things", (7) "depressed", (8) "that everything was finished" (9) "so sad or bored that nothing could cheer one up" and (10) "worthless". Flood-related psychological health (Ph) of respondents as a dependent variable was regressed on age and sex as independent variables.

The predictor or independent variables that can influence vulnerability include age, sex, marital status, household size, level of education, residential status, religious background, ethnic background, employment status, household income level, social networks, housing quality, proximity of settlements to major streams, rivers and major storm outlets and location within wetlands. Whilst age in years and income like other variables were entered as continuous variables, sex (males = 0; females = 1), settlement type (rural = 0; urban = 1), location within wetlands (No = 0; Yes = 1), proximity to a waterbody (No = 0; Yes = 1), proximity to stormwater outlet (No = 0; Yes = 1) and possessing of flood insurance (No = 0; Yes = 1) were entered as dichotomous variables. Classification of other variables as employment, religious affiliation and type of dwelling unit can be gleaned from Appendix 1.

3.4 Sources and Types of Data

This work made use of both primary and secondary data sources. Primary data were sourced and collected from households in the various selected study communities that lie within flood-prone areas. These include both the quantitative data gathered from the household respondents using the interview schedule and the qualitative data from households and key informants using the interview guide. Data from the household include the background information as well as those related to their flood experience. Specifically, it covers socio-demographic and economic characteristics of the respondents such as age, sex, educational background, marital status, number of children, religious affiliation, occupation/employment status and income levels. Other information collected at the household level include the residential status, type/quality of dwelling, choice of present location, flood occurrence frequency, flood experiences, damage or losses due to floods, health effects of floods, knowledge of flood risks, flood risk communication, flood risk perceptions, coping with floods, adaptations to floods and so forth. Data was also collected from key informants from institutions, including Environmental Protection Agency (EPA), National Disaster Management Organisation (NADMO), Metropolitan, Municipal and District Assemblies (MMDAs), Town and Country Planning Department (T&CPD), Department of Parks and Gardens (DP&G) Ghana Meteorological Agency (Gmet), Hydrological Services Department (HSD), Water Resources Commission (WRC) and traditional authorities. Data covered broader issues of perennial floods, impacts, intervention, collaboration and support systems including policy issue.

In addition, secondary information from documentary sources were collected to complement and validate the primary data collected. Secondary data in the form of daily rainfall in Kumasi Metropolis and the Central Gonja District were collected from the Ghana Meteorological Services Agency, Accra covering a period of 36 years (1980-2016). Since Central Gonja has no weather station, rainfall statistics from the nearest station, Damongo was used as surrogate or proxy for Central Gonja. In selecting this station, one took into consideration the maximum radial distance threshold of the World Meteorological acceptance distance for weather stations located in Africa. Thus, Central Gonja is approximately 50km from Damongo station.

The World Meteorological Organisation (WMO), Intergovernmental Oceanographic Commission (IOC), the United Nations Environment Programme (UNEP), and the International Council for Science (ICSU) require that stations classified as functional must meet target requirements acceptable and located at a distance of at least 60 to 95 kilometres from the nearest reference station (WMO/ IOC/ UNEP/ ICSU, 2010 cited in Appiah, 2016). The climate data was analysed to determine rainfall trends and variability over the period. Secondary flood data was obtained from the Ashanti Regional and Central Gonja District offices of NADMO from which relationship between flood events and rainfall and heavy rainfall events were determined. Information from books, book chapters, journal articles, periodicals, monographs, national surveys documents such as Ghana Demographic and Health Survey (GDHS), Ghana Living Standard Survey (GLSS) and Population and Housing Census reports on the socio-economic and demographic characteristics of the population of the study districts were accessed. It also includes relevant quarterly reports from institutions such as EPA, NADMO, Metropolitan, Municipal and District Assemblies.

To determine the extent of urban expansion of Kumasi Metropolis relative to the green, open and permeable space, land use and land cover (LULC) change analysis was carried out. Data for the LULC change analysis were ortho-rectified Landsat Thematic Mapper (TM) 1986, Enhanced Thematic Mapper Plus (ETM+) 2004 and Landsat 8 Operationalised Landsat Imager/Thermal Infrared Sensor (OLIS/TIRS) 2016 images, downloaded from the United States Geological Survey (USGS) Global Visualisation Viewer website using path 194 and row 055. Landsat TM 1986, Landsat ETM+2004 and 2016 images were used because the image sensors have seven spectral bands at a medium resolution of 30m which is adequate for the analysis. These multispectral bands sufficiently captured data on other vegetation, built up/bare areas and farmlands which are target objects for analysis. The images were clear and nearly free of clouds and readily available and accessible without any extra cost. These image scenes were sub-setted using the district boundary shape file in ArcGIS 10.2 software. The characteristics of the satellite images used are shown in Table 3.2. The satellite images were supplemented with land use and topographical maps of Kumasi, as well as ground-referenced spatial information that were collected with a Global Position System (GPS).

Table 3.2: Satellite images characteristics

Image Year	Landsat Sensor	Bands used	Date acquired	Spatial resolution
1986	Thematic Mapper (TM)	1, 2, 3, 4, 5, & 7	11th January	30m × 30m
2004	Enhanced Thematic Mapper plus (ETM+)	1, 2, 3, 4, 5 & 7	6th February	30m × 30m
2016	Operationalised Landsat Imager/ Thermal Infrared Sensor (OLI/TIRS)	1, 2, 3, 4, 5 & 7	7th February	30m × 30m

Source: Author's construct (2017)

Digital Elevation Models (DEMs) of the study districts were used to show the relief of the study areas from which the stream networks were derived. DEM is a digital representation of the Earth's relief that consists of an ordered array of elevations relative to a datum, and referenced to a geographic coordinate system (Forkuo, 2010). DEMs are the main source to produce information of land topography and provides elevation information that is useful for many environmental applications including hydrologic modelling and flood management planning (McDougall et al, 2008). Shuttle Radar Topography Mission (SRTM) data was obtained from USGS from which DEM of 30m resolution for the study areas were created. The stream networks were derived from the DEM by using the hydrology tools in Arc toolbox.

3.5 Study Participants

The research participants were made up of male and female heads of households as well as heads of key institutions that serve as key informants. The key unit of analysis therefore was the household. A household as used here takes its definition from Ghana's 1984 Population Census, which defines a household as a person or a group of persons who live together in the same house or compound, share the same housekeeping arrangements and are catered for as one unit. In general, a household consisted of a man, his wife, children and some other relatives or a house help living with them. However, it is important to note that members of a household are not necessarily related (by blood or marriage) because non-relatives (e.g. house helps) may form part of a household. A household head however was either a male or female member of the household recognised as such by other household members and generally one having economic and social responsibility for the household.

3.6 Sampling Procedure

Available records indicate a number of flood-prone communities in Kumasi Metropolis (See Table 3.3). These areas are regarded as the most frequently flooded suburbs in the metropolis and have received media coverage over the years. Since most of these communities are not familiar to the researcher, field reconnaissance survey was conducted to acquaint the researcher with the study communities, assess their suitability in terms of the problem under investigation and to find out how accessible they are. The study areas were stratified broadly into rural and urban to ensure adequate representations of each for the purpose of comparative study. Using a simple random sampling technique, eight (8) communities were selected as part of the sample for the study. These are Old Tafo, Atonsu, Kwadaso (Estate), Ayigya (Zongo), Buokrom, Dichemso, Anwomaso and Breman. This was done using the fishbowl draw method. It involved writing each of these communities on a small slip of paper which was then folded and put into a bowl. Shuffling was done thoroughly and then picked one-by-one until the required sample size was obtained (see Kumar, 2011). In each community, a simple random sampling was used to select individual houses using the fishbowl draw method. In each house visited, the head of a household was selected for interview. This was strictly adhered to in order to ensure that the people with the right information were targeted. This same selection procedure was followed in recruiting respondents for interview in the rural Central Gonja.

Table 3.3: Flood-prone areas in Kumasi Metropolis

1. Anwomaso	2. Dichemso
3. Oforikrom	4. Krofrom
5. Ahinsan	6. Buokrom
7. Atonsu (S-line)	8. Airport Roundabout
9. Breman(g)	10. Dakwadwom (TUC Junction)
11. Tafo	12. Santase
13. Asuoyeboa	14. Ayigya Zongo
15. Anloga; Accra town	16. South Suntreso (Friends Gardens)
17. Suame	18. Kwadaso (Estates, Odiniho Kwadaso)

Source: Compiled from NADMO (2017); Campion and Venzke (2013)

The sample size for KMA was determined by applying the formula $n = \frac{N}{1+N(e)^2}$ (Jensen and Shumway, 2010) where, n is the sample size; N is the total population of the four selected communities; e is the margin of error usually (0.05) or (5% or error margin), but 0.05 was used. Using this formula, the sample size is calculated as follows:

$$n = \frac{410145}{1+410145\,(0.05)^2} = 400 \text{ respondents}$$

Using a simple proportion formula, the actual number of respondents for each community was calculated (see the last column in Table 3.4).

Table 3.4: Sample size determination of selected urban communities in KMA

S/No	Communities	*Population	Sample Size (n)
1	Anwomaso	26,160	$\frac{26,160}{410145}$ x400 = 26
2	Atonso (S-line)	65,225	$\frac{65,225}{410145}$ x 400 = 64
3	Ayigya (Zongo)	55,476	$\frac{55,476}{410145}$ x400 = 54
4	Dechemso	17,916	$\frac{17,916}{410145}$ x400 = 17
5	Tafo (Old)	87085	$\frac{87085}{410145}$x400 = 85
6	Buokrom	49,510	$\frac{49,510}{410145}$ x400 = 48
7	Kwadaso (Estate)	37,638	$\frac{37,638}{410145}$ x 400 = 37
8	Breman	71135	$\frac{71135}{410145}$x400 = 69
	Total	410145	= 400

Source: Fieldwork (2017)

* Information is based on 2010 Population and Housing Census

In Central Gonja, fifty-two (52) flood-prone communities were identified. Some of the highly affected communities include: Tsikonto, Buipe (urban area), Agege, Nigeria Camp, Rome, Bamako, Kikale No. 4, Debre Port, Mataheko, Bethlehem, Bonyamu and Yapei. These communities among others are shown in Table 3.5. Using a simple random sampling technique, eight (8) communities were selected from the list of communities in Table 3.5 including, Amedzorovi, Bonyamu, Kopedeke, Debri Port, Adidodeke, Agege, Nigeria Camp and Kikali No.4.

Table 3.5: Main flood-prone rural communities in Central Gonja District

1. Kaklito	12. Agege
2. Debri Port	13. Don’t Touch Me
3. Nigeria Camp	14. Gbavukpo
4. Dokupe	15. Santa
5. Tsikonto	16. Kikale No. 4
6. Bettlehem	17. Amedzorovi
7. Adidodeke	18. Nigeria Camp
8. Adape	19. Bonyamu
9. Tsikonto	20. Yala
10. Kopedeke	21. Rome
11. Bamako,	22. Mataheko

NADMO, Cental Gonja (2010)

Using the household population of selected communities in Central Gonja, the sample size is calculated as follows: $n = \frac{4479}{1+4479\,(0.05)^2} = \ 367$ respondents

Using a simple proportion formula, the actual number of respondents for each community was calculated as shown in the last column in Table 3.6.

Table 3.6: Sampled rural flood-prone communities in Central Gonja

Zone	S/No	Settlements	*Population	Sample size
White Volta	1	Amedzorovi	532	$\frac{532}{4479}$ x367 = 44
	2	Bonyamu	483	$\frac{483}{4479}$ x367 = 40
	3	Kopedeke	647	$\frac{647}{4479}$ x367 = 53
Black Volta	4	Debri Port	248	$\frac{248}{4479}$ x367 = 20
	5	Adidodeke	309	$\frac{309}{4479}$ x367 = 25
	6	Agege	236	$\frac{236}{4479}$ x367 = 19
	7	Nigeria Camp	1121	$\frac{1121}{4479}$ x367 = 92
Confluence location	8	Kikali No.4	903	$\frac{903}{4479}$ x367 = 74
Total			**4479**	**= 367**

Source: Fieldwork (2017)

*Obtained from Central Gonja Community Water and Sanitation Agency, 2015

In addition, nineteen (19) key informants from institutions like EPA, NADMO, the assemblies, T&CPD, DP&G, Gmet, HSD, WRC, traditional authorities and the Lands Commission were purposively sampled. They represented the heads of their respective institutions. Besides, fifty-five (55) and thirty (30) heads of households in Kumasi Metropolis and Central Gonja respectively were conveniently sampled for qualitative in-depth interviews.

3.7 Data Collection Method

Data collection took place between July and August, 2017. The study made use of both structured and unstructured interview, using interview schedule and interview guide respectively. Since the study communities were predominantly settled by non-literate population, the interview schedule was considered the appropriate data gathering instrument for quantitative data at the household level. Data on the background of respondents, flooding, amount of loss suffered and adaptations for example were obtained by administering interview schedules to heads of households. Both close- and open-ended questions were used to elicit information on various themes. Binary 'No' and 'Yes' response questions were used for example to assess the physical and economic effects of floods on households. A five-point Likert scale (Likert, 1932) was used to assess psychological health-related effects of floods as well as flood risk perception of households. A Likert is a psychometric scale commonly used in questionnaires or interview schedules where respondents specify their level of agreement to a statement. The range of answers on the Likert scale provided a more nuanced response options than the categorical dichotomous Yes or No responses. In other words, the degree of agreement or disagreement gave more scope for understanding the varying shades of opinion, which is deemed superior to using yes or no (Dawes, 2008).

The interview guide was used to collect qualitative data from household respondents and key informants in the form of either one-on-one in-depth interview or focus group discussions (FGDs). Two focus group discussions made up of eight (8) discussants each were held in each of the communities covered at locations convenient to both the participants and the researchers. The two focus groups in each community being gender-based, included adult men and women discussants. Discussions covered specific themes and included respondents' views, feelings and perceptions on a wide range of issues regarding the locational choices they make, effects of floods, as well as matters relating to vulnerability, adaptation and coping strategies. In the KMA, interviews were conducted in Twi (the main local dialect) while in the Gonja District it was conducted in Dagbani, Gonja and Ewe and later transcribed into English for analytical purposes. However, English was used where the interviewees opted for it. Discussions ended when a point of saturation was reached and when no new issues seemed to arise. All interviews and related discussions were tape-recorded. In addition, interviews were recorded in the field notebook which enabled one to cross-check this later with the recorded version for consistency. One-on-one interviews were conducted with key informants as well as individual households in Kumasi Metropolis and Central Gonja.

The study also employed direct observation as a method of gathering data using observation checklist. This involved observation of the nature and quality of buildings, location of buildings, proximity to storm drain outlets and waterbodies, drainage characteristics of the study communities, general sanitation among others. Observed phenomena were captured with a digital camera and presented in the final report as plates. The interview schedule and other instruments were developed after a thorough and extensive literature search on all issues relevant to the research and taking into consideration the specific objectives of the research and the relationships to be established. Field testing (or pre-testing) of all research instruments were carried out. The purpose was to identify problems associated with the instruments and so afforded one the opportunity to revise some portions of the instruments before the actual survey. One area of focus was whether specific questions were clear and unambiguous and that the potential respondents would have no difficulty understanding or interpreting them.

Other areas of concern included whether the questions were of the right length, time required to administer the instruments, respondents' willingness to answer specific questions, correctness of sequence of questions, response rate, adequacy of spaces for responses and so forth. The pre-testing was necessary because as Backstrom and Hursch (1963) have pointed out, there is no amount of intellectual exercise that can substitute for testing an instrument designed to communicate with ordinary people. As is the rule, the pre-test of the instruments was not carried out on the sample of population studied. The Aboabo and Sepe Dote were selected for the pre-testing exercise. The selection of these two communities was premised on the fact that they are also flood-prone and having population with characteristics similar to those of the actual study population.

The researcher also ensured that the test items of the research instrument (interview schedule) were valid and reliable. Content validity was ensured as the questions of the structured interview were theoretically defined and situated within the appropriate literature on flood risk perception, vulnerabilities and adaptation measures in rural and urban context. The researcher employed triangulation technique to cross-check the information gathered from variety of sources with varied methods. The data collected through the structured interview were also cross-checked with those obtained from the key informant interviews and focus group discussion to ensure accuracy and internal consistency. Besides, the reliability statistics using the Cronbach's alpha which is widely used in the social sciences was also employed to ascertain the internal consistency of the test items of the research instrument. The Cronbach's alpha coefficient of .89 was obtained giving an indication of a good internal consistency i.e. 89% of the test items in the scale. This alpha value (.89) obtained falls within the acceptable range of .70-.99 as proposed by Fraenkel and Wallen (1996).

Ten field research assistants and three supervisors were engaged to assist in the pre-testing and the actual field data collection. They were selected from among the Teaching/Research/Graduate Assistants within the Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi. In the Central Gonja, field assistants included some Teaching Assistants, some graduate teachers and students. The selection or recruitment process was rigorous and one basic criterion for selection was experience in social science field research. In spite of the stringent selection process, further training was offered to all the field research assistants and the supervisors in order to acquaint them with the demands and expectations of the research as well as the responsibilities of all participants. Whilst the interviewers were responsible for the conduct of all face-to-face interviews, the field supervisors were required to manage and supervise the fieldwork. These field supervisors were charged with the responsibility of ensuring that the field assistants adhered strictly to the tenets of scientific research as applied to the current research and agreed on by the team. Sampling procedures regarding the selection of houses and respondents for example were followed to the letter. Besides, the supervisors offered immediate assistance to the research assistants in the event of any problem arising during the field data collection. Finally, the supervisors were responsible for inspecting the completed questionnaires at the end of each day. The training session that lasted about 3 days afforded the research team to go through the instruments one-by-one to ensure a common understanding of the questions and consistency in the interpretation.

Concerning spatial data, ground-referenced spatial information was collected with a Global Position System (GPS) apart from the use of satellite images, land use and topographical maps of Kumasi.

3.8 Data Processing and Analysis

3.8.1 Household data analysis

The quantitative primary data were critically and carefully verified for accuracy, gaps and consistency. The data were cleaned, coded and entered into an electronic database and analysed using IBM SPSS (Version 21) and Microsoft Excel 2010. Both descriptive and inferential statistics were employed. Bivariate and multivariate techniques were used. Cross-tabulation were used to show the relationships between dependent and predictor variables. Logistic regression has been used to assess how well the study predictor variables explain categorical dependent variables. A non-parametric Pearson's Chi-square (χ^2) tests of hypotheses were carried out. Data has been organised and presented using tables and proportionate counts. Bar and pie charts have also been used to depict and present data.

The qualitative data obtained from the various categories of interviewees were analysed within thematic analytical framework, a method for identifying, analysing, organising, describing, and reporting themes found within a data set (Braun and Clarke, 2006; Nowell et al., 2017). This analytical method involved several steps. In the first place, the audio recordings were transcribed into English. This was followed by meticulous reading of the transcripts, field interview and observational notes in order to familiarise oneself with the data. Following this, the transcribed interviews were exported to NVivo 9 analytical software, during which deductive and inductive coding of data were done. Codes are labels, assigned to whole or potions of transcripts and interview notes for the purpose of cataloguing key concepts (Miles and Huberman, 1994). During coding, the researcher identified key sections of the text to which labels were attached in order to index them because they related to a theme or an issue in the data. The coding process continued to a theoretical saturation point. At this stage of the data analysis, no new concepts emerged from further coding of data. The third step began when all data were initially coded and collated and a list of the different codes identified across the data set was developed. Step three mainly involved sorting and collating all the potentially relevant coded data extracts into themes. The fourth step began after obtaining the set of themes that required refinement. At this stage, the coded data extracts were reviewed theme-by-theme in order to ascertain whether they formed a coherent pattern. The validity of each theme was considered to determine whether each appropriately or accurately reflect the meanings captured in the whole data set. This made it possible for identification and correction of all inadequacies in the initial coding and themes. Next, themes were defined and named to give readers a sense of what it is exactly about. The story that each theme tells was then identified followed by a detailed analysis of each individual theme. The final thematic categories identified and sub-categories have been presented as narratives (storylines) while making sure that no distortion or misrepresentation occurred regarding the perspectives of the research participants. Direct or verbatim quotations from interview transcripts were used to illustrate relevant themes where necessary.

3.8.2 Analysis of rainfall data

The MAKESENS and time series plots were used to detect the monotonic trend of the rainfall data. These data were analysed using various descriptive statistics to reveal the trends and patterns of these variables. Specifically, the Mann-Kendall test (Z) and Sen’s slope (Q) were used. The Kendall’s tau and the Sen’s slope have been used to determine the direction and level of trend in the time series climate data (Campion and Venzke, 2013). The alpha level was set at 0.05. The time series plots, trend line and the trend equation were used as proxies in determining whether there is a monotonic trend of the climatological data in Kumasi Metropolis and the Central Gonja District.

As a method, Mann-Kendall test is used to ascertain whether or not there is a trend in a certain time series data. The data values are evaluated as an ordered time series. Each data value is compared to all subsequent data values. The initial value of the Mann-Kendall statistic, S, is assumed to be 0 (for example, no trend). As a non-parametric test, the Mann-Kendall tests the data randomness against time. Let X_1, X_2, ..., X_n be a sequence of measurements over a period of time, Mann proposed to test the null hypothesis, H_0, that the data come from a population where the random variables are independent and identically distributed; and therefore having no trend. The alternative hypothesis, H_1, is that the data follow a monotonic trend over time. Under H_0, the Mann–Kendall test statistic is: under the hypothesis of independent and randomly distributed variables, when $n \geq 18$, the S statistic is approximately normally distributed, with zero mean and variance in equations 1—4 as follows:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}\left(X_j - X_i\right) \quad ....1$$

Where $$Sgn(\theta) = \begin{cases} +1......\theta > 1 \\ 0......\theta = 0 \\ -1......\theta < 1 \end{cases} \quad .... 2$$

$$\sigma^2 = \frac{n(n-1)(2n+5)}{18} \quad ....3$$

In this regard, the standardised Z statistics follow a normal standardised distribution as follows:

$$Z = \begin{cases} \dfrac{S-1}{\sigma} \; if \; S > 0 \\ 0 \;\; if \; S = 0 \\ \dfrac{S+1}{\sigma} \; if \; S < 0 \end{cases} \quad ....4$$

The hypothesis that there is no trend is rejected when the Z value computed in Equation (2) is greater in absolute value than the critical value $Z\alpha$, at a chosen level of significance α.

The true slope of the linear trend, Q (change in rainfall per year), can be estimated using nonparametric Sen's method (Gilbert, 1987). The Sen's method employs a linear model to estimate the slope of a linear trend. The method of calculating the Sen's slope estimator used a time series of equally spaced data. Sen's method proceeds by calculating the slope as a change in measurement per change in time, as shown here in equation (5):

$$Q = \frac{X_j - X_i}{j - i} \qquad \text{.....................................} \; 5$$

Where: Q = slope between data points X_j and X_i

X_j = data measurement at time j

X_i = data measurement at time i,

j = time after time i,

X_j and X_i constitute the pairs of observations identified by place in the series. The median of these estimates is Sen's estimator of slope.

While Mann-Kendall test is insensitive to outliers, it also gives an efficient computation of slope. Besides, it can be significantly more accurate than simple linear regression for rainfall data which may be skewed and heteroscedastic (Campion and Venzke, 2013). The Mann-Kendall trend test is noted for its robustness, simplicity and amenability to missing values (Mann, 1945). Being a non-parametric test, it does not require the data to be normally distributed.

3.8.3: Satellite image processing and analysis

Using the district boundary shape file in ArcGIS 10.2 software, the Landsat Thematic Mapper (TM) 1986, Enhanced Thematic Mapper Plus (ETM+) 2004 and Landsat 8 Operationalised Landsat Imager/ Thermal Infrared Sensor (OLIS/TIRS) 2016 images obtained were subsetted for KMA. The images were then loaded into ERDAS imagine 2013 software for image pre-processing using bands 4, 3, 2 and 5, 4, 3 in false-colour composite, for visualisation for the TM/ETM+ and the OLIS/TIRS images respectively. These bands were chosen because of the spectral properties which show high reflectance of green vegetation as they are chlorophyll absorbing bands (Lu *et al*., 2015). Specifically, bands 2 and 3 were used because they produced distinct spectral signatures for vegetation which is needed for analysis. Band 4 is a near infra-red band which shows contrast between vegetation and soil and band 5 which is a mid-infrared band helped to differentiate between vegetation and built-up/bare areas for easy image classification. For all the dataset, level 1 data which has been geometrically corrected to Universal Traverse Mercator (UTM) by USGS was obtained. For the Radiometric correction, Top of Atmosphere (ToA) reflectance and Dark Object Subtraction (DOS) were applied to all the images. Also, line correction was performed on the 2004 image to correct for the Scan Line Corrector (SLC) error before applying the radiometric corrections.

Maximum likelihood supervised image classification algorithm was used to classify the three images because of *a prior* knowledge of the area and its popularity and accuracy in classification. As one of the well-known parametric classifiers, maximum likelihood classification has the advantage of taking into account the variance–covariance within class distributions and performs better than other known parametric classifiers for normally distributed data (Otukei and Blaschke, 2010).

Accuracy assessment of classified imagery was done by comparing identified point locations such as urban/built-up areas, arable land and vegetation on the classified imageries with the referenced coordinate samples for these features. A total of 308 referenced points were used for the assessment. The ground referenced data for 2004 and 2016 images were delineated using on-screen digitising method by drawing polygons around identified land cover classes that fall into similar pixel spectral characteristics on Google Earth and on the raw image for 1986. For the 2016 image, Etrex garmin GPS was used to collect point data in geographic coordinates from sites in addition to samples extracted from Google Earth and loaded onto the classified imagery for accuracy assessment. A confusion matrix was obtained from which the overall accuracy was calculated for each classification. The overall accuracy was determined by dividing the total correct (i.e., the sum of the major diagonal) by the total number of pixels in the error matrix. The accuracies of the individual land uses were also computed in a similar manner but in this case using total number of pixels in the corresponding row or the corresponding column. From the producer's and user's errors, the omission and commission errors were computed. The areal extent of each LULC type of each of the three images were analysed quantitatively in hectares to show the changes that have occurred over the period.

The results of the 1986, 2004 and 2016 satellite images as classified for Kumasi Metropolis, were broadly put into three classes: farmland, urban, and vegetal cover. The results analysed quantitatively in hectares on comparative basis to assess the pattern of change. According to Stefanov *et al.* (2001), one of the major confounding factors accounting for poor classification accuracy in urban areas is its heterogeneous nature. While it is recognised that KMA is characteristically complex and heterogeneous in terms of land use and cover types, the three classes indicated above are enough, appropriate and relevant given the focus of this research.

3.8.4: Digital elevation Model and drainage network

Digital Elevation Models (DEMs) were used to show the relief of the study areas from which the stream networks were derived. DEM is a digital representation of the Earth's relief that consists of an ordered array of elevations relative to a datum, and referenced to a geographic coordinate system (Forkuo, 2010). DEMs are the main source to produce information of land topography and provides elevation information that is useful for many environmental applications including hydrologic modelling and flood management planning (McDougall et al., 2008). The stream networks were derived from the DEM by using the hydrology tools in Arc toolbox. First, the depressions or sinks were filled using the fill tool to help improve the accuracy of the representation of the direction of flow across a surface. After the filling, a flow direction raster was created from the 'Filled DEM' to determine the direction of flow from every cell in the raster. Having obtained the flow direction data, a flow accumulation raster was created which was then used to generate the drainage network based on the direction of flow of each cell. Drainage network was delineated by applying threshold values to the results of the flow accumulation. The accumulation raster was then converted to vector (polylines).

3.9 Ethical Issues

Ethical issues were addressed in line with the Declaration of Helsinki (World Medical Association, 1964) before data collection began. It has been established, that it is the responsibility of the researcher to protect the life, health, privacy and dignity of the human subject (Carlson et al., 2004; Delamonthe and Smith, 2004). Israel and Hay (2006) indicate that Social Scientists do not have an inalienable right to conduct research involving other people.

Ethical clearance (Ref: CHRPE/AP/548/17) for fieldwork was obtained from the Committee on Human Research, Publications and Ethics, School of Medical Sciences at Kwame Nkrumah University of Science and Technology (KNUST) and Komfo Anokye Teaching Hospital (KATH), Kumasi. Besides, participation in the study was made voluntary. Nobody was coerced into providing information. The purpose of the research was also clearly explained to the participants.

Informed written and verbal consents were sought from all research participants. Informed consent according to Berg (2001) means the knowing consent of individuals to participate in an exercise of their choice, free from any element of fraud, deceit, duress, or similar unfair inducement or manipulation. Individual respondents/participants were requested to sign or thumbprint a written informed consent form that were read out clearly to them. Those who felt uncomfortable signing or thumb printing the written consent form for whatever reason were given the option to give verbal consent. The individual's right to decline to participate was respected in this study. The established agreement did not place the respondents/discussants under the obligation to continue participating in the project where they showed reluctance to continue. In this regard, they were made aware of their right to withdraw if they so wished at any stage.

To protect the identities and anonymity of participants, only pseudonyms were used in the analysis and presentation of data. Actual names of participants were not required. Research participants were assured of the confidentiality of information. The participants were therefore assured that all information received from them would be held in the strictest confidence. Opinion leaders and traditional rulers were briefed on the main purposes of the study and the necessary permissions were sought before data collection commenced. The respondents were also afforded an opportunity to ask questions. The research was conducted with respect and concern for the dignity and welfare of the informants.

3.10 Summary

This chapter employed a concurrent triangulation mixed method design involving the triangulation of quantitative and qualitative methods, using both primary and secondary sources of data. Secondary data included satellite images and rainfall data from the Ghana Meteorological Agency (Gmet). A survey of eight communities from KMA and eight communities from rural Gonja were undertaken. Data from household survey were analysed using appropriate statistical tools in IBM SPSS (Version 21) and Microsoft Excel 2010 for quantitative data and NVivo 9 qualitative data analysis software for the qualitative data.

Satellite images were analysed using ERDAS imagine 13 remote sensing and ArcGIS 10.2 geo-information software. Digital Elevation Models (DEMs) of the study districts were used to show the relief of the study areas from which the stream networks were derived. MAKESENS and time series plots were used to detect the monotonic trend of the rainfall data with data analysed using the Mann-Kendall test (Z) and Sen's slope (Q) tests. The next chapter deals with the profile of the study communities.

CHAPTER FOUR

BACKGROUND CHARACTERISTICS OF KUMASI METROPOLITAN AREA AND THE GONJA DISTRICT

4.1 Introduction

Chapter three presented the design, methods and procedures by which data was gathered and analysed. This chapter presents the profile of Kumasi Metropolis and the Gonja District where the study was conducted. It addresses the physical (the location, extent, climate, drainage, soil and geology), demographic and socio-economic characteristics of the study areas. This is mainly derived from secondary sources of data obtained mainly from the metropolitan and district assemblies. The chapter starts with the profile of Kumasi Metropolis and followed by that of the Gonja District.

4.2 Kumasi metropolis

4.2.1 Physical characteristics and natural environment

4.2.1.1 Location and size

Kumasi Metropolis is one of the forty-three (43) administrative districts in Ashanti Region. It stretches between latitude $6^0 35'$ – $6^0 40'$N and longitude $1^0 30'$ – $1^0 35'$W, on an elevation between 250 and 300 metres above sea level (GSS, 2014a). To the north of the Metropolis lie Kwabre East and Afigya Kwabre Districts, to the west, the Atwima Kwanwoma and Atwima Nwabiagya Districts, to the east, Asokore Mampong and Ejisu-Juaben Municipality and lying south of the Metropolis is Bosomtwe District. (see Figure 4.1). It is approximately 270km north of the national capital, Accra. It has a surface area of approximately 214.3 square kilometres, which is about 0.9% of the region’s land area. However, it accommodates about 36.2% of the region’s population.

The Metropolitan is divided into nine sub-metropolitan areas (now four sub-metros) and include Bantama, Suame, Manhyia, Tafo, Kwadaso, Nhyiaeso, Subin, Asokwa, and Oforikrom (GSS, 2014a).

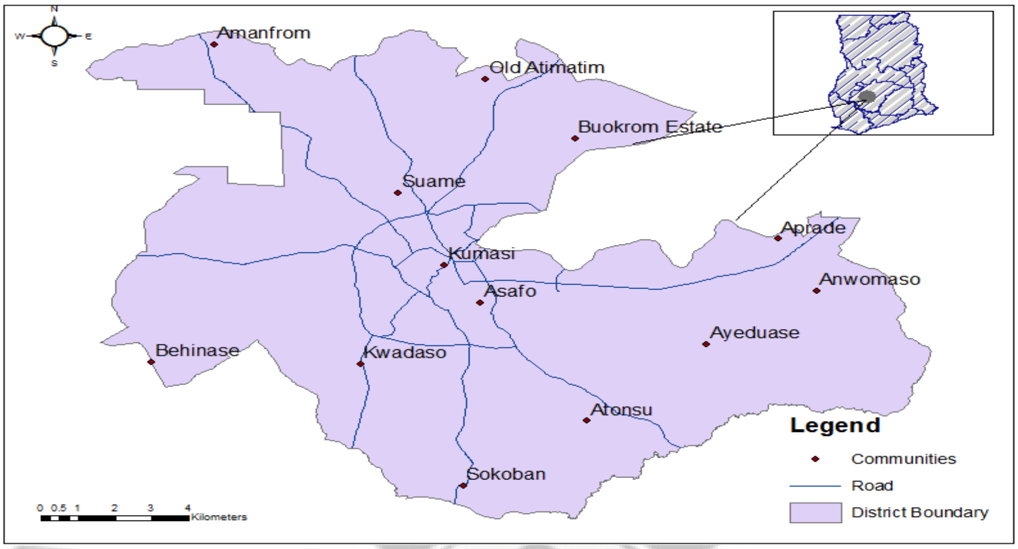

Figure 4.1: Map of Kumasi Metropolis

Source: GERGIS, UG, Legon (2017)

4.2.1.2 Geology and soil

The Kumasi Metropolitan area is dominated by the Middle Precambrian Rock. There are a few small-scale mining activities and the proliferation of stone quarrying and sand winning industries that have resulted in environmental degradation. The major soil type of the Metropolis is the forest ochrosols. The detailed soil associations are the following: Kumasi-Offin Compound Association; Bomso-Offin Compound Association; Nhyanao-Tinkong Association; Bomso–Suko Simple Association; Bekwai-Oda Compound Association and Bekwai-Akumadan-Oda Compound Association (Abass, 2009; Amoateng et al., 2017). These physical conditions, as Amoateng et al. (2017) noted, have not particularly been linked to floods in the

Metropolis.

4.2.1.3 Climate and vegetation

The Metropolis falls within the wet sub-equatorial climatic region with average minimum and maximum temperatures of about 21.5˚C and 30.7˚C respectively. It has an average humidity of about 84.16 % at sunrise and 60 % at sunset. Temperature and humidity are moderate with double maxima rainfall regime [214.3mm in June and 165.2mm in September] (GSS, 2014a). The mean annual rainfall is between about 1250 and 2000 millimetres. The dry season is experienced from November to early March (GSS, 2014a). The Metropolis therefore falls within a climatic region the experiences heavy rainfall which may partly account for perennial floods.

The Metropolis lies within the moist semi-deciduous forest. However most of its vegetative cover is lost to rapid urban expansion which, a situation that may have accounted for frequent flood occurrence in the Metropolis (GSS, 2014a).

4.2.1.4 Relief and Drainage

Kumasi Metropolis lies within the plateau of the South–West physical region ranging from 250-300 meters above sea level and characterised by undulating topography. Several streams and rivers traverse the Metropolis including Owabi, Aboabo Subin, Sisa, Wiwi and Nsuben. These streams have however come under human threat due to uncontrolled urban expansion. Building in waterways and dumping of wastes of all kinds into these waterbodies have exacerbated flood situation in the Metropolis (GSS, 2014a).

4.2.2 Demographic and Socio-economic characteristics

Kumasi Metropolis had population of 346,336, 487,504 and 1,170,270 in 1970, 1984 and 2000 respectively. The 2010 population figure was 1,730,258 which was about 36.2% of the total population of Ashanti Region (GSS, 2014a). This makes the Metropolis the most populous and most rapidly growing urban area in Ghana. Its share of the Ashanti regional population went up from 32.4% in 2000 to the current 36.2% in 2010 (GSS, 2014a). The population of migrants according to the 2010 Population and Housing Census stood at 929,203 people and represent 53.7% of the total population of the Metropolis (GSS, 2014a). The metropolis is densely populated with a density of 8074 persons/km^2. Kumasi Metropolis has total household population of 1,674,862 with 440,286 households, with an average size of households being 3.8 persons. About 60.8% of households are headed by males. The Metropolis is fully urbanised. Out of a total number of 1,303,168 of persons aged 11 years and older, 89.5% are literate.

Kumasi is a hub for commercial activities in the country offering also variety of services. Majority (86%) of the active population in Kumasi are economically active. Majority (72%) of the economically active labour force are employed in the commercial and service sector. Agriculture in Kumasi consists of farming, aquaculture, horticulture and some animal rearing. Farming is limited to small scale staple crops production including maize, plantain, cocoyam, cassava and vegetables, both traditional and exotic types. Out of a total number of 1,267,685 of the population aged 12 years and older at all the different categories of economic status, 706,404 (55.7%) are employed, 66,327 (5.2%) are unemployed while 494,954 (39.0%) are economically not active. The Metropolis is a hub for scattered pockets of industrial activities in the country.

Management of solid waste is a challenging issue. Indiscriminate waste disposal has negative consequences for public health, the environment and flood management. Development in waterways and urban agricultural practices partly explain the frequency of floods in the Metropolis (GSS, 2014a).

4.3 The Central Gonja District

4.3.1 Location and size

The Central Gonja District is located at the south-western part of the Northern Region of Ghana and lies within longitude 1˚5' W and 2˚58' W and latitude 8˚32' N and 10˚2' N with Buipe as its district capital. The district shares boundaries with the Kintampo North Municipality of the Brong Ahafo Region to the south, the West Gonja District to the west, the Tamale Metropolis to the north, the Tolon District to the Northwest and the East Gonja District to the east (see Figure 4.2). The District covers approximately 7,555km^2 which represents 11.0 % of the total land area of the region (GSS, 2014b).

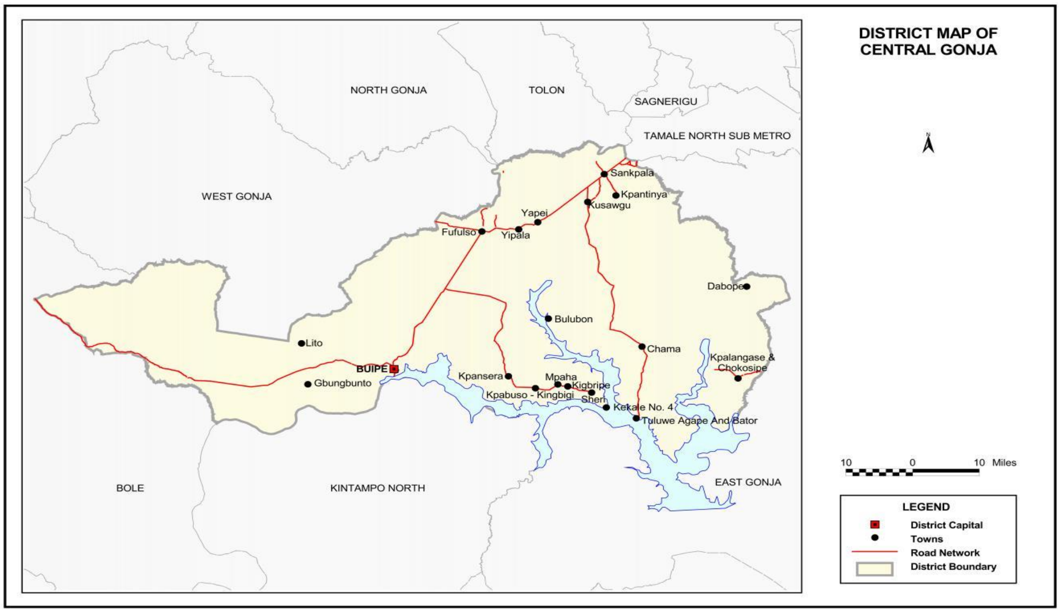

Figure 4.2: Map of Central Gonja District

Source: Ghana Statistical Service (2014b)

4.3.2 Weather and Climate

Central Gonja district experiences North East Trade Winds also known as the Harmattan Winds from the months of December to February which are characterised by cold nights and dry winds during the day time. Unlike Kumasi Metropolis, the District experiences extreme temperatures for greater parts of the year. The mean monthly temperature is 27℃ with the annual temperatures ranging from 17℃ to 35℃. The rains begin around May and ends in October. Unlike KMA, Central Gonja district experiences seasonal rainfall, characterised by a single maximum. The mean annual rainfall is about 1,144mm. The rainfall pattern is erratic, beginning in late April to late October. The period from June-August generally records the highest rainfall and also the greatest number of rainy days. The rainfall is characterised by thunder storms or sharp showers. The irregular distribution and short duration of the rainfall are a great limitation to crops and vegetative growth (GSS, 2014b).

4.3.3 Relief, geology and Drainage

The topography of the Gonja district is generally undulating with altitude of between 150-200 meters above sea level and situated in an old geological area. The district's generally low elevation may partly explain its vulnerability to floods. In the Central Gonja district, the rocks are mainly of the Voltaian formation of the Palaeozoic era, with isolated Cambrian rocks that consist mainly of sandstones, shales, mudstone and limestone. The formation consists principally of sandstones, shales, mudstones and limestone. Except at the eastern margin of this formation where there has been weak folding, the rocks are generally flat-bedded or horizontal. The presence of iron pan at shallow depths (Abass, 2009; Obeng, 2000) may give rise to flood conditions.

The district is traversed by two major rivers, the White Volta and the Black Volta which form the southern boundary of the Northern Region of Ghana and usually overflow their boundaries causing flooding (GSS, 2014b). These two rivers have been the main sources of floods in the Central Gonja.

4.3.4 Vegetation and soil

The natural vegetation of the District is Guinea Savannah. Its richness is however determined by the soil types. The major tree species are Sheanut, *dawadawa*, baobab, acacia, neem and some ebony. These trees are scattered except in most valleys where isolated wood land or gallery forest are found (GSS, 2014b). The original vegetation in major settlements such as Buipe, Yapei, Mpaha and Kusawgu has been destroyed by human activities such as bush fires, charcoal burning, slash and burn farming method and fetching of firewood (GSS, 2014b). The loss of vegetation can have implications for flooding as it increases surface runoff.

The groundwater lateritic soils are the most extensive in the district and are developed over both the Voltaian shales and granites. Their principal characteristic is the presence, at generally shallow depths below the surface of the soil, of a more or less cemented layer of ironstone, called iron pan, through which rainwater does not penetrate easily, a condition which has implications for flooding. Thus, the top layers of the soil become waterlogged right up to the surface in the rainy season but dry out in the dry season. Where the underlying iron pan is not a continuous sheet and therefore allows better downward drainage, waterlogging in the rainy season occurs only in the lower layers of the soil, just above the iron pan, and not right up to the surface (Abass, 2009).

4.3.5 Population and Household Characteristics

The population of Central Gonja District, according to the 2010 Population and Housing Census, is 87,877 representing 3.5% of the region's total population. Males constitute 49.9% and females represent 50.1%. About 80% of the population is rural. The district has a sex ratio of 99.6 which translates almost into equal number of males to females.

There are 12,041 houses in the district representing 4.7% of the total stock of houses in the region. There are more houses in the rural (9,631) than the urban areas (2,508) (GSS, 2014). The district has a household population of 86,432 with a total number of 11,413 households. The majority of these households however live in the rural areas. The average number of households per house for the district is about 1 while the average household size in the district is 7.6 persons per household (close to the regional figure of 7.7 members). Children constitute the largest proportion (50.8%) of the household members. This may suggest that these households would be vulnerable in the event of flood disaster (GSS, 2014b).

4.3.6 Economic Activities

The main economic activity of the people is agriculture involving food crop production, livestock and fish farming. Some of the crops cultivated are maize, sorghum, millet, groundnut, cowpea, soy beans, yam, rice, as well as cassava. Fishing and livestock are considered supplementary activities to crop farming. This explains why most of the settlements are located close to the Black and White Volta. Industrial activities undertaken in the district are large and small-scale agro-based industries such as Shea butter processing, rice milling, groundnut oil extraction and gari processing. Income from these economic activities is generally low, thus increasing their vulnerability in times of disaster (GSS, 2014b).

4.4 Summary

Kumasi Metropolis is one of the forty-three (43) administrative districts in Ashanti Region. It has varying socio-economic and physical characteristics. It is the fastest growing metropolis with a total population of 1,730,258, representing 36.2% of the total Ashanti regional population. Building on water courses by the expanding population partly explains the frequent occurrence of flooding in the Metropolis (GSS, 2014a).

The Central Gonja District is located at the south-western part of the Northern Region of Ghana. The district experiences seasonal rainfall, characterised by a single maximum. The Topography is generally undulating with the presence of iron pan at a lower depth, a condition which may give rise to floods. The area is traversed by the White Volta and Black Volta, the principal sources of fluvial floods in the district. Compared to KMA, Central Gonja district has a lower population of 87,877 representing 3.5% of the region's total population. The main economic activity in the district is agriculture. The next chapter focuses on the physical and human triggers of floods in rural Gonja and Kumasi Metropolis.

CHAPTER FIVE

UNDERSTANDING THE NATURAL AND HUMAN CONTEXTS OF FLOODS IN RURAL AND URBAN GHANA

5.0 Introduction

Chapter four presented the physical and socio-economic characteristics of KMA and Rural Central Gonja. This chapter analyses the physical and human factors that cause and intensify flooding in rural Central Gonja District and Kumasi Metropolis. In particular, the chapter examines socio-environmental factors that give rise to floods in rural and urban Ghana. It draws information from secondary and primary data to explain the spatio-temporal incidence of floods in Ghana.

5.1 Climatic factors and floods

5.1.1 Rainfall trend in Kumasi Metropolis

The Metropolis experiences the wet sub-equatorial climatic type characterised by moderate temperature and humidity with double maxima rainfall regime as described in the study area. The classical Mann-Kendall non-parametric trend test within the MAKESENS Software was used to analyse and determine the monotonic trend of annual rainfall in Kumasi Metropolis between the years of 1980 and 2016. It is evident from the trend analysis that annual rainfall has seen a marginal increase over the past three decades (1980-2016) (Figure 5.1).

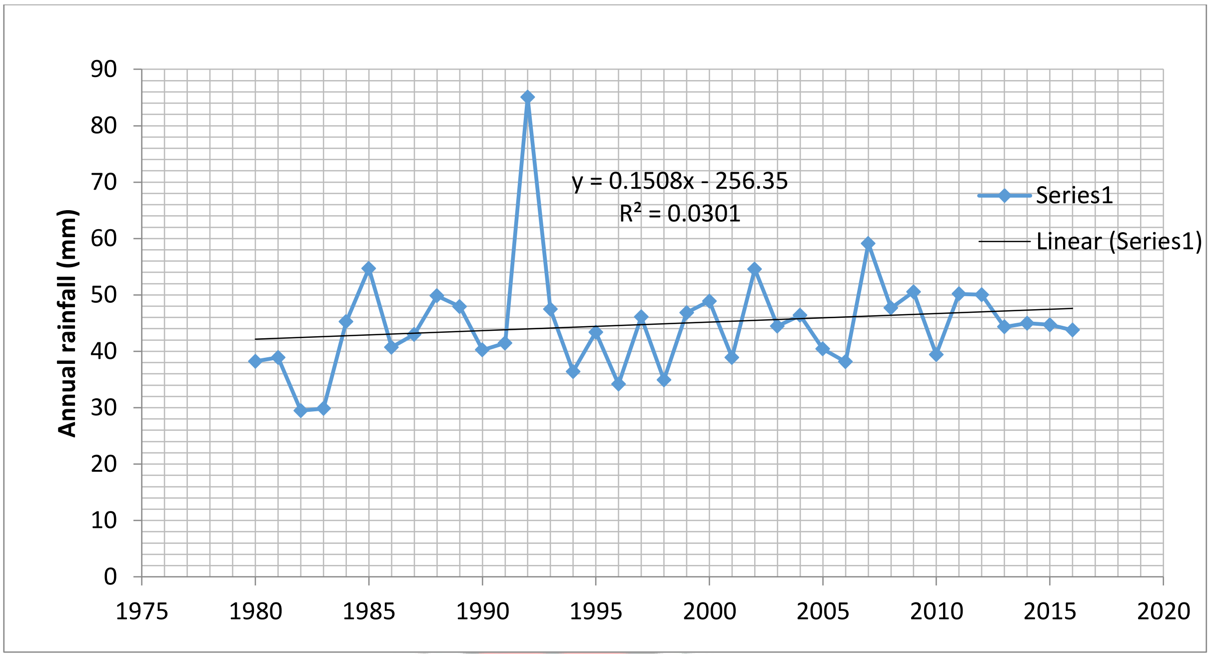

Figure 5.1: Annual rainfall trend in Kumasi Metropolis (1980-2016)

Source: Fieldwork (2017

From Figure 5.1, the Mann-Kendall trend statistics of the time series rainfall data in Kumasi Metropolis over the years (1980-2016) indicates a marginally positive increase in rainfall with several variability. The positive marginal trend is evident in the Kendall's tau value of 0.159 and a Sen's slope of 0.161. However, the probability value of 0.915 at alpha level 0.05 indicates that there is no statistically significant trend ($P>0.05$) in the rainfall pattern between 1980 and 2016 (Table 5.1). Again, on fitting the linear trend line, it is observed that the trend is increasing in the area of study under investigation. Also, the trend equation shows a positive trend of rainfall with a degree in rainfall variation ($R^2 = 0.0301$) of less than 1%. An increase in the years has the potential to increase the rainfall amount by 0.1508mm. Hence, the positive value of the slope (0.1508x) of the trend equation indicates an increase in the annual rainfall amount.

The monthly rainfall for June which is noted as the peak rainfall month, revealed an insignificant ($p>0.05$) decreasing trend ($-0.0377x$) with less than 1% degree of variation ($R^2 = 0.0024$) (Figure 5.2).

Table 5.1: Mann-Kendall trend statistics for rainfall in Kumasi Metropolis

Description	Rainfall Statistics
Kendall's tau	0.159
Mann-Kendall statistics (S)	100.000
Var(S)	5390.000
p-value (one-tailed)	0.915
alpha	0.05
Sen's slope	0.161
Confidence interval	0.127-0.214

Source: Fieldwork (2017)

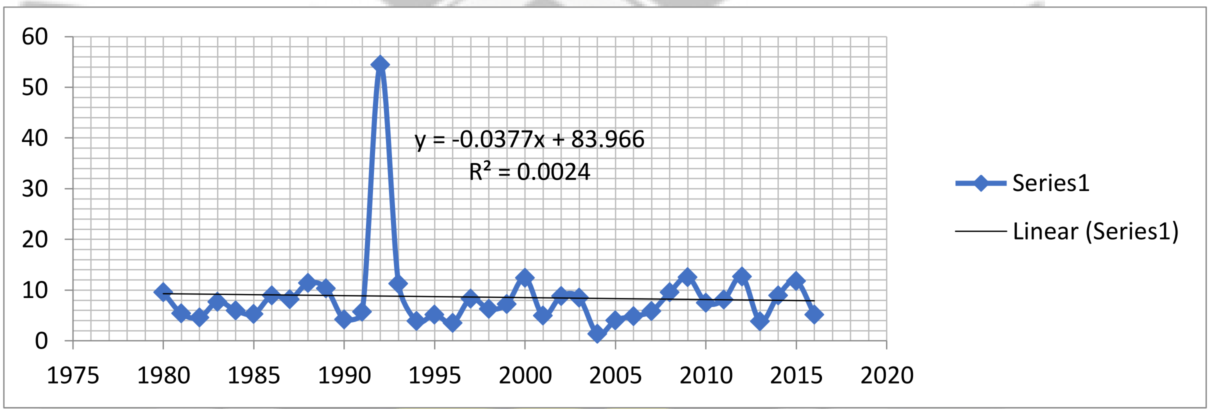

Figure 5.2: Rainfall events for the month of June in Kumasi (1980-2016)

Source: Fieldwork (2017)

5.1.2 Rainfall trend for Central Gonja District

The rainfall regime in the Central Gonja District is seasonal and unimodal. The rains begin around May and end in October. The mean annual rainfall is about 1,144mm with erratic rainfall pattern, beginning in late April to late October. The period from June to August generally records the highest rainfall and also the greatest number of rainy days (GSS, 2014b).

The Mann-Kendall non-parametric trend test within the MAKESENS Software was used to analyse the time series monotonic trend of annual rainfall in the Central Gonja District in the Northern Region from 1980 to 2016 at 5 percent significant level and a 95 percent confidence interval. The trend analysis shows a considerable decrease in the annual rainfall over the past three decades (1980-2016) (Figure 5.3).

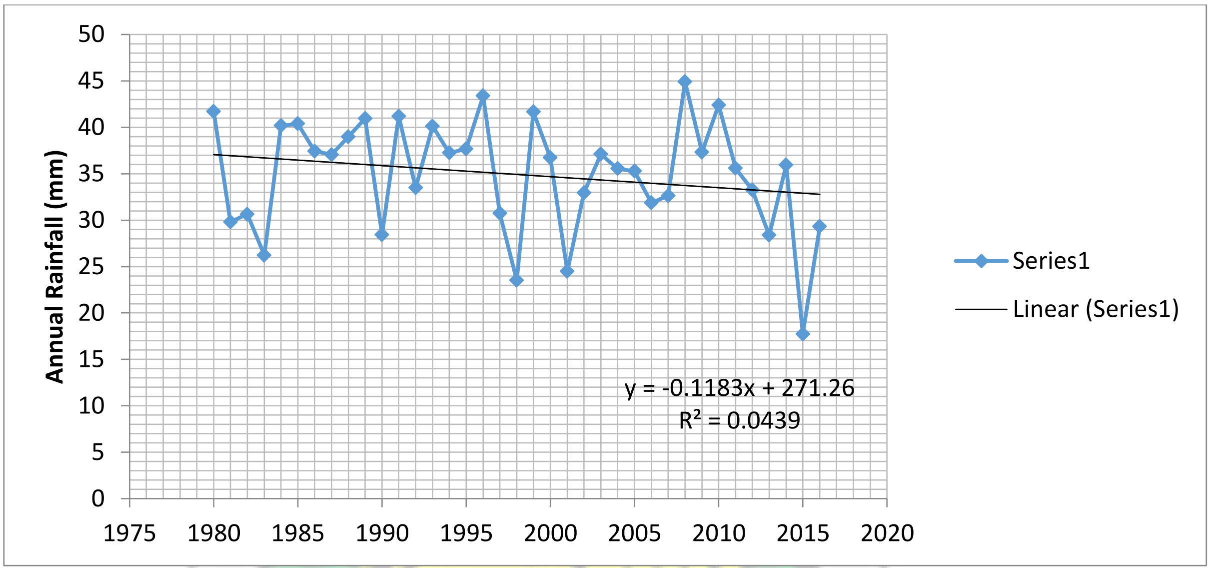

Figure 5.3: Annual rainfall trend in the Central Gonja District (1980-2016)

Source: Fieldwork (2017)

From Figure 5.3, the Mann-Kendall trend statistics of the time series climatological data (rainfall) in the Central Gonja District over the past three decades (1980-2016) indicates a decrease (negative) in rainfall with several variability. The negative trend is evident in the Kendall's tau value of -0.117 and a Sen's slope of -0.109. However, the probability value of 0.161 at alpha level 0.05 indicate that there is no significant trend (P>0.05) in the rainfall pattern over the period of 1980 and 2016 (Table 5.2). Again, the linear trend line and the slope of the trend equation (-0.1183) give an indication that the rainfall trend is decreasing in the Central Gonja District with a degree in rainfall variation ($R^2 = 0.0439$) of less than 1%. As the years increase by one, there is a corresponding decrease in the rainfall amount by 0.1183mm. Therefore, the negative value of the slope of the trend equation indicates a decrease in the rainfall amount in the district.

Table 5.2: Mann-Kendall trend statistics for rainfall in Central Gonja District

Description	Rainfall Statistics
Kendall's tau	-0.117
Mann-Kendall statistics (S)	100.000
Var(S)	5390.000
p-value (one-tailed)	0.161
alpha	0.05
Sen’s slope	-0.109
Confidence interval	-0.169- -0.065

Source: Fieldwork (2017)

The monthly rainfall for June which is noted as the peak rainfall month, revealed an insignificant ($p>0.05$) increasing trend (0.0126x) with a degree of variation ($R^2 = 0.0047$) of less than 1% (Figure 5.4).

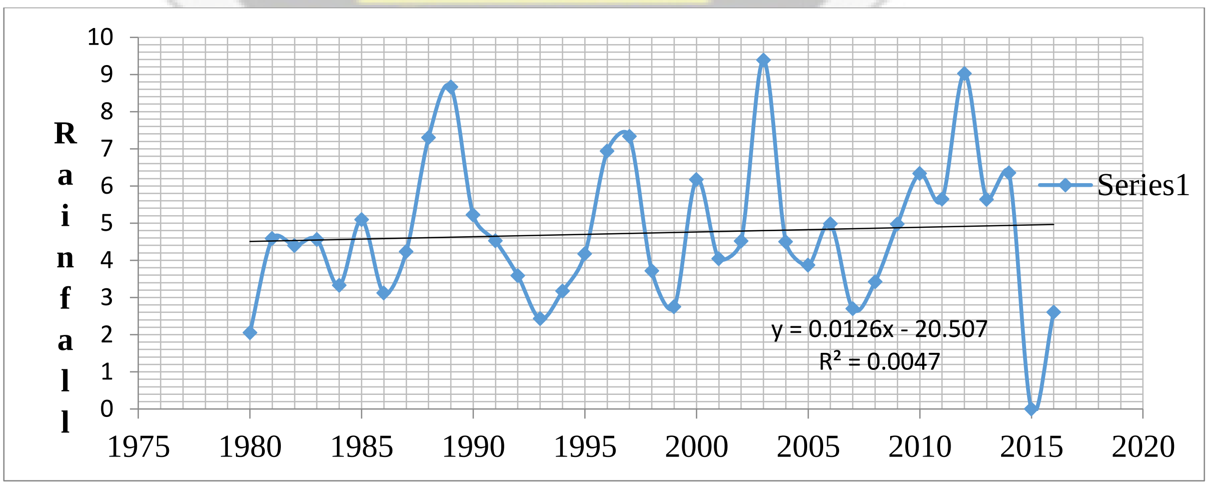

Figure 5.4: Rainfall events for the month of June in Central Gonja

Source: Fieldwork (2017)

5.1.3 Rainfall events and flood incidences in KMA and Central Gonja

Table 5.3 provides an interesting picture regarding the rainfall events and flood incidences in Kumasi metropolis. It specifically indicates the specific days on which floods occur, the amount of rainfall on flood days and days before the flood. Over the period, 33 flood cases were recorded in the Metropolis with June registering the maximum number of flood occurences (39.4%) (see Table 5.4).

Due to the challenge of establishing correlation between rainfall trends and flood cases, the amount of individual rainfall events on flood days and the amount of rainfall events on the day before flood between 2012 and 2016 were used as proxies to ascertain the relationship between rainfall events and the occurrence of flood in Kumasi Metropolis (Table 5.3). From the statistics, it is clear that the month of June registered the highest number of floods incidence (see Table 5.4).

It is also noteworthy that floods were experienced during and/or after moderate to heavy rainfall events, with a minimum of 24.6 mm of rainfall on flood day or 38.4 mm on the day preceding flood day needed to trigger floods in Kumasi Metropolis from 2012 to 2016 (see Table 5.3). A careful examination of daily rainfall data for Kumasi Metropolis from 2012 to 2016 (that is data from Gmet) shows that 87 out of the 556 rainfall events experienced during the period were potential flood triggers with at least 24.6 mm of rainfall (i.e., rainfall ≥24.6 mm) on flood day (see Table 5.5). In other words, 87 rainfall events should have resulted in floods in Kumasi between 2012 and 2016 if rainfall was the key cause of flooding in the city. Alternatively, 39 out of 556 rainfall events could potentially have caused floods the following day (i.e.,rainfall ≥38.4 mm) (see Table 5.5). In sum, 126 (39+87) rainfall events between 2012 and 2016 should have given rise to floods. From available floods record however, only 32 flood cases were recorded over the period (see Table 5.3). It may be argued that flood in the metropolis between 2012 and 2016 could be attributed to some other confounding non-climatic factors of anthropogenic origin rather than rainfall. This supports studies by Amoateng et al. (2017) and Campion and Venzke (2013) who found flooding in Kumasi metropolis to be influenced by bad spatial development practices and poor urban development planning respectively, other than rainfall variability in the metropolis.

Table 5.3: Rainfall events and reported floods in some suburbs of Kumasi, 2012-2016

*Flood day	**Amount of Rainfall on flood day (mm)	**Amount of rainfall on day before flood day (mm)
25-March-12	42.9	0.0
20-April-12	0.0	**38.4**
29-May-12	89.6	1.0
01-June-12	0.8	57.6
02-June-12	57.6	0.8
20-June-12	76.1	0.0
28-June-12	35.6	0.0
13-April-13	**24.6**	0.0
17-April-13	30.4	0.2
26-April-13	24.0	1.5
17- May-13	43.7	0.0
27-May-13	33.8	1.0
28-May-13	45.0	38.8
04-July-13	36.8	0.0
08-Sept-13	28.0	1.6
25- Sept -13	0.0	51.2
06-Oct-13	50.3	0.0
08-Oct-13	38.2	0.0
23-March-14	42.9	3.9
06-June-14	97.4	20.2
23-June-14	41.1	10.5
16-June-14	1.5	54.5
08-April-15	38.2	22.7
02-June-15	76.2	0.6
04-June-15	22.2	32.6
05-June-15	43.2	22.2
06-June-15	15.0	43.2
13-July-15	0.0	48.9
12-March-16	32.1	5.5
16-June-16	77.4	0.0

10-Sept-16	53.8	0.1
11-Sept-16	77.1	53.8

Source: *Compiled from NADMO, Kumasi (2017)
** Ghana Meteorological Agency (Gmet), Accra

Table 5.4: Flood incidence by month in KMA (2012-2016)

Month	Flood incidence/events	Proportion of total events (%)
March	3	9.4
April	5	15.6
May	4	12.5
June	**12**	**37.5**
July	2	6.3
Sept	4	12.3
October	2	6.3
Total flood cases	**32**	**100.0**

Source: Compiled from NADMO, Kumasi (2017)

Table 5.5: Rainfall events and potential flood triggers, KMA

Year	**Number of rainfall events**	**Potential flood triggers**	
		Number of rainfall events (≥24.6 mm)	Number of rainfall events (≥38.4 mm)
2012	114	20	9
2013	119	19	6
2014	118	17	9
2015	102	15	8
2016	103	16	7
Total	**556**	**87**	**39**

Source: Compiled from Gmet, Accra

In the rural Central Gonja, records show that floods have been associated mainly with the dual factors of heavy rainfall and spillage of the Bagre dam. Table 5.6 shows flood days as against rainfall statistics in 2010, the reference year for the study. If a minimum of 5.6 mm of rainfall a day before floods day was enough to trigger the 2010 Central Gonja flood disaster, then it is hard to understand why the staggering rainfall statistics as shown in Table 5.7 could not have generated floods. This evidence further weakens the strength of any argument about the 2010 Central Gonja flood disaster that makes a single attribution to heavy rainfall within Central Gonja. This corroborates the study of Bawa et al. (2015) who found that the principal indicator of flood in the Central Gonja district is the spillage of the Bagre Dam in Burkina Faso which is normally opened to ease pressure on the river wall.

Table: 5.6: Floods incidence by month in Central Gonja (2010)

*Flood day	**Amount of Rainfall on flood day (mm)	**Amount of rainfall on day before flood day (mm)
09-Aug.-10	1.6	1.5
04-Sept-10	0.0	5.6
12-Oct-10	89.6	1.0

Source: * NADMO (2010) Central Gonja   **Gmet (2017), Accra

Table 5.7: Rainfall statistics, Central Gonja (2010)

Rainfall day	Rainfall (mm)
12-Feb-10	34
22-April-10	34.3
05-April-10	40.5
01- May-10	34.4
07- May-10	43.0
03- June-10	54.4
16-June-10	99.3
05-July-10	40.7
10-Aug-10	61.5
20- Aug-10	31.9
08-Sept-10	35.8
11- Sept -10	46.0
14- Sept -10	46.3
22- Sept -10	37.8
04-Oct-10	47.6
22-Oct-10	37.9
24-Oct-10	31.2
31-Oct-10	30.5

Source: Compiled from Gmet (2017), Accra

The respondents somewhat had different views. Results show that 46.4% of the respondents attributed floods in Central Gonja to heavy rainfall while 28.7% placed it at the door step of the opening of the Bagre dam (see Table 5.8). Other causes from the perspective of households include building in waterways and waterlogged areas, development along river banks and siltation of river channel. An in-depth interview with the Central Gonja District NADMO Co-ordinator further supports the position of the household respondents. The officer had this to say:

> *Central Gonja is a disaster-prone area as communities, mostly fishing localities, are found along the two main rivers – Black and White Volta. Rainfall and the opening of Bagre and other dams in Burkina Faso are the principal causes of floods in the district. Farming along the Black and White Volta could cause siltation of the rivers due to erosion of cleared (bare) agricultural land into these rivers (NADMO-Gonja, 2017).*

From the perspective of rural Gonja respondents, floods in the district are the result of heavy rainfall that causes the level of water in the Black and White Volta to rise. This results in these rivers overflowing their banks inundating low-lying communities dotted along them. This and the spillage of dam water upstream in Burkina Faso underlie the flood cases in the district. Similar to the rural household perspective, the two main causes of floods from the point of view of urban respondents were prolonged heavy rainfall (30.1%) and choked drainage systems (20.5%) as shown in Table 5.8.

Table 5.8: Respondents' views on causes of floods in their communities

Causes of causes	Rural		Urban	
	Freq.	%	Freq.	%
Building in waterways	22	2.8	89	7.1
Building in waterlogged areas/wetlands	75	9.5	75	6.0
Building too close to river bank	9	1.1	63	5.0
Choked gutters/storm drains	-	-	257	20.5
Inadequate storm drains	-	-	225	17.9
Prolonged heavy rainfall	367	46.4	380	30.1
Opening of the Bagre dam	227	28.7	-	-
Siltation of river channel	91	11.5	159	12.7
Urbanisation/urban expansion	-	-	8	0.6
***Total =Multiple response**	791	100.0	1256	100.0

Source: Fieldwork, 2017

5.2 The role of other natural factors in the rural and urban flood dynamics

Aside rainfall, there are many other physical conditions that may explain the intensity and severity of floods in a particular location. Research has shown that the peak discharge of a flood is influenced by many factors. Aside the intensity and duration of storms, the topography and geology of stream basins, vegetation, and the hydrologic conditions preceding storm events can affect the peak discharge of a flood (Konrad, 2003). Topography and soil conditions can be influential factors in the exposure to and incidence of flash floods since they affect the quantity and extent of overland flow (Amoateng et al., 2017; Okyere et al., 2012).

In the Central Gonja district, the rocks are mainly of the Voltaian formation of the Palaeozoic era, with isolated Cambrian rocks. The formation consists principally of sandstones, shales, mudstone and limestone with ironstone impregnations. The presence at shallow depths below the surface of the soil, of a more or less cemented layer of ironstone, called iron pan, through which rainwater does not penetrate easily

(Abass, 2009; Obeng, 2000) may give rise to flood conditions. The highest points of the Central Gonja District are 150-200 meters above sea level (GSS, 2014b). Figure 6.1 (chapter 6), produced using Digital Elevation Model (DEM) for the district however gives comparatively a wider range of 39-294 metres. The relief within the belt ranges from flat to gently undulating lowland. The generally flat area makes it possible for rising water levels in the Black and White Volta to travel fast and far inland. It is not surprising therefore to find houses in Kikali No. 4 and Debri Port, over 300 metres away from the banks of the Black Volta completely pulled down by the riverine floods.

Kumasi Metropolis is dominated by the Middle Precambrian Rocks within the plateau of the South-West physical region which ranges between 250-300 metres above sea level (GSS, 2014a). The topography is generally undulating. Analysis of the relief using Digital Elevation Model (DEM) reveals that the topography is generally undulating, with inselbergs separated by lowlands characterising greater part of the landscape. Elevations range from 206 metres to 315 metres above sea level (see Figure 6.2). Slopes are generally gentle, which in most cases are less than 5 percent (Amoateng et al., 2017). Precisely, due to its location within the forest dissected-plateau physiographic region of Ghana and its associated heavy rainfall and forest vegetation which prevents sheet erosion, the landscape of the Metropolis is dominated by flat topped ridges, that form interfluves (Abass, 2009). The major soil type of the Metropolis is the Forest Ochrosols, which develop over a highly weathered parent material. Due partly to their high clay accumulation, little or no primary porosity with nearly impermeable sub-horizons close to the surface (Adjei-Gyapong and Asiamah, 2002), they lead to high runoff rate.

While not denying the significance of these physical factors in floods occurrence, field research and available literature diminish the significance of these factors in explaining flood incidences. The characteristics of the soil and undulating landscape may account for the presence of waterlogs in some places. Interestingly, the role of these factors in the specific flood cases did not crop up both in the household interviews and key informant interviews. This is what a hydrological engineer said in an in-depth interview regarding whether the landscape and in particular the soil could have a major role to play in the urban flood incidence:

> *It is true that the topography, rock type and soil characteristics of an area can determine frequency and intensity of floods but these cannot be blamed for the current situation in the Metropolis. To me the floods are human-induced. We build where we are not supposed to. (Male, HSD, KMA)*

A study by Amoateng et al. (2017) in Kumasi Metropolis rather found the undulating landscape to be a blessing as it helps to limit the likelihood of flood disasters occurring in the city. In their view, the recent flood occurrences in Kumasi Metropolis have not particularly shown any link with the edaphic conditions. This conclusion is consistent with reports by previous studies (e.g. Owusu-Ansah, 2015; Okyere et al., 2012) that physiographic features do not in any significant way influence the frequency of recent floods in Ghanaian cities.

5.3 Anthropogenic causes of floods

5.3.1 Urban expansion and land use and cover change: implications for flooding

In the rural Central Gonja where the survey covered, effects of urban expansion on land use and flood incidence did not apply. The problems of inadequate storm drains as well as poor solid waste disposal also did not apply at all. These problems may be associated with urban areas like Buipe and Yapei which were not the focus of this study. For the eight rural communities covered in the Central Gonja, the main exposure factor to floods is their proximity to the Black Volta, White Volta or the confluence of the two.

In terms of topography the areas are generally flat and low-lying (see chapter five). Any slightest trigger that caused the water level to rise (according to the information gathered from the District NADMO Director) resulted in past destructive floods. As indicated earlier, rising water levels necessitating the opening of the Bagre dams in Burkina Faso has been identified as flood triggers in the Central Gonja. In addition, silted river channels, low-lying topography, sand winning and 'galamsey' activities have been identified as triggers of floods according to official sources (Central Gonja District NADMO report, 2010). Beyond the 2007 and 2010 catastrophic floods, which received widespread media coverage and international attention, Central Gonja District as a whole has not recorded any serious flood case per the available records. Flooding along the banks of Black Volta and White Volta does occur that affects mostly farms that are located along the Volta River. One cannot but agree with Aboagye et al. (2013) that the various past flood disasters and the devastating annual floods in the Central Gonja District indicate that hazards are more than a force of nature. It was evident from the field research that most of these communities would remain in their present location for a long time to come. This is so because their livelihoods are tied to the rivers as fisher folks or the land as farmers. This was what the chief and head of the fishing community said in an in-depth interview:

> *We've settled here and lived with the Gonjas for years and take this place as our hometown. Some of our offspring have even married the Gonjas. Since our main source of livelihood is fishing and we get it here why think of leaving? We have no intention of relocating from here unless we are forced to do so. (Male, Bonyamu)*

In the case of KMA, urban expansion and growth processes have been identified as important factors as far as flooding is concerned. Satellite image analysis of KMA (see Table 5.9, Figures 5.5a, 5.5b and 5.5c) shows that the Metropolis has expanded in spatial terms. Tables 5.10 (a-c) show the error matrices for the respective image classified. In 1986, vegetation was the dominant land cover, covering about 42% of KMA, followed by farmland (37.7%) and urban land (20.3%). In sum, arable and vegetation covered 79.7% of the total land area of the Metropolis.

Table 5.9: Proportion of Land use/cover types based on classification of 1986, 2004 and 2016 Landsat images

Land-use/Land-cover Type	Area (hectares)			Percentage change		
	1986	2004	2016	1986-2004	2004-2016	1986-2016
Urban/Built-up/Bare land	4382.67 (20.30%)	12378.69 (57.34%)	16742.34 (77.56%)	182.4	35.25	282.01
Farmland	8140.33 (37.71%)	6134.85 (28.42%)	3391.83 (15.71%)	-24.6	-44.7	-58.3
Vegetation	9064.31 (41.99%)	3073.77 (14.24%)	1453.14 (6.73%)	- 66.09	-52.72	-83.97
Total	21587.31	21587.31	21587.31	-	-	-

Source: Extract from analysed USGS satellite images data

Between 1986 and 2016 there was remarkable increase in the extent of urban land use from 20.30% to 77.56%, whilst farmland and vegetation cover (green space) drastically reduced from 79.7% to 22.44% over the same period. This finding is consistent with similar ones which also recorded substantial gains in the built-up area of KMA and a corresponding decrease in non-urban land use forms (Afriyie et al., 2014; Amoateng et al., 2017; Campion and Venzke, 2013).

That Kumasi Metropolis has expanded in both numbers and spatial extent over the years is not in dispute. It is the most rapidly growing Metropolis in the country, having grown at 5.2% annually between the 1984 and 2000 inter-censal years but much greater rate of 5.4% from 2000 to 2010 (Afrane and Amoako, 2011; GSS, 2014a). These growth figures show clearly that the Metropolis is growing at a comparatively faster rate in terms of population than the regional and national growth rates of 2.7% and 3.4% respectively (Afrane and Amoako, 2011; GSS, 2014a). The rapid pace of urban expansion however, is taking place within a context where the growth of the Metropolis has been anything but planned and controlled (GoG, 2012).

Similar trends have been observed in other parts of the world. In Akure in Nigeria, between 1986 and 2002, the built-up area increased by 58.44% (from 2431.60 hectares to 3852.70 hectares) while vegetation decreased by 34.82% (from 75359.70 to 49120.60) (Oyinloye and Kufoniyi, 2011). In Japan, Taiwan, South Korea, and China, large conversions to urban uses have been at the expense of cropland areas (del Mar López et al., 2001). In the Kunming city (China), rapid urbanisation process has been blamed for huge green space loss. But unlike Kumasi Metropolis, the city authority in the Kunming city implemented a number of urban greening policies to revive or rejuvenate the city (Zhou and Wang, 2011). Similarly, temporal land cover analysis by Ramachandra et al. (2015) of Delhi (India) shows about 75% reduction in the area covered by vegetation while the area under non-vegetation increased by 121%. Land use analysis of the same study on the other hand shows an increase in built-up area from 3.6% in 1977 to 25% in 2010 with the past four decades seeing more than 638% increase in built-up area mainly from the conversion of green spaces, agriculture land and other non-urban areas.

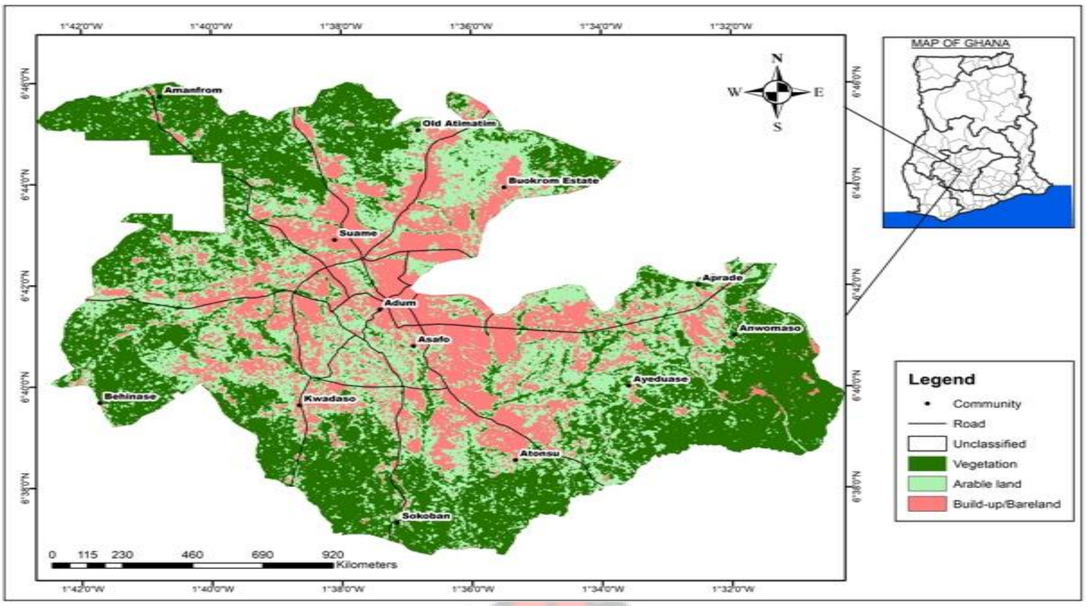

Figure 5.5a: Classified Land Cover of KMA (1986)

Source: Analysed USGS 1986 satellite image

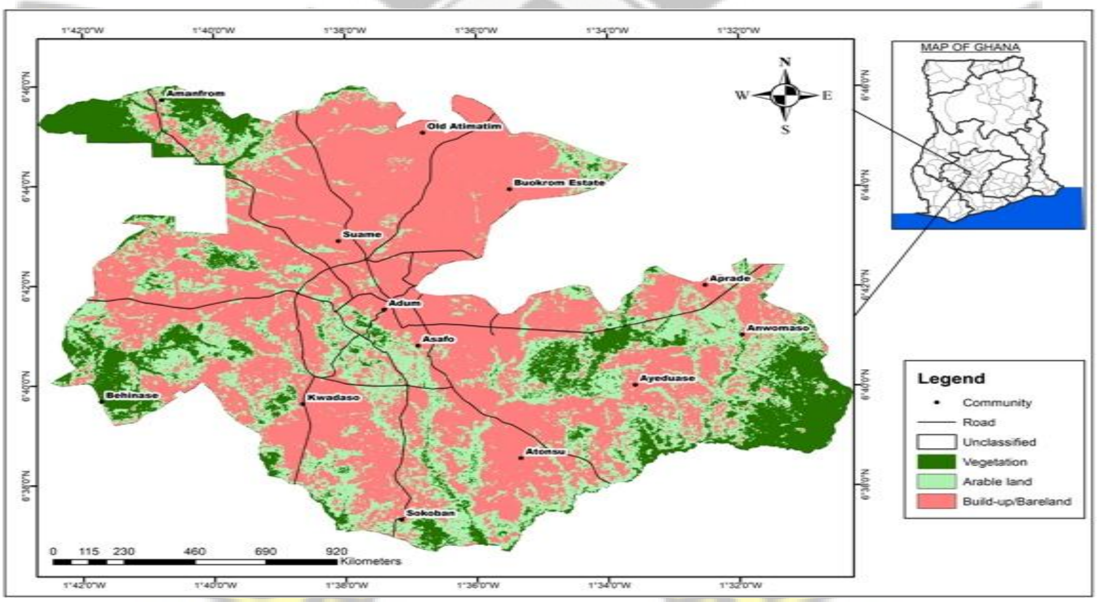

Figure 5.5b: Classified Land Cover of KMA (2004)

Source: Analysed USGS 2004 satellite image

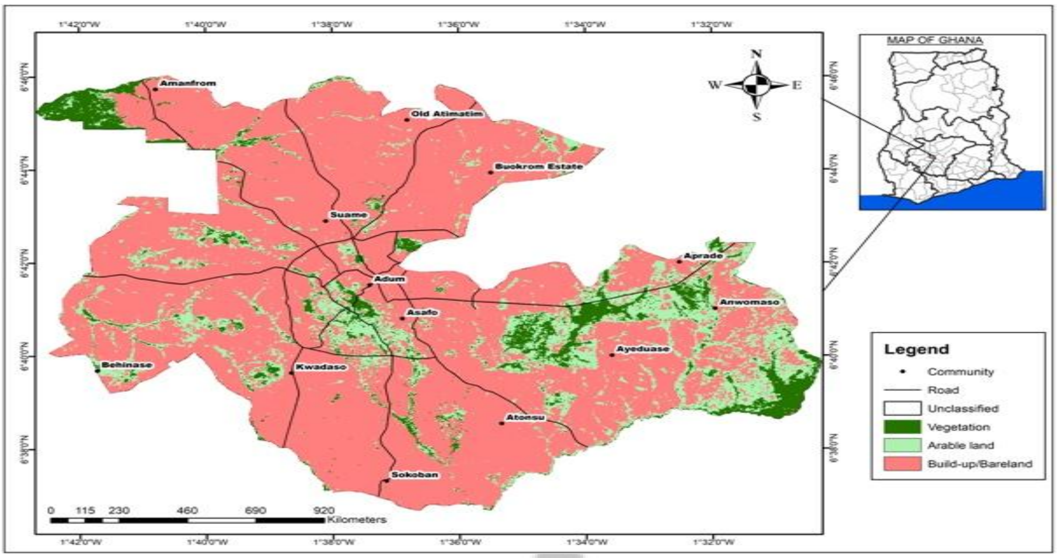

Figure 5.5c: Classified Land Cover of KMA, 2016

Source: Analysed USGS 2016 satellite image

Table 5.10a: Error Matrix, 1986

Classified Data	*Arable*	*Built-up/ Bare land*	*Vegetation*	*Total*	*User's accuracy*
Arable	88	4	24	116	75.86%
Built-up/Bare land	13	88	1	102	86.27%
Vegetation	12	0	78	90	86.67%
Total	113	92	103	308	
Producer's accuracy	77.88	95.65	75.73		

Overall Classification Accuracy = 82.47%

Source: Analysis of USGS 1986 satellite image

Table 5.10b: Error Matrix, 2004

Classified Data	*Arable*	*Built-up/ Bare land*	*Vegetation*	*Total*	*User's accuracy*
Arable	71	3	21	95	74.74%
Built-up/Bare land	3	102	1	106	96.23%
Vegetation	18	2	87	107	81.31%
Total	92	107	109	308	
Producer's accuracy	77.17	95.33	79.82		

Overall Classification Accuracy = 84.42%

Source: Analysis of USGS 2004 satellite image

Table 5.10c: Error Matrix, 2016

Classified Data	*Arable*	*Built-up/ Bare land*	*Vegetation*	*Total*	*User's accuracy*
Arable	64	0	16	80	80.00%
Built-up/Bare land	8	106	7	121	87.60%
Vegetation	24	0	83	107	77.57%
Total	96	106	106	308	
Producer's accuracy	66.67	100.00	78.30		

Overall Classification Accuracy = 82.14%

Source: Analysis of USGS 2016 satellite image

The expansion of the Metropolis has implications for flood incidence through land use land cover changes. It is also recognised that land-use changes can affect the hydrological regime and promote the risk of flooding (Ouellet et al, 2012; Wissmar and Timm, 2004). Various studies have shown that the progressive clearing of forest cover in favour of the growth of urban areas or the expansion of farmland has led to an increase in surface runoff and river flow, resulting in greater flood risk (Tao et al., 2011). Urban floods according to Douglas et al. (2008) are not just related to heavy rainfall and extreme climatic events; they are also related to changes in the built-up areas themselves. As people crowd into the city, human impact on land surfaces and drainage intensifies. Even just moderate storms can produce quite high flows in rivers because of surface runoff from hard surfaces and drains (Douglas et al., 2008). Water flowing through a series of culverts and concrete channels cannot adjust to changes in the frequency of heavy rain, as natural streams do. The situation worsens when they are obstructed by solid waste, silt and urban debris (McGranahan et al., 2007).

Field research has found that one major cause of floods in the Metropolis is development in wetlands and waterways, places which under normal circumstances are not suitable for human settlement (see Plates 5.1a, 5.1b, 5.2a and 5.2b). They also have become sites for waste disposal. The use of such areas in most cases involves a number of processes: stream diversion, filling with loads of truck-filled sand and compaction especially by the well-to-do developers to raise the ground level to a level that makes it difficult for floodwaters to reach. Those who are unable to do this or fail to seek proper advice often are left vulnerable to floods. Typical examples of development of wetlands and riparian areas for residential purposes were found at Atonso S-line and Kwadaso Estate areas.

At Atonso S-line for example, it was observed that a number of buildings have been completely ruined and ravaged by years of persistent floods and covers a vast stretch of land. However, there were few undisturbed concrete structures or buildings that have been abandoned by their owners which have been presented and discussed in the next chapter (chapter six). In some cases, we found newcomers or squatters who have taken occupation of such abandoned buildings. Also evident is the presence of water-loving (hydrophilic) plant indicative of unsuitability of such areas for human habitation. Even though flood incidences took place during or after heavy rainfall events, the relatively long time it takes for the floodwaters to recede in these communities suggest that not all the floods in the Metropolis are flash floods (Campion and Venzke, 2013). The flood experiences of most of these flood-prone areas are regarded as consequences of the spread of physical developments into wetlands. The rising of the water table during the rainy season creates a network of effluent streams in large parts of these suburbs with their flow and duration being triggered by heavy annual rainfall events. The view of Campion and Venzke (2013) that effluent streams, rather than flash floods, best explain the delay of the floodwaters in drying out from the neighbourhoods remains valid from field observations.

During the household survey respondents mentioned a number of human factors that trigger flooding in the Metropolis as shown in Table 5.8. These are building in waterways (7.1%), building in waterlogged or wetland areas (6.0%), building too close to river bank (5.0%), choked gutters/storm drains (20.5%), inadequate storm drains (17.9%), siltation of river channel (12.7%) and urban expansion (0.6%). At Old Tafo for instance, the Sub-Metropolitan District NADMO coordinator linked the problem of flooding in the community to people building in waterways, narrow and inadequate storm drains. He bemoans people building in unauthorised areas which often causes loss of life and property. A NADMO officer in the Metropolis summarises it succinctly this way:

> *People must stop building in waterways, marshy and waterlogged areas if we are to win the fight against floods in the Metropolis. If we block the natural course of a stream or river, it will hit back at us because water will always try to find its way.* (Male, IDI)

Urban growth contributes to flooding in the metropolis in another way by limiting where floodwaters can go by covering large parts of the ground with roofs, roads and pavements. Urban expansion comes with conversion of land use from green, permeable surfaces to grey, concrete, hard and impermeable surfaces. Evidence from the satellite image analysis shows a marked reduction in the urban green space but a huge increase in the Built-up area. This has serious implications for flooding in the Metropolis. This makes it difficult for rainwater to infiltrate, percolate and influence the peak discharge of floods. In less developed rural areas for instance, rainfall is stored in the soil column or in surface depressions and would start flowing slowly as surface or subsurface flow when this storage capacity is filled. Plants and tree roots further act to reduce the speed of surface runoff. This is in sharp contrast with urban areas which have less capacity to store rainfall as considerable part of the land surface is covered by roads and buildings, mostly impermeable. As Konrad (2003) noted, the permeable soil is replaced by impermeable surfaces such as roads, roofs, parking lots, that store little water, reduce infiltration of water into the ground, and accelerate runoff to ditches and streams.

With rapid urban expansion, not only are natural channels obstructed, but the various storm drains constructed ensure that water moves to rivers more rapidly than it did under natural conditions (Douglas et al., 2008). With less storage capacity for water in urban basins and more rapid runoff, urban streams rise more quickly during storms and have higher peak discharge rates than do rural streams. In addition, the total volume of water discharged during a flood tends to be larger for urban streams than for rural streams.

Kumasi used to be called the Garden City of West Africa (Quagraine, 2011). Today, most of its green and open spaces have either suffered encroachment or rezoned into other uses. Thus, the role of green spaces as sponges for soaking excess water is lost. Several scientific publications sought to throw light on this worrying development (see Adjei Mensah, 2014a, 2014b; Cobbinah and Amoako, 2012; Quartey, 2013; Quagraine, 2011) but the trend continues. Yet green spaces have been linked to hydrological improvement by reducing surface runoff and recharging ground water or aquifer (Gill et al., 2007) and acting as both buffers and natural stormwater drains during floods, thus reducing climate-related risks (Munang et al., 2013). The continuous destruction of urban green and open spaces due to conversion into urban land use forms means that an end to the perennial floods in Kumasi Metropolis may not happen soon.

Plate 5.1a: Residential facility within a wetland, Dichemso (Source: Fieldwork (2017)

Plate 5.1b: Residential facility within a wetland, Dichemso (Source: Fieldwork (2017)

Plate 5.2a: Abandoned buildings situated in a wetland, Atonso S-line (Source: Fieldwork (2017)

Plate 5.2b: A building situated in a wetland, Atonso S-line (Source: Fieldwork (2017)

5.3.2 Sanitation challenges, drainage infrastructure and flooding

As would be expected, sanitation and poor drainage infrastructure were not identified as causes of floods in the rural Central Gonja communities studied. Related to the rapid urban growth is the poor solid waste management culture in Kumasi Metropolis. Rapid urban growth has led to increased and uncontrolled generation of wastes. With an estimated per capita daily municipal waste generation rate of 0.75 kg in the Metropolis

(Miezah et al., 2015), the city authorities are overwhelmed by the sheer volume of waste to be managed on daily basis due to rapid population growth and a corresponding rise in per capita waste generation. As such, a substantial volume of waste often remains uncollected. Left with no option, nonchalant citizens dispose their wastes indiscriminately with drainage channels not spared. In 1995, the rate of domestic waste generation in Kumasi was estimated at 600 metric tons per day. By 2005, 1,000 metric tons of solid waste was generated each day in the city, increasing to 1,200 tons a day in 2008 and then 1,500 metric tons in 2010 (Owusu-Sekyere et al., 2013). The inability of KMA and other waste management companies to cope with the huge tonnes of waste being generated on daily basis has created a messy situation for the city. This has been compounded by the mushrooming of new settlements that fall sometimes outside the radar of city authorities.

Field research reveals that waste littering and indiscriminate waste disposal is a common scene (see Plates 5.3 and 5.4). Huge volumes of unmanaged solid waste eventually find its way into streams or rivers by surface runoff after heavy rainfall or are deposited into them deliberately by those living close to the drainage systems. Subin, Wiwi, Sisa, Aboabo, among others have over the years received huge doses of wastes of all kinds. This phenomenon has led to widespread narrowing and eventual choking of major storm drains. A careful perusal of NADMO records reveals waste-induced floods as the predominant cause of floods in the Metropolis.

There is also evidence of collapsed bridges (Plates 5.4 and 5.6) and incomplete construction of drains exacerbating the flooding situation in the metropolis. Generally, storm drains are inadequate to direct stormwater away from most of the flood-prone communities. In most cases too, storm drains are too narrow which get them easily choked. While collapsed bridges may partly be due to poor engineering work, the inability of floodwaters to get enough space to flow through due to waste-induced constricted drains may be a contributing factor. Silting and choking of drains, resulting from poor drainage systems themselves and improper disposal of refuse prevent the easy flow of water. As such, most communities become flooded whenever it rains heavily. This finding concurs with the observation of Lamond et al. (2012) that blocked drainage is particularly implicated in localised flash flooding. Similarly, Karley (2009) notes that lack of adequate infrastructure limits free flow of water and causes severe environmental problems such as flooding (Karley, 2009). These concerns were affirmed by a NADMO officer during an in-depth interview.

> *The main cause of floods in the Metropolis is dumping refuse in the drains. When they dump waste into these streams, they get choked leading to floods. Some of the drains are so narrow that, they are unable to contain the volume of water flowing through them. These result in the streams overflowing their banks and spreading out into communities as floods. (Male, IDI)*

The officer continued:

> *The main problem areas these days as far as flooding is concerned are the new sites, which are mostly not served with the requisite storm drains. They have no defined drainage system to contain the amount of water flowing through these areas. Also due to the lack of monitoring by building inspectors, people build anywhere including the waterways. Some of the drainage channels have become shallow due to sand accumulation and accumulation of waste. We need to dredge or de-silt them. (NADMO, IDI)*

In an in-depth interview with a 57-year old resident of Kwadaso, it was noted that the perennial flood problem is due to dumping of waste in the river Kwadaso and the bad state of the bridge which lies about 40 metres away. They failed however to accept as a problem the very decision to settle in their present location. The resident puts it this way:

> *Floods have been perennial problem here. It has minimised somewhat these days due to the dredging of the main stream. We cannot however predict what would happen since we have about five months to end the year. The main cause of floods is the way people handle the wastes they generate. The truth is that*

people dump their refuse into the stream which leads to floods. But I will blame it on the bridge which is too narrow for the amount of water that pass through it. Look at the bridge; half of it has been washed away by the sheer force of the water and almost dividing the road into two. Isn't it a pity? (Male, IDI)

At Atonso S-line however, respondents have different reasons for the flooding situation there. They were all unanimous in the exact cause of perennial flood in their area. While they acknowledged the inadequacy of storm drains as being a problem, they were all of the view that flooding is a recent phenomenon. A 35-year old female participant at Atonso S-line said this in a focus group discussion:

I was born here and have been living here for 35 years now. This is my family house. The truth is that we were not experiencing floods those days. The whole problem started when the Joy Standard School was built. The owner of the school graded the whole area, sand filled his part of the land and diverted the course of the main stream. The topography of the land also changed in the process with our side becoming a low-lying area. Since then we've never known peace. This has exposed us since then to perennial floods. (Female, FGD)

Another 57-year old female participant added:

But for the construction of the Joy school complex, we wouldn't have been here talking about floods. When all these flood issues started, the authorities should have done something about the drains. The gutters are too small and inadequate. We need more and bigger gutters to carry the stormwater. Also adding to the problem is the way people deposit their waste into the main stream. (Female, FGD)

At Ayigya Zongo, a male participant shared this with the research team in a focus group discussion:

The flood problem started with the construction of this bridge. I have been living here for the past 40 years and living in this same building; my own building. We were not experiencing this in the past but the problem started with the construction of the bridge and the poorly constructed drains. As you can see, the river (i.e. Sisa) has changed its course. Rather than flowing through the main channel or the culvert constructed for it, it has taken a different course altogether. It sometimes gets flooded even when it does not rain here. The river has already eaten up part of my building and is still undermining it. I don't have the means to handle this. We need your help. (Male, FGDs)

Interestingly the respondents did not associate the flood problem they faced with the conspicuously poor and disgusting waste disposal culture in the Ayigya area. When they were quizzed further whether they appreciate the link between the dumping of waste into the stream and the flood problem they face, this was the response from another participant:

> *My brother, we deposit this waste into the stream to stop the flooding. The water cannot come here. It blocks it. That is why you were able to cross over the other bank. We need more of the waste. The heaps of saw dust you see in the river bed were deposited there deliberately. But for this, our buildings would have collapsed long ago. (Male, FGDs)*

Studies have shown that waste management is a perennial problem in developing countries and it is increasingly a matter of concern in respect of flood risk management (Lamond et al., 2012; UN HABITAT, 2010) due to the poor disposal of waste which frequently leads to blockages in drainage and watercourses (Muñoz-Cadena et al., 2009), thereby reducing their capacity to store and convey water which results in flooding (Appiah, 2012; Marfai, 2011). During floods, waste and other debris collected by floodwaters can cause increased damage to property and lead to higher flood losses (Chen et al., 2007).

In Ghana, deficiencies in solid waste management (SWM) are most visible in and around urban areas where equally important competing needs and financial constraints have placed an inordinate strain on the ability of the authorities to implement proper SWM strategies in tandem with the rapid population growth (Oteng-Ababio, 2011). But literature demonstrates that poor waste management, a perennial problem, is set to get worse with the rapid expansion of urban areas in the developing world and the inability of municipalities to provide the needed resources necessary for waste collection (Lamond et al., 2012). Thus, the management of solid waste should be seen as one of the options for reducing flood risk; contributing as it does to quality of life, health and development generally, while also lowering the impact of disasters (Jha et al., 2012).

Plate 5.3: Waste-laden storm drain (Kwadaso)
Source: Fieldwork (2017)

Plate 5.4: Waste-strewn Sisa River bank (Ayigya Zongo)
Source: Fieldwork (2017)

Plate5.5: Undermined bridge (Kwadaso)

Source: Fieldwork (2017)

Plate. 5.6: Stream erosion-induced Collapse Bridge (Kwadaso)
Source: Fieldwork, 2017

5.3.3 Land use planning, regulatory framework and flooding

Building in wetlands and riparian areas within the Metropolis and associated floods have been reported by several newspaper reports and scholarly publications (e.g. Amoateng, 2016; Amoateng et al., 2017; Campion and Venzke, 2013; Korah and Cobbinah, 2017). This leaves one surprised what the city authorities are waiting for. It was evident from key informant interviews that there are influential players in the whole land allocation and sales arrangement. Land allocation and sales is a complex transaction involving a number of actors from KMA, Land Commission and the Traditional Authority. This makes it very difficult to place the current problem at the doorstep of one actor. A key informant from the T&CPD of KMA indicated that:

> *Our outfit cannot be held for uncontrolled physical development in the Metropolis. There are clear policy guidelines but the problem is enforcement lax. There are powerful and influential players in the whole land sale business. It is practically very difficult to stop people from building in areas not zoned for that project because these powerful people often are behind them. Individuals have taken the laws into their own hands and act with impunity. They know the laws don't work and indiscipline everywhere. (Male, IDI)*

Interaction with a key informant from the Department of Parks and Gardens expressed worry and disgust at the way physical development in Kumasi Metropolis is ripping the city of its green and open spaces. It was remarked:

> *There is no doubt that green and open spaces can help tackle the flood problem. They can act as sponges that will absorb excess water. Our Department (Parks and Gardens) is a decentralised one…and not autonomous body under the KMA. We take instructions from the Assembly and we do not have any say regarding where and where not to develop in the Metropolis. I will put the blame squarely on the Assembly and in particular the Kumasi Planning Committee which has representatives from the Assembly, the Lands Commission, Manhyia and other bodies associated with land. They should be blamed as they do the rezoning and, in the process, creates the mess. (Male, IDI)*

But the Metro Engineer shared this view regarding physical development and the flood situation in the Metropolis:

> *The city is expanding very fast and people need space to lay their heads. People put up buildings anywhere, without permit. River catchment areas are not spared and so open and green spaces that are not zoned for development. The problem is caused by human beings. We are responsible for the mess, all of us. Everybody wants to build in the City. Individuals and some developers alike cut down trees to pave way for their projects. In more developed countries my brother green spaces are integral parts of housing and street designs. Here the story is different. It is clear in the kind of building designs we see these days. Instead of maintaining green spaces within their building area people prefer concrete surfaces and tiles in the name of modernity. All these contribute to the flooding we are all witnessing. This mentality must change. (Male, IDI)*

In Central Gonja, the story is not all that different. It appears relatively easier to manage and control physical development in the urban areas than in the rural communities. In the remotely located and scattered rural communities along the Black and White Volta, most of which are inaccessible, it is difficult to force them to relocate. This is what an official of NADMO shared with me in an in-depth interview:

> *What we do is to sensitise them. We tell them of the risks of settling close to the river. These people came to settle there on their own. These are mainly fishing communities. Whatever you do they will still come back. It is easier to control and manage people in the urban areas like Buipe. (NADMO, Central Gonja)*

The management and control of land use in Kumasi Metropolis can best be described as poor in spite of the number of planning regulations which were put up to guide the development of structures. A number of institutions are involved in urban space planning and management in Kumasi Metropolis and includes Kumasi Metropolitan Assembly (lying at the apex), Town and Country Planning Department (TCPD), Department of Parks and Gardens (DP&G), Environmental Protection Agency (EPA), the Office of the Administrator of Stool lands, Forestry Commission (FC). It also includes the Lands Commission with its subsidiary institutions namely: The Survey and Mapping Division (SMD), the Land Registration Division (LRD), the Land Valuation Division (LVD) and the Public and Vested Land Division (PVLD) (Amoako and Adom-Asamoah, 2017). These institutions however have not lived up to expectation due to a number of factors. At the management level, the sheer number of institutions leads to conflicts and unnecessary duplication of functions. This, coupled with poor institutional co-ordination and collaborations make these institutions ineffective in delivering their mandate (Addo-Fordwuor, 2014; Amoako and Adom-Asamoah, 2017; Oduro-Ofori et al., 2014).

Other challenges include resource constraint, political interference, uncooperative public attitude and non-enforcement of laws (see Adjei Mensah, 2014a; Amoako and Adom-Asamoah, 2017; Stow et al., 2016). Undue delays coupled with high cost in securing a building permit for example, make developers resort to putting up buildings without permit. Between 1990 and 2000, it is estimated that only 7.2 per cent of buildings in the Metropolis had permits (Botchway et al., 2014). Estimate has it that over 80% of buildings sprouting out in the Metropolis are without the appropriate building and development permits from the Town and Country Planning Department and the Kumasi Metropolitan Assembly (KMA) respectively (Botchway et al., 2014). As is the situation in Ghana, planning has thus failed to exert effective influence on the growth and expansion of human settlements resulting in chaotic growth of the cities (Yeboah and Obeng-Odoom, 2010). Ubink and Quan (2008) have described physical development in Ghanaian cities in general as haphazard and several works have also illustrated the inadequacy of effective urban management in the country (Gough and Yankson, 2000; Yeboah, 2003; Yeboah, 2006).

The uncontrolled physical development and the depletion of the natural landscape in the Metropolis is taking place within the context of weak policy and regulatory framework. For years, the legal framework that guided planning practice and functions in Ghana were contained in various legislations. The operation of these different legislations concurrently was not only cumbersome but confusing because the procedures and mechanisms for plan preparation, approval and implementation were different (Kyei, 2016; MESTI, 2015).

Besides, the functions to be performed by different institutions established under the various enactments to undertake land use planning and management were duplicated. Some of the planning standards adopted by the T&CPD under the Town and Country Planning Ordinance, 1945 (CAP 84), and the Town and Country Planning

(Amendment) Act, 1960 (Act 33) have for long been outdated and out of tune with current international standards. These factors, coupled with the lax in legislative enforcement as regards land use in Ghana in general and Kumasi Metropolis in particular, provide the space for uncontrolled physical development in the Metropolis. The public has taken advantage of the loopholes in the system to put up structures where they should not. Interestingly, some officials of government institutions and traditional authorities are often blamed for the mess as they collude and connive with private land developers in flagrant disregard of land use regulations. While these actions may pose serious challenge to sustainable use of urban environment, it is not uncommon phenomenon. As urban and peri-urban lands become commodified and highly priced, it is more economically rewarding to convert even hitherto unattractive areas, including wet lands to urban use forms such as residential accommodation, industrial and commercial buildings (Afriyie, et al., 2014).

In Ashanti Region, a large proportion of the land is so-called 'stool land', which the Constitution describes as land vested in a stool – a customary community – on behalf of and in trust for the subjects of a stool in accordance with customary law and usage (Ubink, 2008). Since such lands in practice are under the control of the traditional leaders, it is difficult to bring them under the strict control of institutions whose mandate it is to ensure orderly physical development. In fact, customary institutions still hold over 80% of lands in Kumasi Metropolis in trust for their citizens. For this reason, access to and use of land come under the control and management of chiefs and family heads (Korboe, 2001; Amoako and Adom-Asamoah, 2017). This makes urban space planning and management more difficult. A study by Addo-Fordwuor (2014) reveals that open spaces meant to be under the control and management of state institutions are instead controlled by traditional and customary institutions. This provides the opportunity for traditional institutions to lease sections of open spaces and reserved areas to private developers and demand rezoning of such spaces for residential or commercial uses.

While this is a clear violation, Amoako and Adom-Asamoah (2017) indicate that many customary institutions and chiefs in the Metropolis see their institutions as the rightful owners of green and open spaces within their areas of jurisdiction. In the view of Amoako and Adom-Asamoah (2017), the apparent conflicts between state and city institutions on the one hand and traditional owners of the land lie at the root of the changes witnessed in the use or functions of urban spaces in Kumasi Metropolis and the never-ending fight against floods. Lying between these two key actors are prospective developers and encroachers who manipulate and take advantage of the conflicts and lacunae to make use of these spaces to satisfy their land use needs.

This study concurs with Amoateng et al. (2017) and Campion and Venzke (2013) that the nature of floods being experienced in the Metropolis may not be the result of climate change or natural environmental factors but poor spatial planning and management. While climate and other environmental factors may not be completely out of the equation, they serve as triggers. The drainage and waste management systems put in place simply do not have the capacity to cope with increased overland flow. Physical development into wetlands and water courses as well as urban agricultural practices have been implicated for the frequent occurrence of floods in KMA (GSS, 2014a). Anthropogenic factors are thus the major factors accounting for the increasing perennial floods in Kumasi Metropolis.

In the absence of physical environmental factors as main causes of floods, the conclusion then is that human or anthropogenic factors are the prime causes of the worsening flood situation in both rural and urban Ghana. This then supports the proposition that anthropogenic factors rather than climatic factors account for increasing flood incidence in rural Ghana. The fact that the Bagre dam spillage is the result of excess water from probably heavy rainfall and that floods in KMA have always been associated with the rainy season suggest floods cannot occur without natural forces. It is therefore sound to say that floods in the two study areas are the results of man-environment interactions as shown in the conceptual framework of the study. The MOVE framework emphasises coupling relations between environmental and societal dimensions meaning floods are given form and meaning by the interaction with social systems and social systems also influenced by their actual and perceived hazard context and environmental conditions. This is validated in the light of the current findings.

5.4 Summary

This chapter has examined the natural and anthropogenic factors that underlie perennial flooding and flood disasters in rural and urban Ghana. Analysis of rainfall statistics from the Ghana Meteorological Agency for a period of 36 years has not established increasing rainfall as a key factor for past flood cases in both Central Gonja and Kumasi Metropolis. Indeed, annual rainfall has witnessed a decreasing albeit insignificant trend in the Central Gonja but showed an insignificant increasing trend for June heavy rainfall. In KMA, the trend has been an insignificantly increasing annual rainfall trend, but a decreasing trend for June. From the available evidence, the study has also not been able to prove that flooding in the study areas is the result of other natural physical factors such as topography, geology and soil. While these physical factors may have a role to play in the floods dynamics, the conclusion is that anthropogenic factors rather than physical-environmental factors are responsible for the past cases of floods in both rural Central Gonja and Kumasi Metropolis. While the opening of the Bagre dam in the neighbouring Burkina Faso is a key factor for flooding in Central Gonja, poor spatial planning and land use management as well as poor solid waste management underlie the perennial flooding in Kumasi Metropolis. This confirmed the proposition that human factors are the main causes of floods in rural and urban Ghana. The chapter however shows that floods in both rural and urban Ghana are socio-natural events. The next chapter examines household characteristics and their vulnerability to floods

CHAPTER SIX

HOUSEHOLD CHARACTERISTICS AND FLOOD VULNERABILITY ANALYSES IN RURAL AND URBAN GHANA

6.0 Introduction

Chapter five examined the natural and human contexts of floods in rural and urban contexts. Household vulnerability to floods is affected by many factors. These factors operate to undermine capacity for self-protection, limit or reduce access to social protection, hamper or complicate recovery, or expose some groups to greater or more frequent hazards than other groups. This chapter therefore assesses household vulnerability to floods in terms of their exposure, sensitivity and resilience/adaptation using the MOVE framework. It examines the physical, demographic and socio-economic conditions that predispose rural-urban households in Ghana to flood vulnerability.

6.1 Household background characteristics vulnerability to floods

6.1.1 Socio-demographic characteristics and household susceptibility to floods

The socio-demographic attributes of population may place its members at greater risk of harm before, during, and after a disaster (Donner and Rodríguez, 2011). These characteristics as indicated in the conceptual formulation are important in explaining differential impact of floods as they affect household vulnerability in varying ways.

The study reported more female heads of households (55%) in KMA compared with the Central Gonja, where 20.7% of the respondents were males. Female headed households are generally more vulnerable than male-headed households for various reasons (Donner and Rodríguez, 2011). Women also face unique challenges when facing disasters. Women are relatively poorer than men and may not have the vital resources to respond to and recover from disasters (Donner and Rodríguez, 2011). This problem is particularly grim among single mothers, who generally are economically disadvantaged relative to single or married women, and who must not only protect themselves but must also safeguard the lives of their children in disaster situation (Donner and Rodríguez, 2011). Women's vulnerability to disasters is also shaped by traditional gender roles, power and privilege, low wages, and secondary responsibilities such as child care (Enarson and Morrow, 1998). Women are more affected psychologically than men (Choudhury et al., 2006; Du et al., 2010; Fothergill, 2001; Liu et al, 2006).

In terms of level of formal education, overwhelming number of respondents (60.8%) from Central Gonja compared to 22% of respondents from KMA had no formal education. Education no doubt is key to knowledge. Low level of education of household head will inhibit or limit the amount of flood-related information available to that household from variety of sources, principally through print and electronic sources (Correia, 2002). Household heads with higher levels of education for example would be able to interpret much easier and better weather warnings or flood safety information materials if available than households with poor educational backgrounds. They would also be able to tap into social networks or make use of basic resources that would help them adapt better to flood situations. Households with no formal education may be seriously disadvantaged when it comes to appreciating, understanding and responding to early warnings and would have no scientific understanding of flood risks. Education is also a means by which one secures formal sector job placement and to a large extent how economically secured one may be. Education not only increases labour market returns, but it also allows individuals to adapt more efficiently and effectively to crisis and uncertainty (Correia, 2002). Thus, low levels of education are linked with high vulnerability (Philip and Rayhan, 2004). The better educated tend to use assets more efficiently; have greater capacity to obtain credit, and other productive resources; and are better able to exploit new income opportunities (Correia, 2002). If this argument is extended to the rural and urban communities studies one can conclude on the basis of formal educational attainment that the rural communities are more vulnerable than the urban communities in KMA.

In the eight rural communities covered in the Central Gonja, Ewes were the dominant ethnic group (67.6%). These were Ewes drawn mainly from Volta Region and other parts of Ghana and settled along the Black and White Volta. They were mainly fisher folks, who also supplemented fishing with farming and charcoal burning. They however owed allegiance to their mainly Gonja overlords. In KMA, the dominant ethnic group was the Akan which constituted 65.8% of the urban respondents.

The proportion of households aged 50 years and over in Central Gonja was 41.1% as against 46.1% in KMA. From the point of view of Cherniack (2008), alongside children, older people are more likely to suffer adverse physical consequences during floods. They may also not be able to generate enough income either because they have retired or are physically incapable of doing works that bring in income to the household. In terms of household size, rural Gonja registered 50.4% of households with size seven (7) and above as against 30.2 % in KMA. Furthermore, 70.8% of respondents in rural Gonja had 4 or more dependants, while 25.6% had 8 or more dependants. In KMA however, 48.7% respondents had 4 or more dependants with 10.4% having 8 or more dependants (see Table 6.1). Children and other dependants can undermine household financial security (Schiller, 1995) and thus make them more vulnerable. A large number of children means an increased need for household income, constraints to women entering the labour force, and increases in childcare and other domestic work (Correia, 2002). As regards gender-differentiated effects for women, a large number of children implies limited opportunities to take part in economic activities and generate income, with corollary implications for their power to negotiate at the household level. The presence of young children also has implications for the type of work that mothers can take on (Cunningham, 2001).

Table 6.1: Socio-Demographic characteristics of respondents

Variables	Categories	Rural		Urban	
		Freq.	%	Freq.	%
	Male	291	79.3	180	45.0
Sex	Female	76	20.7	220	55.0
	Total	**367**	**100.0**	**400**	**100.0**
	No formal education	223	60.8	88	22.0
	Basic education	115	31.3	161	40.3
Education	Secondary/Technical/ Vocational education	24	6.5	125	31.2
	Tertiary education	5	1.4	26	6.5
	Total	**367**	**100**	**400**	**100.0**
	Akan	-	-	263	65.8
	Gonja	101	27.5	26	6.5
	Dagomba	-	-	32	8.0
	Mamprusi	1	0.3	12	3.0
Ethnicity	Dagarbas	3	0.8	17	4.3
	Konkomba	1	0.3	11	2.8
	Ewes	248	67.6	34	8.5
	Other groups	13	3.5	5	1.3
	Total	**367**	**100.0**	**400**	**100.0**
	20-29	23	6.3	27	6.8
	30-39	96	26.2	89	22.3
Age	40-49	97	26.4	100	25.0
	50-59	79	21.5	111	27.8
	> 59	72	19.6	73	18.3
	Total	**367**	**100**	**400**	**100.0**
Household size	*1-3*	39	10.6	103	25.8
	4-6	130	35.4	176	44.0
	7-9	88	24.0	69	17.2
	≥10	110	30.0	52	13.0
	Total	**367**	**100**	**400**	**100.0**
	None	15	4.1	44	11.0
Number of dependants	1-3	92	25.1	162	40.5
	4-7	166	45.2	153	38.3
	8-11	83	22.6	33	8.3
	12-15	6	1.6	5	1.3
	> 15	5	1.4	3	0.8
	Total	**367**	**100.0**	**400**	**100.0**

Source: Fieldwork (2017)

6.1.2 Financial and Human Capital and household vulnerability to floods

Financial capital according to Ellis (2000) refers to cash, savings loans, remittances and credit and other economic savings while human capital covers skills, knowledge, physical capability and ability to labour. These assets are critical for enhancing resilience and reducing susceptibility of households to floods. One useful indicator of household vulnerability is the employment status of the household head. This is because gainful employment is a determinant of how much income that comes to the household and how financially secured that household would be.

The study found that majority of the respondents in both rural and urban settings were engaged in informal sector employment. Of the 367 respondents in Central Gonja, 95.4% engaged in informal economic activities with fishing and farming being the dominant occupation. But income from these primary activities was found to be unstable and unreliable due to natural factors as climate variability, extreme climatic events and soil conditions. This was the bane of the rural communities studied. The equivalent proportion of urban households engaged in informal activities was 80.7% with majority of the respondents engaged in trading (Table 6.2). Other forms of occupation that respondents were engaged in were private security works, drivers and religious activities such as pastors. The more households there are working to bring in financial income, the greater the recovery capacity of that household from flood disaster. A household whose majority members bring nothing or little by way of income would be financially insecure and more susceptible to floods.

The income that accrues to members of a household could affect its resilience or capacity to adapt to floods. Results show that 75.2% of respondents in rural Gonja earned average monthly income of 300 Ghana Cedis or less as opposed to 52.3% for urban KMA. But 35.1% and 47.2% respectively of households in Central Gonja and KMA got additional income from working household members albeit not quite significant to change their economic fortunes. With generally low income for these flood-prone communities and remittances from family members working abroad being limited and unreliable (see Table 6.2), households in both the rural and urban communities studied may be exposed to vulnerabilities in the event of floods. If this is related to the number of dependants per household head, then the situation becomes more problematic. A solid financial base potentially widens the choices available in terms of flood protection of a household and facilitates rapid recovery from flood impacts. If household members other than the head contribute to household's purse, the more secured the household would be financially. This makes such households less susceptible and more resilient to floods. The poorest households on the other hand are more likely to sustain absolute losses and have little in reserve that would help them to recover after disaster.

Access to credit is absolutely necessary especially after floods to help victims in the recovery process. This increases their financial muscle to undertake some repair works after damage from flood disaster. This assists poor flood disaster-stricken households such to recover and also build resilience after having suffered major losses due to floods. Unsurprisingly, access to credit facilities by the study population was equally low. In rural Gonja, 14(3.8%) of the respondents had access to credit facilities in the form of loans. In KMA, 99 (27.8%) had access to credit. Access to credit by the small number of respondents was largely limited to the informal money lending institutions due primarily to informality of their economic activities and lack of collateral. This meant that beyond their limited savings, majority of households in the study communities would be constrained in securing additional financial support in times of disaster.

The role of insurance is to increase the resilience of households in the face of damage to their assets or property. A household without insurance cover would be more vulnerable, all things being equal, than one without one. Beside a third-party vehicle insurance cover, the results revealed that National Health Insurance Scheme (NHIS) is the dominant scheme that applies to 42.8% and 78.8% of the total respondents in the Central Gonja and KMA respectively. Since NHIS has a direct bearing on health, enrolment with the scheme could unleash positive outcomes. The relatively smaller number of rural folks as opposed to the urbanites covered by NHIS; and the fact that most of the study communities were inaccessible and far away from health facilities, make the rural communities potentially more vulnerable in the event of flood disaster. It was not surprising that flood insurance policy cover, a critical non-structural mechanism by which flood-prone communities could adapt in the event of disaster, was not reported in the study. For both rural and urban households studied, flood insurance cover did not apply.

Although rural Central Gonja registered more physically challenged persons (12%) relative to KMA (2.8%) during the survey, the overall number was not significant. These were cripples, the blind, death and dumb and individuals suffering from stroke, yet no special provisions had been put in place by the individual households to protect these vulnerable groups in time of disaster.

Table 6.2: Households Financial and Human Capital

Variables	Categories	Rural		Urban	
		Freq.	**%**	**Freq.**	**%**
	Employed (government/large companies)	5	1.4	33	8.3
Employment status	Employed by relatives/SMEs	3	0.8	11	2.8
	Self employed	347	94.6	312	78.0
	Unemployed	12	3.3	44	11.0
	Total	**367**	**100.0**	**400**	**100.0**
	Fishing/ farming	315	85.8	-	-
Occupation	farming	20	5.4	8	2.0
	Trading/business	7	1.9	230	57.5
	Civil/Public Service	5	1.4	27	6.8
	Artisanal work	4	1.1	81	20.3
	others (Pastor/Labourer/security/ driving/charcoal burning)	4	1.1	10	2.5
	N/A	12	3.3	44	11.0
	Total	**367**	**100.0**	**400**	**100.0**
	Less than GH¢100	107	29.2	121	30.3
	GH¢100 -GH¢ 300	169	46.0	88	22.0
Monthly income of household head (formal & informal sources)	GH¢301- GH¢500	36	9.8	94	23.5
	GH¢501- GH¢700	27	7.4	56	14.0
	GH¢701- GH¢900	19	5.2	15	3.8
	Above GH¢900	9	2.5	26	6.5
	Total	**367**	**100.0**	**400**	**100.0**
Number of other household members earning income	None	238	64.9	211	52.8
	1-3	129	35.1	170	42.5
	4-7	-	-	15	3.8
	8 and above	-	-	4	1.0
	Total	**367**	**100.0**	**400**	**100.0**
	Up to GH¢100	28	7.6	23	5.8
Total monthly income from other household members	GH¢101 -GH¢ 300	45	12.3	65	16.3
	GH¢301- GH¢500	21	5.7	39	9.8
	GH¢501- GH¢700	14	3.8	18	4.5
	GH¢701- GH¢900	7	1.9	17	4.3
	Above GH¢900	14	3.8	27	6.8
	None	238	64.9	211	52.8
	Total	**367**	**100.0**	**400**	**100.0**
Family member working abroad	Yes	61	16.6	83	20.8
	No	316	83.4	317	79.2
	Total	**367**	**100**	**400**	**100.0**

Access to /benefit from credit facilities	Yes	14	3.8	111	27.8
	No	353	96.2	289	72.3
	Total	**367**	**100**	**400**	**100.0**
Source of credit (if above applies)	Micro-lending sources	12	3.3	63	15.5
	Banks	2	0.5	16	4.0
	Credit union	-	-	19	4.8
	Susu agents	-		13	3.3
	None (N/A)	353	96.2	289	72.3
	Total	**367**	**100.0**	**400**	**100.0**
Enjoyment of insurance cover	Yes	157	42.8	336	84.0
	No	210	57.2	64	16.0
	Total	**367**	**100.0**	**400**	**100.0**
Type of insurance cover	House	-	-	-	-
	Vehicle	-	-	21	5.3
	Medical (NHIS)	157	42.8	315	78.8
	Life Assurance	-	-	-	-
	None (N/A)	210	57.2	64	16.0
	Total	**367**	**100**	**400**	**100.0**
Household member physically challenged	Yes	44	12.0	11	2.8
	No	323	88.0	389	97.3
	Total	**367**	**100.0**	**400**	**100.0**

Source: Fieldwork (2017)

Records show that majority of the inhabitants in Central Gonja are poor and lack adequate infrastructure and social protection (Ghana Statistical Service, 2015). As noted by Correia (2002), the most vulnerable to disaster are people within the low-income bracket, those without insurance or financial reserves, migrants, those living in flimsy houses, the elderly and the infirm. It is not just that the poor may be more exposed to flooding but are also more likely than the wealthy to suffer when flooding strikes (Correia, 2002). Widespread poverty is noted to have played a critical role in increasing vulnerability of population to many recent disasters (Donner and Rodríguez, 2011). Generally, the poor suffer more from hazards than the wealthy (Correia, 2002). It is poverty that drives people to occupy flood-prone environments, which the wealthy historically have avoided. At the household level, the poor have fewer resources upon which to draw to counteract the impacts of flooding (Chan and Parker, 1996). Blaikie et al. (1994) point out that susceptibility is often cyclical with regard to flood hazards, because disruption to assets and livelihoods by one event often make households yet more vulnerable to future flood hazards. Health status affects human capital, productivity, income-earning capacity, and thus vulnerability (Correia, 2002). Studies have shown that the health of people before flooding can be a major determinant of the health impact outcome of floods (Tapsell et al., 2002). A person with pressure-related health problem for instance may have a worsened or an aggravated situation due to floods.

6.1.3 Physical and natural assets and household vulnerability to floods

Lack of physical and natural assets can increase household's susceptibility to floods. Not only will their susceptibility be increased but also their resilience to floods will be lowered. By physical asset, mention must be made of such things as electricity, water, telephone, radio, television (TV) among others, possession of or access to which can make households less vulnerable in flood situations. Natural assets used here encompass land for farming and other economic activities as well as rivers for fishing. The role of these assets in defining household position along vulnerability-resilience continuum is well documented. One cannot but agree with Prowse (2008) that, a broad asset base is critical in adaptive response of the poor against extreme weather events.

From Table 6.3, 94% of households in rural Central Gonja lived in their own houses with the remaining living in family house. This implies that no respondent lived in a rented apartment. This means that should their property be destroyed in the event of flood disaster, they would be hit hard. In KMA however, 37.5% lived in rented houses, 5.8% were squatters and 56.8% lived in own and family house. For those who lived in rented houses, the financial loss of a collapsed building due to floods will be borne by the landlord and not the tenant. They can also look for an alternative place for relocation. But these tenants may have difficulty recovering their rent paid in advance if it applies making a quick relocation impossible.

Access to electricity is crucial in household vulnerability analysis since it enables households to obtain information flood risks and the necessary safeguards. Absence of electricity means households may not only be disconnected from various sources of information such as radios, televisions and other electronic sources (online/internet sources) of information, it would also make charging of cell phone batteries impossible. Table 6.3 shows that rural Gonja is disadvantaged with as low as 17.4% of households having no access to electricity, whether solar, thermal or hydro-power. Apart from Kikale No.4, all the seven rural communities studied were yet to be linked to the national electricity grid. Households therefore devised innovative ways of getting the cell phones charged including the use of power banks.

In the flood-prone communities in Kumasi Metropolis however, 90.8% of households had access to electricity. But in the most vulnerable communities of Atonso S-line, ECG had disconnected electricity to most households due to fear of electrocution should such compounds and rooms get flooded. Thus, households without electricity supply may be more vulnerable than those connected to electricity. But illegal connections in flood-prone areas must be noted, can expose households to risks of electrocution, making the relationship between access to electricity and vulnerability non-linear.

The possession of or access to telephone, whether landline or cellular, by household members is a useful indicator for measuring household vulnerability to floods. This is because it would determine the ease with which a household can communicate with the appropriate agencies such as NADMO, the Red Cross as well as other family members, neighbours or friends in time of emergency for support. Results show the use of mobile phones among both rural and urban study population. While 82% of rural respondents had functional cell phones, there was similarly high use of mobile phone in the urban areas. In the same way, possession of television (TV) or radio determines the capacity of a household to receive information about possible occurrence of floods. Early warnings on severe storms and floods and needed safeguards to be taken by households can be obtained by watching the weather forecast on television and listening to radio.

As regards possession of radio 75.7% of rural Gonja as opposed to 88.3% of KMA possessed radio. Clearly, radio is the dominant source of information for majority of respondents in both rural and urban communities studied. Apart from its affordability, absence of electricity in most of these communities explains the preponderance of use of radios which could also easily be operated with dry cells or batteries. While only 22% of rural respondents possessed TV, 89% of urban respondents possessed it. It needs emphasis that possession of TV does not necessarily mean use. While some of these TVs were reported as dysfunctional, in many instances, lack of electricity in most of these flood-prone areas rendered them not being used. Thus, majority of respondents were constrained in terms of access to information. This arguably puts them in a vulnerable situation. Studies have shown that weather warnings are generally understood and heeded where households have reasonable access to radio and television and rural households without TV or radio would be more vulnerable to floods than their urban counterparts (Pyle, 2006). The active role of Disaster Volunteer Groups on the ground in the rural study communities however helped to keep households up-to-date on any imminent disaster.

Other assets as canoe, engine boats, sewing machine and the like and access to fertile arable land and rivers for fishing provide opportunity for households to make a living, the lack of which would make them economically vulnerable. The proportion of rural Gonja and KMA possessing other categories of assets are captured in Table 6.3.

Table 6.3: Physical and Natural Assets of Households

Variables	Categories	Rural		Urban	
		Freq.	%	Freq.	%
Ownership of house	Own house	345	94.0	140	35.0
	Family house	22	6.0	87	21.8
	Rented apartment	-	-	150	37.5
	State-owned	-	-	-	-
	Squatter	-	-	23	5.8
	Total	**367**	**100.0**	**400**	**100.0**
Possession of radio	Yes	278	75.7	353	88.3
	No	89	24.3	47	11.8
	Total	**367**	**100.0**	**400**	**100.0**
Possession of television	Yes	81	22.1	356	89.0
	No	286	77.9	44	11.0
	Total	**367**	**100.0**	**400**	**100.0**
Possession of telephone	Yes	301	82.0	365	91.3
	No	66	18.0	35	8.8
	Total	**367**	**100.0**	**400**	**100**
Possession of vehicle	Yes	6	1.6	21	5.2
	No	361	98.4	379	94.8
	Total	**367**	**100.0**	**400**	**100.0**
Possession of bicycle/motor bike	Yes	188	51.2	48	12.0
	No	179	48.8	352	88.0
	Total	**367**	**100.0**	**400**	**100.0**
Possession of sewing machine	Yes	52	14.2	44	11.0
	No	315	85.8	356	89.0
	Total	**367**	**100.0**	**400**	**100.0**
Possession of canoe/engine boat	Yes	240	65.4	-	-
	No	127	34.6	400	100.3

	Total	**367**	**100.0**	**300**	**100.1**
Possession of computer	Yes	11	3.0	54	13.5
	No	356	97.0	346	86.5
	Total	**367**	**100.0**	**400**	**100.0**
Access to electricity for domestic use	Yes	64	17.4	363	90.8
	No	303	82.6	37	9.3
	Total	**367**	**100.0**	**400**	**100.1**
Access to adequate waste disposal system	Yes	12	3.3	262	65.5
	No	355	96.7	138	34.5
	Total	**367**	**100.0**	**400**	**100.0**
Access to in-house water supply	Yes	14	3.8	247	61.8
	No	353	96.2	153	38.3
	Total	**367**	**100.0**	**400**	**100.0**
Access to in-house toilet facility	Yes	37	10.1	225	56.3
	No	330	89.9	175	43.8
	Total	**367**	**100.0**	**400**	**100.0**
Access to water/river for irrigation and fishing	Yes	287	78.2	-	-
	No	80	21.8	400	100.0
	Total	**367**	**100.0**	**400**	**100.0**

Source: Fieldwork (2017)

6.1.4 Social capital and household resilience to floods

Studies have shown that adaptation to disasters does not only depend on the amount of physical or financial assets of individuals but on other factor as social relations or capital (e.g. Adger, 2003; Dulal et al., 2010). Being a dynamic social process, adaptation is facilitated, in part, by the presence reciprocal relationship, the ability of societies to act collectively and the presence of supportive formal and informal institutions (Afriyie et al., 2017). Based on Ellis (2000), social capital includes safety networks, social claims and social relations. Social networking provides a form of shield or security for individuals and therefore critical in vulnerability analysis. This would enhance the resilience of a household before, during and after floods.

As shown in Table 6.4, 95.1% of the respondents in Central Gonja district belonged to some social network group (mainly informal) while 82.3% actually benefitted from their membership of such groups. It was clear from the survey that overwhelming majority depended on their immediate relatives, family members and friends. This was particularly apparent in the remote and isolated rural communities of Adidodeke, Amedzrovi, Debri port, Agege, Bonyamu, Kikale No.4, Nigeria Camp and Kopedeke in Central Gonja. In these communities, there was a general feeling of oneness; every community member saw the other fellow as brothers or sisters. Community help spirit was high and harmonious use or sharing of common natural resources – Black and White Volta, arable and grazing land, forest resources – was evident.

Compared with rural Gonja, 62.5% of respondents in KMA indicated membership of either formal or informal social network groups, an obviously lower figure. The cosmopolitan nature of KMA and the breakdown in familial ties made respondents look for other network groups or associations including religious, work-related or professional groups from which members derive varying benefits. In KMA, 37.5% of respondents claimed their memberships of social groups have somehow been beneficial to them. However, these benefits were not related to floods. As respondents themselves indicated (see also discussions in chapter eight), the support from these social network groups in addressing the individual households' flood predicaments is non-existent. Most flood-related support or relief operations in Ghana are co-ordinated by NADMO in collaboration with state security agencies and other institutions and it is these institutions unfortunately that individuals within flood-prone environments look up to.

Table 6.4: Social Capital as a form of support

Asset	Response	Rural		Urban	
		Freq.	**%**	**Freq.**	**%**
Membership of formal/informal social network group	Yes	349	95.1	250	62.5
	No	18	4.9	150	37.5
	Total	**367**	**100.0**	**400**	**100.0**
Household benefitted/received support from social capital	Yes	302	82.3	89	22.3
	No	65	17.7	311	77.8
	Total	**367**	**100.0**	**400**	**100.0**

Source: Fieldwork (2017)

6.1.5 Location, physical geography and household flood vulnerability

Results from the field study show that majority (57.5%) of respondents in rural Central Gonja have lived in their respective communities for over 20 years. A total of 78.4% have lived in the various communities for over 10 years. In KMA, 19.7 of respondents have lived in their communities for over 20 years with 49.8% living in their communities for over 10 years. It is believed that longer stays in a community may have offered an individual the opportunity to understand the flood circumstance and properly adapt to the area. Such households could possibly be well connected with other community members and institutions or organisations through social networking. Early settlers or older residents, most of whom may be living in their own or family houses, may be less susceptible and more resilient than new comers or residents.

All the study communities in Central Gonja were located along the Black and White Volta, the two main streams that flow through the district (see Figure 6.1). The proximity of these settlements and the generally flat nature of the land put them in a high flood risk situation. Similarly, the proximity of the study communities in KMA to urban drainage systems and effluent streams that traversed the length and breadth of the city expose households to extreme flood vulnerability (see Figure 6.2). This accounts in part for the perennial floods that these households experience. This is further aggravated by extensive concrete surfaces that inhibit permeability anytime it rains.

From Table 6.5, 52.9% of respondents in rural Central Gonja were located less that 100 metres from either the Black or White Volta, while within 200 metres, 96.8% of them had their houses located close to Black or White Volta. The equivalence for KMA were 83.3% and 97.7% for households located less than 100 metres and within 200 metres respectively. The estimated distance (using the pacing method) of each dwelling unit from rivers and streams are captured in Table 6.5. Thus, houses that are located close to either major rivers, streams or stormwater channel or outlet as Du et al. (2010) have observed would be more exposed to floods than those that are located far away from these water bodies but the impact of floods on these households would depend on their sensitivity and resilience (Birkmann et al., 2012). This would also depend on the nature of the relief (highland or lowland) of the settlements relative to the waterbody as well as the size of the waterbody. The relationship is therefore non-linear.

From the DEM for KMA (Figure 6.2), it can be noted that the communities have low elevation relative to the surrounding area. When it rains, the runoff starts from the places of high elevation to these low areas before finding its way to the streams. Similarly, the DEM for rural Central Gonja shows low elevation for the study communities. The generally low elevations for both the urban and rural communities, coupled with their proximity to stream networks render them highly exposed to flood risks. In terms of household exposure, the rural households appeared more vulnerable. This is grounded on the fact that the settlements are not only sited close to relatively larger waterbodies but the relief is generally lower compared to the urban study communities. Besides, the buildings were of the flimsy type. These conditions,

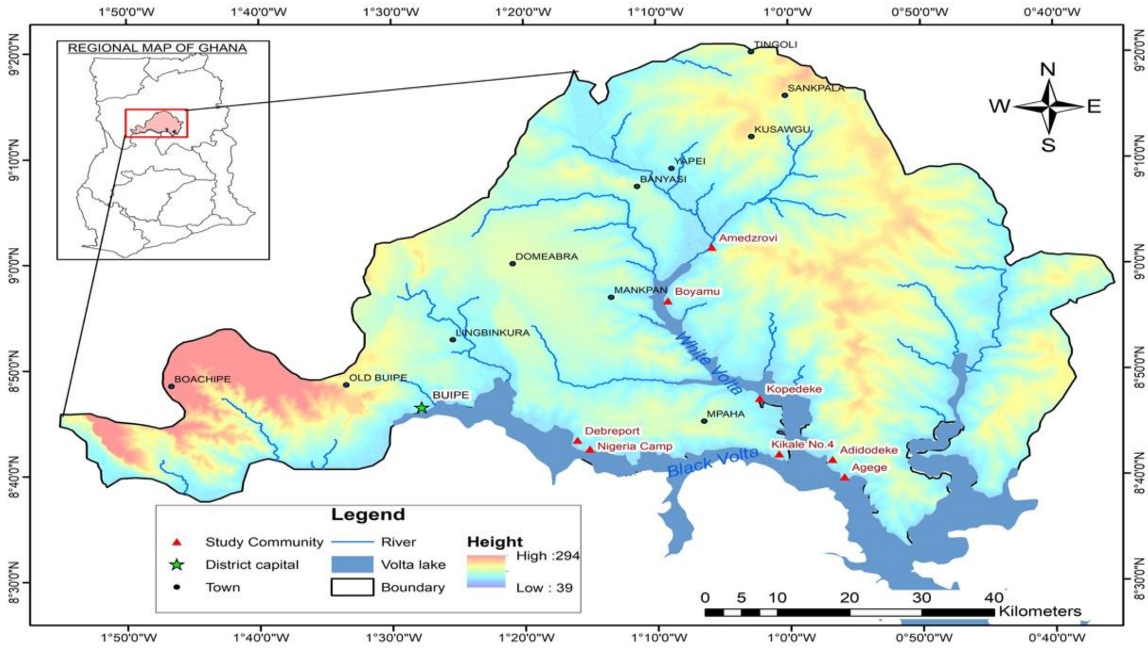

Figure 6.1: Physical context of Central Gonja study communities

(Drawn using SRPM data, USGS) - Source: Fieldwork (2017)

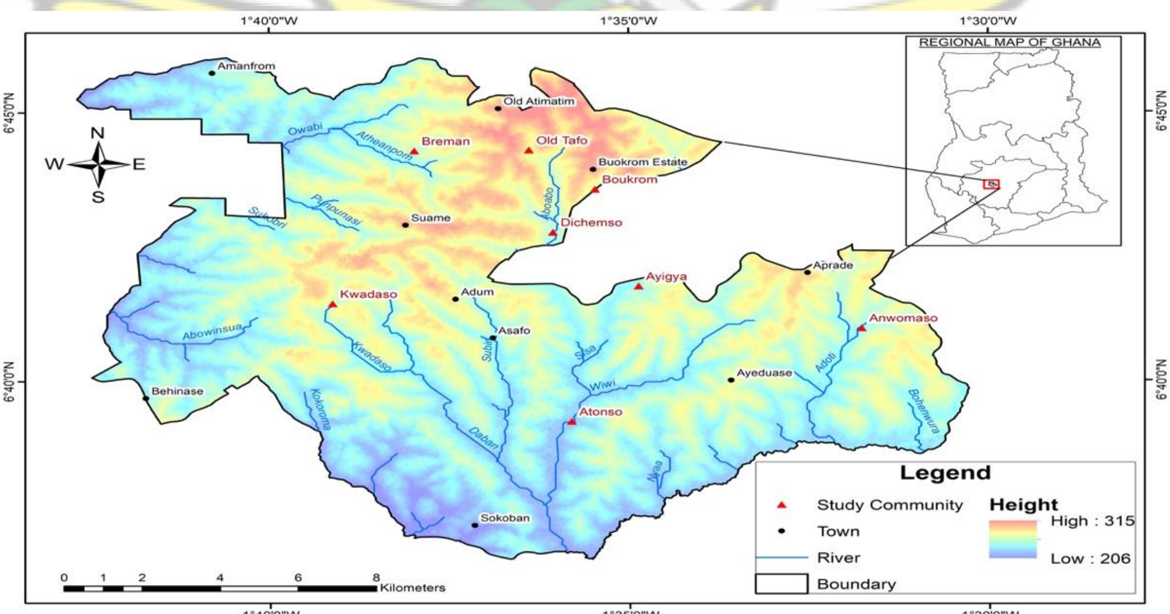

Figure 6.2: Physical attributes of KMA study communities (Drawn using SRPM data, USGS) - Source: Fieldwork (2017)

combined with other characteristics would suggest that the rural study communities were more vulnerable than the urban households.

Related to the above is the issue of settlements location within wetland and waterlogged areas. Negative areas such as natural waterlogged areas and wetlands are generally unattractive to settlement. But poor urban households and some poor farming and fishing communities with strong attachment to their lands and with limited choices sometimes erect their houses close to or within such naturally repulsive areas. The study found that 19.3% of respondents in rural Gonja have been located within or near waterlogged/wetlands while 86.2% of respondents in KMA have their residences located within or near waterlogged/wetlands. This, in addition to locations close to stormwater outlets expose urban settlements to additional risk in terms of flood menace. The nearer they are to waterlogged and wetlands, the higher the flood risks and the farther they are from such negative areas, the lower would their exposure to floods be. This was evident in Atonso S-line, part of Kwadaso Estate in KMA, where houses in waterlogged areas were found to be the worst affected ones.

The dwelling site or the nature of the land surface on which a building is sited could influence its degree of exposure to floods. The research therefore sought information on whether a house is located in a valley, hill top or generally level or plain land surface. From Table 6.5, it is clear that over 76.3% of respondents in rural and 92.8% of urban localities lived in Low-lying area. Arguably, buildings that are sited on elevated ground could withstand flood impact compared with those within valleys or low-lying areas. Low-lying settlements are therefore more likely to face greater risks of flood damage than those on elevated ground (Coppola, 2007; Du et al., 2010). This explains why many settlements along the Black and White Volta in rural Gonja have suffered more devastation from fluvial floods. In KMA, most flood-prone areas as

Atonso S-line, Dichemso, Boukrom, Breman and Old Tafo are also low-lying and so places with frequent flood cases.

One key characteristic of settlements investigated was their accessibility. It was considered whether the place is accessible by road using a vehicle or not. The nature of the road surface (whether motorable or not) and density of settlement (high or low density) were critical considerations. Inaccessible areas or remote villages are more vulnerable as it will make it very difficult for emergency vehicles needing to access flood victims to get to such areas for assistance in the form of evacuation and support services during disaster (see Pyle, 2006). All the Rural flood-prone communities were far away from the District capital, Buipe and off the main Buipe-Tamale highway. While the roads linking them were untarred, circuitous and riddle with potholes, it was only Kikale No.4 and Kopedeke that could be reached without crossing the Black and White Volta. Reaching these communities in the event of floods in time is an impossibility. This condition further makes them vulnerable. The Atonso, Kwadaso, Dichemso, Old Tafo, Breman, Buokrom, Anwomaso and Ayigya communities in Kumasi Metropolis were comparatively accessible by road except the problem of vehicular and human traffic. Thus, the rural communities were more vulnerable to flood risks than the urban ones in terms of accessibility.

Table 6.5: Locational attributes of respondents

Variables	Categories	Rural		Urban	
		Freq.	%	Freq.	%
Length of stay in community	< 5yrs	12	3.3	75	18.7
	5-10 yrs	67	18.3	126	31.5
	11-15yrs	40	10.8	55	13.8
	16-20yrs	37	10.1	65	16.3
	> 20yrs	211	57.5	79	19.7
	Total	**367**	**100.0**	**400**	**100.0**
Proximity to major stream/river	Yes	367	99.5	389	97.3
	No	-	0.5	11	2.7
	Total	**367**	**100.0**	**400**	**100.0**
Approximate Distance from stream/river	< 100	194	52.9	321	80.3
	100-200	161	43.9	70	17.5
	201-300	12	3.3	9	2.3
	> 300	-	-	-	100.0
	Total	**367**	**100.0**	**400**	**100.0**
Located within waterlogged/ wetland area	Yes	71	19.3	345	86.2
	No	296	80.7	55	13.8
	Total	**367**	**100.0**	**400**	**100.0**
Dwelling site	Valley	21	5.7	107	26.7
	Hill/elevated ground	87	23.7	31	7.8
	plain	259	70.6	262	65.5
	Total	**367**	**100.0**	**400**	**100.0**
Proximity to stormwater outlet	Yes	-	-	118	29.5
	No	367	100.0	282	70.5
	Total	**367**	**100.0**	**400**	**100.0**
Accessibility (road and other links)	Accessible	129	35.1	300	75.0
	Inaccessible	238	64.9	100	25.0
	Total	**367**	**100.0**	**400**	**100.0**

Source: Fieldwork (2017)

6.1.6 Housing condition and household susceptibility to floods

As illustrated in the conceptual framework, the nature and materials a building is built of are critical in determining household susceptibility to floods. These include the building itself, the roofing material, the nature of the floor, whether cemented or not and whether buildings have foundations or not. These specific elements were investigated and summarised in Table 6.6. In rural Central Gonja, most of the houses were built from local raw materials, mainly clay and thatch and without foundation. Most of the rooms were not cemented. These were typically flimsy houses that are vulnerable to floods (see Plates 6.1 and 6.2). From Table 6.6, 96.5% of respondents lived in mud house, 56.7% had thatch roof, 43.1%, had their rooms not cemented and none of the buildings had a foundation. These conditions could make them susceptible to floods. Huts made of grass as roofing materials normally leak during rainy seasons and coupled with muddy walls, the destruction by floods becomes great. In KMA, 83% of household surveyed lived in houses built with concrete or cement blocks, 89.3% had their houses they lived in roofed with metallic sheets, 77% had their rooms cemented and 89.5% of the buildings had foundations. These housing attributes may only suggest that the urban folks would be less susceptible to floods compared to their rural counterparts.

Mud, wood and thatch houses are generally more prone to destruction than block houses. This means that households who live in such mud or clay houses would be more vulnerable to severe floods than those living in houses made of cement blocks. The type of roofing material is a key measure of its degree of vulnerability to severe floods from rain storms. Buildings with thatch/grass roofs are more prone to roof leakages and may suffer greater losses than those with metallic sheets. Cemented floors can reduce or prevent water seepage from the underground in locations where the water table is close to the surface. Use of floor tiles (porcelain/ceramic, but not wooden) provides a better alternative. Dwelling units that are not cemented expose households to higher levels of vulnerability. In flood-prone and waterlogged areas or in places where the water table is high, it is expected that building foundations would be high and well-constructed. This prevents seepage of water into the building and also prevents ingress of floodwaters into rooms when the level of floodwater rises. Buildings without or poorly constructed foundations are therefore vulnerable to floods than those with strong foundations. Including this in the vulnerability indicators is absolutely critical. In his study, Nethengwe (2007) found that households in a grass-thatched house were found to be more vulnerable to floods than households in a stone house. Thus, housing quality index as found by Nethengwe (2007) to be a key indicator of flood vulnerability. In terms of housing characteristics, rural households were potentially more vulnerable than the urban households.

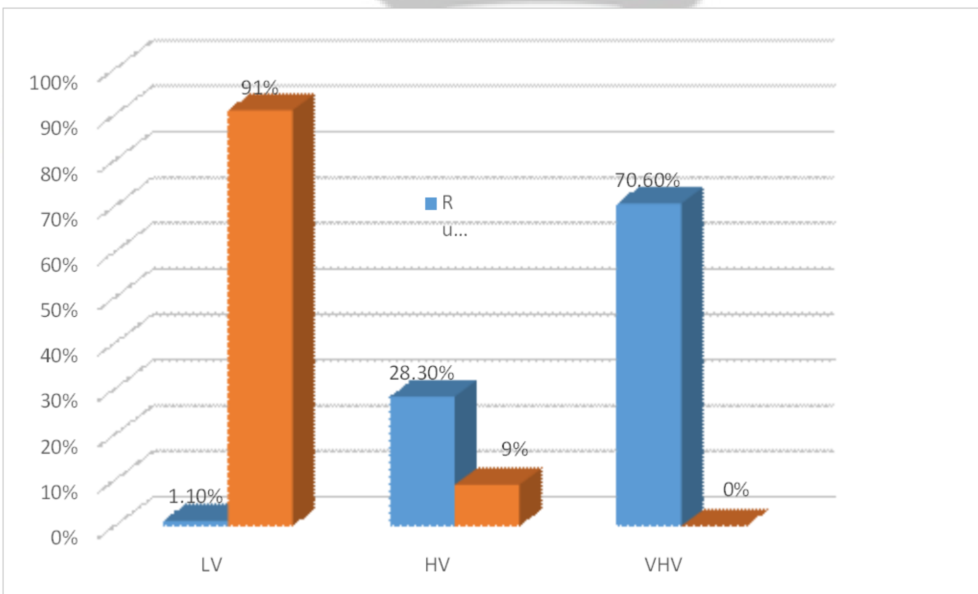

Figure 6.3: Vulnerability by residence using housing quality indicators

Source: Field survey (2017)

Table 6.6: Type and quality of dwelling places of households

Variables	Categories	Rural		Urban	
		Freq.	**%**	**Freq.**	**%**
Building material	Mud	355	96.5	5	1.3
	Stone	-	-	-	-
	Wooden frame	8	2.2	15	3.7
	plastic sheets	-	-	1	0.3
	Metallic sheet	-	-	47	11.7
	Bricks/cement blocks	4	1.1	332	83.0
	Total	**367**	**100.0**	**400**	**100.0**
Roofing material	Plastics sheets	13	3.5	3	0.7
	Grass thatch	208	56.7	-	-
	Metallic sheets	126	34.4	357	89.3
	Roofing Tiles	-	-	35	8.7
	Bamboo	-	-	4	1.0
	Sticks with mud	20	5.4	1	.3
	Total	**367**	**100.0**	**400**	**100.0**
Floor material	Not cemented/bare ground/ clay	158	43.1	19	4.7
	Not cemented but covered with plastic sheets/linoleum	-	-	1	0.3
	Tiled (non-wooden)	1	0.3	21	5.3
	Wooden tiles	75	20.4	48	12.0
	Cemented	133	36.2	311	77.7
	Total	**367**	**100.0**	**400**	**100.0**
Building on foundation	Yes	-	-	358	89.5
	No	367	100.0	42	10.5
	Total	**367**	**100.0**	**400**	**100.0**

Source: Fieldwork (2017)

Plate 6.1: Residential unit, Nigeria Camp
Source: Fieldwork (2017)

Plate 6.2: Residential unit, Agege
Source: Fieldwork (2017)

6.1.7 Vulnerability classes of study communities

Using 19 flood vulnerability indicators, as indicated in the methods section, and a scoring scheme (see Appendix 7) every respondent was placed within a vulnerability class (0%-30%; 31%-69%; 70% and above). From Figures 6.3a and 6.3b, 0.3% rural compared with 26.5% of the urban communities fell within the score of under 31% and represented low level of vulnerability to floods (LV). Within the high vulnerability (HV) category (31%-69%) were 72.5% of urban KMA as against 86.1% of rural Gonja. While only 1% of urban respondents reflected very high vulnerability (VHV), 13% of rural respondents showed very high level of vulnerability (see Figure 6.4). It is clear from the analysis above that majority of both the rural and urban study communities were highly vulnerable to floods with rural Gonja communities showing a higher level of vulnerability. This then validates the second proposition that rural households reflect a higher level of vulnerability to floods than the urban households based on their selected attributes.

Tables 6.7 and 6.8 show cross tabulation of vulnerability class and selected socio-demographic and economic variables for the rural and urban study communities. In terms of sex differences however, a relatively higher proportion of females than males fell within the HV class in KMA than Central Gonja (see Tables 6.7 and 6.8). From educational level point of analysis, there was a higher concentration of respondents with at most basic level of education in rural Gonja (78.2%) in HV group than KMA (42.1%). Additionally, 30.2% of respondents in Central Gonja who were HV fell within the age cohort of 50 years and above. The corresponding figure for KMA was 26.3%. Finally, while 66.2% of HV rural Gonja households earned an average income of GH¢ 300 or less, those of KMA within the same category was

26.3%. This narrative may not be pleasant for this category of respondents in general and rural Central Gonja in particular.

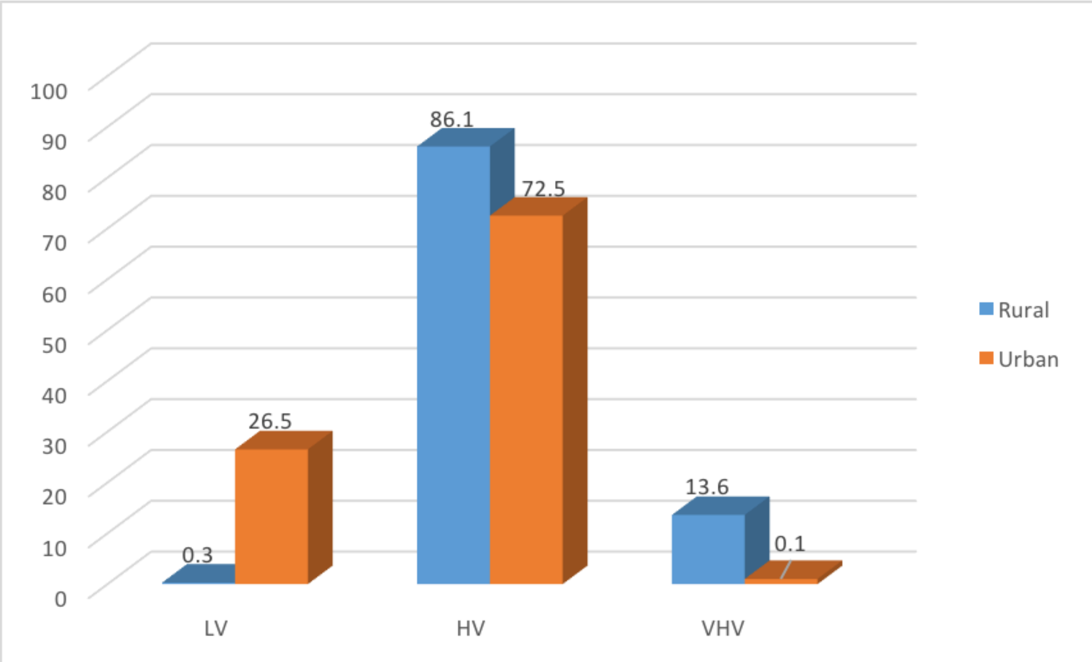

Figure 6.4: Vulnerability of households to floods by locality and class

Source: Fieldwork (2017)

Table 6.7: Vulnerability by class and selected socio-economic attributes of respondents, Central Gonja

Variables	Categories	Vulnerability class			Total
		LV	(HV)	VHV	
Sex	Male	1(0.3)	252(68.7)	38(10.4)	291(79.3)
	Female	-	64(17.4)	12(3.3)	76(20.7)
	Total	**1(0.3)**	**316(86.1)**	**50(13.7)**	**367(100)**
Level of education	No formal education	1(0.3)	185(50.4)	38(10.4)	223(60.8)
	Basic education	-	102(27.8)	13(3.5)	115(31.3)
	Secondary/Technical/Vocational education	-	24(6.5)	-	24(6.5)
	Tertiary education	-	5(1.4)	-	5(1.4)
	Total	**1(0.3)**	**316(86.1)**	**50(13.7)**	**367(100)**
Age of head of household	20-29	-	29(7.9)	4(1.1)	33(9.0)
	30-39	-	90(24.5)	6(1.6)	96(26.2)
	40-49	1(0.3)	86(23.4)	10(2.7)	97(26.4)
	50-59	-	57(15.5)	12(3.3)	69(18.8)
	> 59	-	54(14.7)	18(4.9)	72(19.6)
	Total	**1(0.3)**	**316(86.1)**	**50(13.7)**	**367(100)**
Estimated monthly income	Less than GH¢100	1(0.3)	86(23.4)	20(23.4)	107(29.2)
	GH¢100 -GH¢ 300	-	157(42.8)	12(3.3)	169(46.0)
	GH¢301- GH¢500		24(6.5)	12(3.3)	36(9.8)
	GH¢501- GH¢700		23(6.3)	4(1.1)	27(7.4)
	GH¢701- GH¢900		17(4.6)	2(0.5)	19(5.2)
	Above GH¢900		9(2.5)	-	9(2.5)
	Total	**1(0.3)**	**316(86.1)**	**50(13.7)**	**367(100)**

Source: Fieldwork (2017)

Table 6.8: Vulnerability by class and selected socio-economic attributes of respondents, KMA

Variables	Categories	Vulnerability class			Total
		LV	(HV)	VHV	
Sex	Male	50(12.8)	127(31.8)	3(0.8)	180(45.0)
	Female	56(14.0)	163(40.8)	1(0.3)	220(55.0)
	Total	**106(26.5)**	**290 (72.5)**	**4(1.1)**	**400 (100)**
Level of education	No formal education	1(0.3)	85(21.3)	2(0.5)	88(22.0)
	Basic education	76(19)	83(20.8)	2(0.5)	161(40.3)
	Secondary/Technical/ Vocational education	8(2)	117(29.3)	-	125(31.2)
	Tertiary education	21(5.3)	5(1.3)	-	26(6.5)
	Total	**106(26.5)**	**290 (72.5)**	**4(1.0)**	**400 (100)**
Age of head of household	20-29	2(0.5)	25(6.3)		27(6.8)
	30-39	19(4.8)	70 (17.5)		89(22.3)
	40-49	10(2.5)	90 (22.5)		100(25.0)
	50-59	65(16.3)	45(11.3)	1(0.3)	111(27.8)
	> 59	10(2.5)	60(15.0)	3(0.8)	73(18.3)
	Total	**106(26.5)**	**290 (72.5)**	**4(1.1)**	**400 (100)**
Estimated monthly income	Less than GH¢100	33(8.3)	87(21.8)	1(0.3)	121(30.3)
	GH¢100 -GH¢ 300	30(7.5)	55(13.8)	3(0.8)	88(22.0)
	GH¢301- GH¢500	31(7.8)	63(15.8)		94(23.5)
	GH¢501- GH¢700	4(1.0)	52(13.0)		56(14.0)
	GH¢701- GH¢900	2(0.5)	13(3.3)		15(3.8)
	Above GH¢900	6(1.5)	20(0.5)		26(6.5)
	Total	**106(26.5)**	**290 (72.5)**	**4(1.1)**	**400 (100)**

Source: Fieldwork (2017)

6.2 Summary

The chapter examined rural and urban household vulnerability using their housing conditions, locational attributes as well as their socio-economic and demographic characteristics. Computations from selected vulnerability indicators indicated that rural communities in Central Gonja were more vulnerable to floods than urban settlements of KMA. The second proposition that rural households reflect a higher level of vulnerability to floods than the urban households based on their characteristics was thus validated. The next chapter examines household vulnerability in terms of flood outcomes. It specifically examines effects of floods on rural and urban households.

CHAPTER SEVEN

EFFECTS OF FLOODS IN RURAL AND URBAN GHANA

7.0 Introduction

Chapter six examined vulnerability of rural and urban households in relation to their housing conditions, locational attributes as well as their socio-economic and demographic characteristics. Since vulnerability as defined earlier also relates to the degree of damage, losses or stress households suffer, this chapter examines the actual harm or damage households with differing socio-economic and demographic characteristics suffered due to perennial or periodic floods within rural and urban spatial contexts. Thus, vulnerability is defined by the amount of losses incurred or the amount of health burden households had to bear as a result of floods. Discussion covers immediate, medium-term and long-term effects of floods using both quantitative and qualitative approaches. Effects of floods on households is examined against their socio-economic background why also reflecting rural and urban differences. For Central Gonja, aside the annual inundation of lands immediately bordering the Black and White Volta, the main reference point for the flood impact analysis has been the 2010 flood disaster. For KMA, flooding is an annual phenomenon and so households' accounts were based on their most harrowing experience and vary from one community to another.

7.1 The power of floods and destruction of household assets

In 2010 for example, floods affected 112 settlements, destroyed 6185 houses, displaced 33,305 people, destroyed 42,883 farms (NADMO-Central Gonja, 2010) (see

Table 7.1). The number of affected people in the study communities by sex and household in Central Gonja is shown in Table 7.2.

Table 7.1: August- November 2010 Floods, Central Gonja District

Categories affected	Number/acreage affected
Affected community	112
Displaced Persons	33,305
Collapse Houses	6185
Affected Schools	65
Destroyed Farms (acres)	42,883
Totally Submerged Communities	25
Affected animals (sheep's, pigs, goats)	1,109
Lives lost	02
Submerged bore-holes	15
Submerged public toilets	03

Source: NADMO Central Gonja (2010)

Table 7.2: Number affected by 2010 floods by community, sex and household, Central Gonja

Names of communities	**Number affected**		
	Male	**Female**	**Household**
Debre port	130	78	11
Nigeria Camp	114	112	22
Kikale (No.4)	780	812	97
Adidodeke	171	170	39
Amedzrovi	130	150	35
Bonyamu	162	170	35
Kopedeke	177	184	47
Agege	250	236	97
Total	**1914**	**1912**	**387**

Source: NADMO-Central Gonja (2010)

Perennial floods have also devastated many households in Kumasi Metropolis destroying property and dislodged many in the process. The number of flood cases and number of victims keep increasing. In 2012, Kumasi Metropolis registered 7 flood cases and an estimated number of 391 people affected. In 2017, the number of cases and number of people affected shot up to 38 and 3236 respectively (NADMO-Kumasi, 2017 (see Table 7.3).

Table 7.3: Flood cases, number and affected communities

Year	Number of cases	Number of People affected	Some affected communities/Areas
2012	7	391	Ayigya Zongo, Oforikrom New site, Sepe Aprapram
2013	12	645	Asuyeboah, Ayigya Zongo, Gyinyase, Anwomaso,
2014	04	614	Buokrom, Anwomaso, Anwomaso, Oforikrom New site, Atoso S-Line, Saase, Bomso, Breman,
2015	10	1757	Buokrom, Yennyawso, Moshie Zongo, Atonso S-Line, Ahinsan Bonsum and Estate, Anwomaso
2016	17	2990	Oforikrom, Moshie Zongo; Anwomaso, Dichemso, Buokrom South, Ahinsan Estate, Krofrom East and West, Adoato, Pankrono, Kwadaso Nuom
2017	38	3236	Atoso S-Line, Kwadaso Estate, Kronom, Abrepo, North Suntreso, Adoato, Buokrom, Krofrom, Dichemso, Breman West, Afful Nkwanta, Moshie Zongo, Pankrono Estate, Chirapatre

Source: Compiled from NADMO-KMA (2017)

Field study revealed that floods have affected household's assets in the form of buildings, fence walls and other personal effects. In rural Gonja, many buildings were found destroyed due to the past floods episodes. While some also showed cracks or structural damage, most were found to have been abandoned (see Plates 7.1 and 7.2). The economic losses associated with this cannot be underestimated. From Table 7.4, over 70% of respondents in both rural Gonja and urban KMA indicated that floods have had damaging effects on their buildings. While only 27.8% of the respondents in Central Gonja lost electrical and electronic domestic assets, 70.3% lost similar appliances in KMA. Other affected asset categories included beds and bedding, documents, clothing and furniture. Since most of the communities covered in rural

Gonja were not connected to the national electricity grid, and fetched water from either the Black and White Volta, the issues of flood-induced power interruption and water disruption did not apply to majority of the respondents. While the same condition did not apply in KMA, there were cases where for safety reasons, electricity supply had deliberately been cut to households in flood-prone communities (e.g. Atonso S-line) by Electricity Company of Ghana (ECG). This was to prevent the likelihood of electrocution in the event that floodwaters got into compounds and rooms of inhabitants. Perhaps the fact that erratic water supply and frequent power cuts in urban Ghana (generally referred to as 'dumsor') became part of the daily rhythm of life of people even in the absence of floods, it was difficult for respondents in KMA to link these problems to floods.

Damage to a building can have far reaching psychological, social and economic consequences. Total collapse means one is rendered homeless. Relocating to stay with relatives or friends away from one's original place of domicile can create a big discomfort and psychological malaise. The need to look for money to put up entirely a new house or repair damaged portions of a building can be a strain on already overstressed income of poor households. In rural Gonja district, where all respondents either lived in their own or family houses (see Table 6.3, chapter 6), any loss or damage to building constitutes a huge economic loss to the individual that has the tendency of keeping poor households in never-ending penury. This was what a discussant said at Nigeria Camp:

> *I was staying over there (pointing to a place close to the Black Volta), a bit closer to the river until the 2010 floods disaster. I could not salvage anything; everything of mine were lost. We had to relocate three times to our present location. The floods had no mercy. (A Male discussant, FGD)*

At Debri port a female discussant noted:

> *My son, I lost my house on two occasions. I was driven out from my original house during the devastating floods in 2007 when the floods came. Our house was eventually submerged. The most damaging one occurred when I was away in Navrongo in 2010. The flood destroyed all my valuables. Nothing was left for me to take away. It was a harrowing experience for me and my household. (Female discussant, FGD)*

Perennial floods also had devastating effects on households in Kumasi Metropolis. Flooding of compounds and rooms were widespread. The number of days affected people lived under flood conditions varied greatly depending on location and severity of floods but ranges from 14 days to 64 days. In their study, Campion and Venzke (2013) found that it took twenty days for floodwater to dry up in some suburbs of Kumasi while it exceeds a month in some cases for floodwater to recede. Several abandoned buildings were also observed in KMA especially in Atonso S-line as a result of constant floods and flooding of compounds and rooms (see Plates 7.3, 7.4 and 7.5), where the original owners and occupants had evacuated as they could no longer cope with the fight against the floods. In the place of the original owners were found new generations of urban dwellers, who occupy these buildings for free. The immediate effect was that people were rendered homeless when their houses collapsed due to floods or were forced to relocate temporally to stay with friends or relatives. In the medium to long term, households may have to go through the trouble of raising money to secure a new place of residence by renting or putting up entirely new building. In situations where households were unable to relocate due to economic and other reasons, they have had to put up with the threats of floods.

Besides, the effects of stream erosion on residential facilities were also evident (see Plate 7.6). Frequent flooding in urban streams increases channel and bank erosion. Where channels have been straightened and vegetation has been removed from channel banks, streamflow velocities tend to increase. This enhances the capacity of the stream to transport more sediment. Using its load (rock materials embedded in the stream) and the stream's own force (hydraulic action) the stream is able to widen its channel. This undermines the foundations of buildings and eventually pulling them down. In Ayigya Zongo, scores of houses dotted along the Sisa river have either collapsed, or on the verge of collapse due to lateral erosion of the river channel. Many households expressed their worry and lived in fear. This is what a 62-year old man said in respect of stream erosion of his building foundation in an in-depth interview.

> *Half of my house is almost gone. The stream used to be small and flowed within a narrow channel far away from my residence. Over the years, this Sisa stream has expanded so much that my house is under threat of total collapse. My major headache is that I am quite old now and financially incapable of stopping the stream from destroying my house. I arranged for sawdust to be deposited in the valley to redirect the course of the river but did not yield results. When the volume of water in the channel increases, it is really scaring. I really need your help. (Male, Ayigya)*

Another respondent noted:

> *We don't have our peace here at all. The river keeps widening. The constructed drain is too narrow so the river has taken a different course. Can you see…it is not passing through the culvert. Now our houses are under threat. (Male, Ayigya)*

At Atonso S-line a discussant had this to say:

> *I remember two years ago our compound got flooded while we were all away. It rained so heavily that almost everybody's compound became flooded. The floodwater got to the window level and it took days for the water to recede. Almost everything in my room got soaked and destroyed. Nothing was spared but the most painful and irreparable loss was damage to the certificates of two of my children and my wedding pictures. (Male, FGDs)*

Table 7.4: Flood-induced household property damage by asset categories and settlement type

Flood-affected asset Categories	Rural		Urban	
	No	Yes	No	Yes
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Floods caused destruction/damage to household building/fence wall (structural damage).	78(21.3)	289(78.7)	118(29.5)	282(70.5)
Floods caused damage to household electrical and electronic appliances – radio, TV, computer, mobile phones refrigerator, etc.	265(72.2)	102(27.8)	119(29.8)	281(70.2)
Floods destroyed other household property e.g. books, documents, beds & bedding, furniture, clothing etc.	166(45.2)	201(54.8)	95(23.8)	305(76.2)
Floods disconnected household from water supply/ disrupted water supply	306(83.4)	61(16.6)	349(87.3)	51(12.7)
Floods disrupted power supply	336(91.6)	31(8.4)	312(78.0)	88(22.0)

Source: Fieldwork (2017)

Plate 7.1: Abandoned buildings (Kopedeke)
Source: Fieldwork (2017)

Plate 7.2: Ruins of floods (Nigeria camp)
Source: Fieldwork (2017)

Plate 7.3: Abandoned houses due to floods (Atonso S-line)
Source: Fieldwork (2017)

Plate 7.4: Relics of floods (Old Tafo) -
Source: Fieldwork (2017)

Plate 7.5: A flooded compound (Atonso S-line)
Source: Fieldwork (2017)

Plate 7.6: Flood-induced undermined building (Ayigya Zongo)
Source: Fieldwork (2017)

7.2 Economic effects of floods: The evil and the good in rural and urban Ghana

7.2.1 The evil of floods

Economic effects of floods on the study communities are diverse and far-reaching. The economic effects of floods were both direct and indirect. It is a fact that the year 2010 was the most recent extensive and devastating floods recorded in Central Gonja. From Table 7.4, 78.7% respondents in rural Central Gonja indicated damage to their buildings as a result of floods as against 70.5% in KMA. The proportion of rural Gonja who lost household appliances and other property were 27.8% and 54.8% respectively. In KMA, the proportion with loss of appliances and other property were respectively 70.2% and 76.2%. As indicated earlier, the need to look for money to put up entirely a new house or repair damaged portions of a building could have serious economic implications for victims. The loss or damage to a dwelling place thus constitutes an indirect economic loss. The same applies to other household assets damaged by floodwaters. Households would have to look for money to purchase lost items. This, as the respondents indicated added to their already stressed household budget. In KMA, where some of the buildings were for rental purpose, flooding condition meant lower economic returns to the affected landlords since such property would obviously attract relatively lower rents. In situations where the buildings collapsed or became unusable due to persistent floods, direct economic losses to owners of these property are obvious.

Floods also disrupted businesses, damaged crops, livestock, fishing nets and boat. The number of people in both rural Gonja and KMA who reported one form of loss or the other as shown in Table 7.5 is very high. Compared with rural Gonja, the urban households were less affected in terms of disruption of business, crop damage and livestock destruction. This is not strange as urban economic activities are generally not tied to the land. Indeed, farming is not the main economic activity in the urban milieu and fishing is non-existent in the communities studied. Respondents were asked to give estimated cost of lost or damaged assets due to floods. Damage to productive assets was estimated on the basis of what the particular lost asset would have fetched if sold in the market. These estimates were weighed against the type and number of assets claimed to have been lost and where possible cross-checked with a second person from the same village before recording. This was to ensure that these self-reported estimates were fairly accurate and reliable. Based on these estimates, over 40% of respondents in rural Gonja indicated losses in excess of two-thousand Ghana Cedis (GH ¢2,000), with amounts in some specific cases exceeding 4,000 Ghana Cedis (Table 7.6). In KMA, however, 66.3% of the respondents incurred losses ranging from 501 to 1,500 Ghana Cedis. Only 12% incurred losses exceeding 2,000 Ghana Cedis. The estimated economic losses in rural Gonja therefore exceed that of KMA. This is at variance with the proposition that urban households are more vulnerable in terms of flood-induced economic losses than rural households. This finding however supports Rasid and Haider (2002) who in their study of the Red River basin flood of 1997 found rural residents to have incurred significantly greater losses compared to urban residents with types of damage experienced by the two respective groups also being different.

It is noteworthy that not all respondents reported losses from floods disaster or perennial floods. Only 320 (87%) of the rural population and 317 (79%) of the urban communities reported of losses as shown in Table 7.6. The estimated economic losses from some households especially the Central Gonja may appear excessively high. While due diligence, as a researcher, was done in the field to ensure near accurate results, expectations of support through sympathy from the research team could possibly have made some respondents to exaggerate their losses. In such minor cases, it was difficult beyond the measures taken in the field to independently and accurately verify these claims. This however would not affect the validity and reliability of the overall estimated losses captured in this thesis.

Table 7.5: Flood-specific direct economic damage by settlement type

Affected area	Rural		Urban	
	No	Yes	No	Yes
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Floods caused disruption of household business/economic activities	108(29.4)	259(70.6)	245(61.3)	155(38.8)
Floods caused damage to farm/crops	52(14.2)	315(85.8)	392(98.0)	8(2.0)
Floods caused destruction to livestock/domestic birds	208(56.7)	159(43.3)	386(96.5)	14(3.5)
Floods caused damage to fishing nets	153(41.7)	214(58.3)	400(100.0)	-
Floods caused damage to fishing boats/canoes	175(47.7)	192(52.3)	400(100.0)	-

Source: Fieldwork (2017)

Table 7.6: Estimated cost of household items lost by locality

Locality	**Estimated cost (Gh. Cedis)**					**Total**
	≤ 500	501-1000	1001-1500	1501-2000	> 2000	
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Rural	25 (7.8)	51 (15.9)	62 (19.4)	43 (13.4)	139 (43.4)	320 (100.0)
Urban	20 (6.3)	94 (29.7)	116 (36.6)	49 (15.5)	38 (12.0)	317 (100.0)

Source: Fieldwork (2017)

The economic effects of the 2010 Central Gonja floods from the respondents' own narratives are captured below. A discussant at Amedzrovi was worried about economic losses sustained over the years due to floods. This was what he said in a focus group discussion:

Farming along the banks of the White Volta is unsafe as a result of the floods. The floods come when it wants to come and we (farmers) cannot stop it. It is not possible to predict when floods would occur or not. As a way of safeguarding our crops from rampaging floods we tried sometimes to cultivate our crops earlier in the year. In most cases however, our crops were destroyed by floods anytime it occurred. (Male participant, FGD)

The story was not different in other communities. In Bonyamu, a participant pointed this out:

It seems to me that, the flood is following my family. After destroying my compound house and all valuables in 2007, my entire 12-acre new farm was not spared again in 2010. We cannot predict what will happen next. (Male respondent, IDI)

Other discussants noted this:

This enemy (referring to the floods) ended my business. I lost all my life-time savings. I used to buy fish from here and to sell at Buipe and Kumasi. Frequent past floods had swept away my fortunes. I now depend on my son who is into fishing. But the fishing nowadays is not economically rewarding. (Female, FGDs, Debri Port*)*

Another respondent added:

The floods I witnessed about seven years ago was too frightening. Would you believe that when the floodwater entered our house, snakes accompanied it? Actually, nothing was left unaffected by the floods. My current location was occasioned by floods, if not for the Whites (WONCON LTD) who gave me this store (metallic structure), I would have relocated long time ago. (Male, FGD*, Debri port)*

When the waters came, everything became messy. This whole area down there came under water. The original settlement was submerged. I lost everything including my farm and my fishing equipment. (Male, FGD, Kikale No.4)

In KMA, discussants also reported of economic losses they suffered due to actions of floods. They noted that perennial floods have affected them through loss of property they toiled to acquire which to them run into thousands or millions of Cedis. At Atonso S-line, a participant had this to say:

> *My brother! Look at the three buildings there. Don't you see they are similar in design as the one we are occupying now? We had to abandon them because of floods. The building still stands but can't be used by anybody. This is a huge investment that would have been earning us income through rental charges. We've simply toiled in vain. (Male participant, IDI)*

This is one of many other victims who abandoned their attractive apartments due to floods but who were not there to be spoken to because they have long relocated. At Kwadaso estate, a participant took the research team round his rented house and his supposed bed room. This was completely inundated. He narrated how floods on several occasions destroyed his and other peoples' assets bringing him almost all the time to a starting point. Recounting his bitter experience, a 58-year old man noted:

> *It is not easy for me at all. I am a phone repairer and so always bring some of these phones home to work on. Last year, floods came and destroyed everything of mine. The rain started late in the evening when nobody expected it. We were all asleep and before we could wake up, the whole room was flooded. Some of the phones got spoilt as a result. There was no way that I could convince my customers who insisted that I replace their phones for them. This was a difficult moment in my life. (Male participant, IDI)*

The current research shows that both rural and urban flood-prone communities are at risk of adverse economic losses in the event of future floods. The level of risk, individual vulnerability and losses from flood incidences in rural Central Gonja has been exacerbated by their poor quality of the houses. Similarly, the generally poor quality of the buildings and housing conditions coupled with lack of planning and enforcement of wetland management plans (Campion and Venzke, 2013) predispose urban households to economic losses. The current research shows that the study populations (both rural and urban) are among the most vulnerable groups in Ghana, from economic point of view. Their generally low financial income and the poor housing conditions lend ample credence to this.

7.2.2: The good in evil of floods: A diverging point for rural and urban households

In all the communities studied in KMA, no single respondent said anything good about floods. Perennial floods have largely been a curse to these urban households. In Central Gonja however, flooding is both a blessing and a curse but more of a blessing to them than a curse. From the majority of respondents' narratives perennial floods promote their economic activities. Majority of the respondents, being fisher folks were unhappy about the low level of water in the Black and White Volta these days. As they indicated, the low water in these rivers has bedevilled their fishing operations. They lamented about the difficulty in getting fish after toiling the whole day. Although they did not wish for catastrophic floods of the magnitude recorded in 2007 and 2010, it is the desire of the majority that floods occur every year. The absence of floods, the respondents indicated, has significantly led to low fish catch with implications for their economic wellbeing. This has led to different methods of adaptation in the form of livelihood diversification into farming, charcoal burning and seasonal migration to places like Yeji and Buipe. This was the view of a male discussant at *Kikale No 4.*

> *Those days, the floods used to be problematic. But I think we need it now. Fishing is no longer profitable as catches are no longer heavy due to absence of floods. Floods come plenty of fish which favour we fishermen. We are able to have heavy fish catch and we simply can no longer wait for it. (Male participant, FGDs)*

The discussant continued:

> *Have you seen the empty houses? You may think that it is floods that have chased people out of their homes. On the contrary, people have temporarily relocated to other places due to low fish catch from our side of the river for economic sustenance.*

The views of discussants at Bonyamu reflect similar sentiments. One discussant maintained:

> *…Nothing but fishing is the occupation we cherish. As long as we get plenty catch from the floods, the destruction to the crops will not be a major blow to my family income…I will not event have the time for farming but will concentrate on fishing and fishing only. (Male, Kikale No.4)*

Another discussant at Debri port said:

> *We like and want floods to come…We would get plenty of fish to catch which means plenty of money. With flooding, the fishing business becomes very profitable despite the fact that it sometimes destroys our crops. This community likes the floods especially my colleague fishermen. (Male participant, FGDs)*

At Agege, the chief of the Ewe community had this to say:

> *Our main work here is fishing…It is fishing that brought us here. With the construction of the Bui dam on the Black Volta, the water level has reduced affecting significantly our fishing business. We are praying for the floods…It is our prayer that the water level rises again. (Male participant, IDI)*

Beside fishing, farming (both arable and pastoral) is an important economic activity in the Gonja. While farming is a full-time occupation to some respondents, it is a supplementary livelihood activity for the fisher folks, most of whom are Ewes. In other words, fisher folks also doubled as farmers mainly because of reduced fish catch and the need to augment household income to maintain a certain minimum living standard. Farming, as respondents alluded to, however thrives well on rich alluvial deposits brought by annual inundation of low-lying lands bordering the Black and White Volta. The absence of floods, to the majority of respondents, is additional setback to their farming operations. In the communities along the Black Volta, this was attributed to the Bui Dam, the construction of which has led to a significant reduction in the volume of water in the river. However, communities along the White Volta may be at serious risk of getting their crops destroyed through inundation in the event of heavy rainfall and the opening of the Bagre dam in Burkina Faso. There are however two options available to these farmers. The first one, which they pointed out, is to plant early so that harvesting can be done in due time to avoid any loss from flooding. The second option is to locate farms on higher grounds away from the river banks. The challenge however with the second option as the farmers indicated is destruction of their crops by Fulani herdsmen. This is the view of a frustrated Ewe farmer/fisherman in Adidodeke:

> *We can't do anything to these animals because we are settlers. The cattle belong to the Gonjas and the Fulanis only take care of them. Any attack on these animals means an attack on the landowners (the Gonjas). They will fight and drive us out of their land. We are really suffering my brother. (Male participant, IDI)*

A Similar worry was expressed by a farmer at Bonyamu:

> *Floods used to be our major problems in the past. We could lose acres of our cropped land. Because of this some of us decided to go upland where floodwaters could possibly not reach. But there came another problem – the Fulani nomadic herdsmen – whose cattle destroy our crops. Even when we tried to fence our farms off, these animals would still find their ways into the farms. We are suffering. (Male discussant, IDI)*

A discussant at Adidodeke said.

> *Now that fishing here is not all that profitable, the main source of livelihood is farming. The Fulani herdsmen would also not give us a peace of mind. (Female discussant, FGD)*

7.3 Health effects of floods

7.3.1 Floods and physical health: Empirical study of rural Gonja and KMA

One immediate impact of floods is mortality, which comes about mainly through drowning or collapse of building due to force of floods. In the current study, only a few households reported of flood-induced mortality. For the rural communities, 4 (1.1%) said they lost members as a result of drowning while the proportion of urban households with flood-related deaths is 21(5.3%) (see Figure 7.1). The research however found no cases of flood-related physical injuries in both the rural and urban communities.

Floods pose serious health problems to households in the medium-term in a number of ways. Several reasons may account for increased risk of communicable diseases during flooding. Contamination of water sources can expose households who may not have in-house water supply to faecal-oral diseases including diarrhoea, cholera and other gastrointestinal health problems (see Few, 2003; Milojevic et al., 2012). Stagnant water provides a breeding ground for many vectors, such as mosquitoes, which can lead to a rise in malaria cases (El-Sayed et al., 2000). From Table 7.7, 32.7% of rural households as against 59.5% of urban households suffered from flood-related health ailments. Major diseases mentioned by respondents included diarrhoea, malaria, psychological health problems, with flood-related psychological health problems being the dominant one respondents complained about in both rural and urban study communities. Next to this is diarrhoea and malaria. Although one could not independently establish the veracity of these self-reported ailments, due to their connection to multiple risk conditions and route causes, the case of diarrhoea may be due to contamination of water bodies, some of which serve as households' sources of domestic water. Contaminated water sources according to Casteel et al. (2006) are associated with waterborne disease transmission pathogens, including Escherichia coli, Shigella, Salmonella, and hepatitis A virus. In rural Gonja, for instance, the sources of domestic water are the Black and White Volta. There were no wells or pipe-borne water supplies. Open defecation and use of open pit-latrine were widespread which may serve as risk factors for disease infection during serious flood situations. While the level of risk may be low because the population of these communities are not as high in absolute and density terms, these practices are unhealthy. In the urban communities of KMA, contamination could arise from the generally poor environmental sanitation. Flooding of open sewers or floodwater running through uncollected municipal waste are not uncommon. As noted by Du et al. (2010), floodwaters may contaminate local water and food supply and damage the sewage system resulting in contamination and increase the potential for communicable diseases. Lack of clean water, overcrowding, lack of personal and domestic hygiene, nutritional deficiency, and overall poor sanitation are the major contributing factors for the spread of diarrheal diseases (Sur et al., 2000). It is however difficult to establish a link between these various diseases and flood incidence since they are part of daily health problems reported at Out Patients Department (OPD). To isolate the influence of other conditions on the various household disease burdens would be a daunting task. In terms of flood-related deaths and physical health problems, urban households were more vulnerable compared to the rural households. This therefore does not support the proposition that rural households show a higher level of vulnerability to flood-related physical health than the urban households.

Scientific studies have reported post-flood increases in cholera (Sur et al., 2000), nonspecific diarrhoea (Heller et al., 2003) and typhoid and paratyphoid (Vollaard, 2004). In Indonesia, for example, Vollaard et al. (2004) found flooding of the home to increase paratyphoid fever. The study by Kunii et al. (2002) in Bangladesh shows a substantial impact on the health of the communities affected and caused a particularly high incidence of diarrhoea and respiratory problems (Kunii et al., 2002). Reacher et al. (2004) reported an increase in self-reported gastroenteritis in United Kingdom following the Lewes floods of 2001 while the work of Tapsell et al. (2002) reported cases of diarrhoea, stomach upset and other types of infection following the 2000 floods in northeast England. A rise in malaria cases after floods were reported in several countries in Latin America (Ahern et al., 2005) and Mozambique (Kondo et al., 2002).

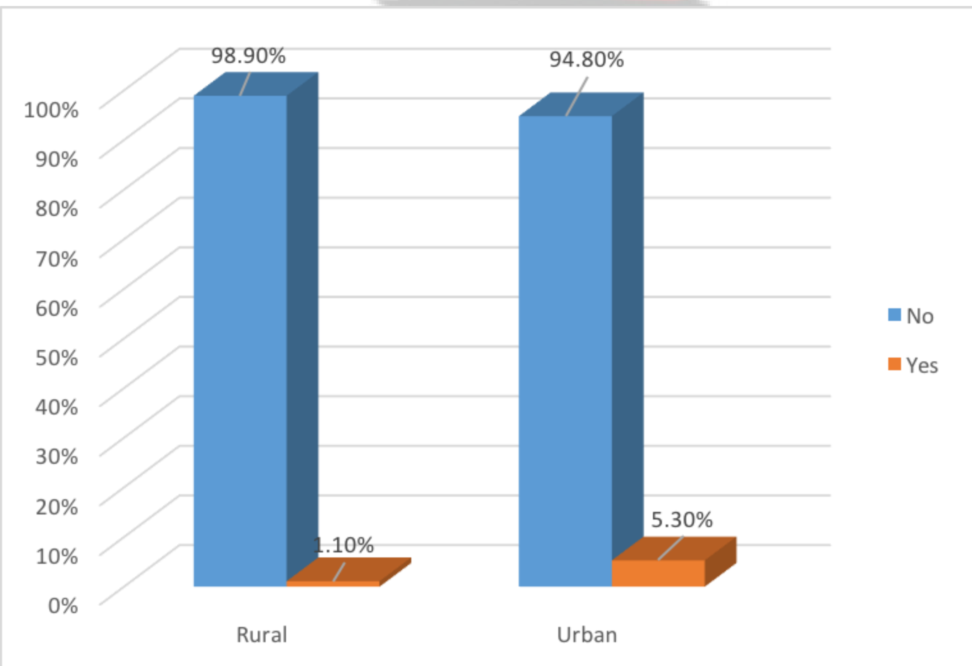

Figure 7.1: Floods and household mortality

Source: Fieldwork (2017)

Table 7.7: Health effects of floods

Effects	Categories/responses	Rural		Urban	
		Freq.	%	Freq.	%
Household suffered from flood-related health problem in recent time	No	247	67.3	162	40.5
	Yes	120	32.7	238	59.5
	Total	**367**	**100.0**	**400**	**100.0**
Floods caused stress/ psychological health problems	No	110	30.0	79	19.8
	Yes				
	Total	**298**	**81.2**	**296**	**74.0**
		367	**100.0**	**400**	**100.0**
Specific flood-related diseases suffered by household	Diarrhoea	120	44.6	210	31.5
	Cholera	2	0.7	5	0.8
	Typhoid	32	11.9	180	27.0
	Malaria	102	37.9	233	35.0
	Skin infections	8	3.0	13	2.0
	Respiratory disease	5	1.9	25	3.8
	***Total = multiple response**	***269**	**100.0**	***666**	**100.0**

Source: Fieldwork (2017)

7.3.2 Floods and psychological health effects

The effects of flooding on people's health and general well-being can continue for many months after the actual flood event (Tapsell et al., 2002). Mental health problems may be linked to physical health problems or from personal losses, social disruption, and economic hardship (Ahern et al., 2005). Loss of treasured possessions during flood event can be heart-breaking, and much more significant than financial losses, which are now commonly recovered through household insurance policies (Penning-Rowsell and Green, 2000).

The study found that flood-prone households experience flood-induced psychological health problems or an aggravation of existing blood pressure-related health conditions resulting from losses from floods with rural households showing a higher psychological health burden than the urban households. Again, from Table 7.7, 81.2% and 74.0% of respondents in Central Gonja and KMA respectively suffered one form of psychological health problem or the other. In Table 7.8, it is obvious that for all psychological health related questions, majority of respondents in rural Gonja were stressed up either most of the time and all of the time in rural study communities. As regards how often respondents felt depressed due to floods for example (item 7), 84.7% indicated most of the time and all of the time. This is comparatively higher than the urban response of 42.3% (see Table 7.9). This is consistent for the rest of psychological health indicator questions. With regard to the long-term psychological effects of floods therefore, the rural households were more burdened than the urban households. The results validate the proposition that rural households show a higher level of vulnerability to perceived flood-induced psychological health problems than the urban households. The reasons are difficult to find. As indicated earlier, rural households, suffered higher economic losses than the urban households. Considering rural households' low economic background, loss of valuable items and sources of livelihood they toiled for years to acquire in the wake of floods was a major source of worry and psychological distress for many of them.

Table 7.8: Flood-related psychological health problem, Central Gonja

Questions (K-10 Items)	None of the time (1)	Little of the time (2)	Some of the time (3)	Most of the time (4)	All of the time (5)	Total
1. During the period of flooding about how often did you feel tired out for no good reason?	2 (0.5)	2 (0.5)	25 (6.8)	195 (53.1)	143 (39.0)	367 (100.0)
2. During the period of flooding about how often did you have thoughts of killing yourself?	1 (0.3)	7 (1.9)	39 (10.6)	168 (45.8)	152 (41.4)	367 (100.0)
3. During the period of flooding about how often did you feel so nervous that nothing could calm you down?	0 (0.0)	14(3.8)	34 (9.3)	166 (45.2)	153 (41.7)	367 (100.0)
4. During the period of flooding about how often did you feel hopeless?	1 (0.3)	5 (1.4)	54 (14.7)	172 (46.9)	135 (36.8)	367 (100.0)
5. During the period of flooding, about how often did you feel restless or fidgety?	2 (0.5)	7 (1.9)	32 (8.7)	195 (53.1)	131 (35.7)	367 (100.0)
During the period of flooding, about how often did you feel upset by little things?	1 (0.3)	7 (1.9)	60 (16.3)	139 (37.9)	160 (43.6)	367 (100.0)
7. During the period of flooding, about how often did you feel depressed?	0 (0.0)	6 (1.6)	50 (13.6)	155 (42.2)	156 (42.5)	367 (100.0)
8. During the period of flooding, about	0 (0.0)	11 (3.0)	59 (16.1)	171 (46.7)	126 (34.3)	367 (100.0)

how often did you feel that everything was finished?						
9. During the period of flooding, about how often did you feel so sad that nothing could cheer you up?	1 (0.3)	16 (4.4)	58 (15.8)	186 (50.7)	106 (28.9)	367 (100.0)
10. During the period of flooding, about how often did you feel worthless?	8 (2.2)	21 (5.7)	63 (17.2)	140 (38.1)	135 (36.8)	367 (100.0)

Source: Fieldwork (2017)

Table 7.9: Flood-related psychological health problem, KMA

Questions (K-10 Items)	None of the time (1)	Little of the time (2)	Some of the time (3)	Most of the time (4)	All of the time (5)	Total
1. During the period of flooding about how often did you feel tired out for no good reason?	9 (2.3)	45(11.3)	135(33.8)	146(36.5)	65(16.3)	400(100.0)
2. During the period of flooding about how often did you have thoughts of killing yourself?	7(1.8)	40(10.0)	122(30.5)	162(40.5)	69(17.3)	400(100.0)
3. During the period of flooding about how often did you feel so nervous that nothing could calm you down?	17(4.3)	38(9.5)	161(40.3)	141(35.3)	43(10.8)	400(100.0)
4. During the period of flooding about how often did you feel hopeless?	26(6.5)	37(9.3)	179(44.8)	118(29.5)	40(10.0)	400(100.0)
5. During the period of flooding, about how often did you feel restless or fidgety?	12(3.0)	38(9.5)	139(34.8)	152(38.0)	59(14.8)	400(100.0)
6. During the period of flooding, about how often did you feel upset by little things?	15(3.8)	45(11.3)	155(38.8)	131(32.8)	54(13.5)	400(100.0)
7. During the period of flooding, about how often did you feel	18(4.5)	56(14.0)	157(39.3)	125(31.3)	44(11.0)	400(100.0)

depressed?						
8. During the period of flooding, about how often did you feel that everything was finished?	29(7.3)	66(16.5)	150(37.5)	109(26.5)	49(12.3)	400(100.0)
9. During the period of flooding, about how often did you feel so sad that nothing could cheer you up?	31(7.8)	57(14.3)	142(35.5)	131(32.8)	39(9.8)	400(100.0)
10. During the period of flooding, about how often did you feel worthless?	97(24.3)	79(19.8)	97(24.3)	79(19.8)	48(12.0)	400(100.0)

Source: Fieldwork (2017)

During the focus group discussions and in-depth interviews, respondents were given the opportunity to share their personal flood-induced stress or psychological health problems. These stress or psychological health problems discussed here represent respondents' narratives of life experiences. Their narratives and discussions centred around their traumatic experiences with floods using the following symptoms generally associated with Posttraumatic stress disorder (PTSD), adjustment disorder and acute-stress disorder (WHO, 2001; Rick et al., 1998): always worried and thinking about past losses or damage to household property or economic assets as a result of floods; sleep disorders or sleeplessness associated with floods; feeling depressed; irritability; anxiety; not wanting to talk to people about floods; lack of concentration; excessive vigilance; and exhibit of suicide tendencies. Apart from the mental agony, restlessness, sleeplessness and stress they had to endure during floods, they always live in perpetual fear of not knowing when the next floods would hit them and how much more damage they are likely to sustain.

Past losses of household assets were a major source of worry to many respondents in the rural Central Gonja. But how severely the flood affected the individual psychological wellbeing depended on the importance of the destroyed asset to the livelihood of the respondents. Destruction of fishing gears of a fisher man and inundation and destruction of large acres of farm as well as extermination of livestock during floods, households' main sources of livelihood, can have a tremendous devastating effect on the rural households. This has left victims in a state of worry for considerably long time. The following are some of the excerpts recorded during the field discussions in the rural Central Gonja, predominantly fishing and farming flood-prone communities.

> *Perennial flooding has been a source of worry to my household. Anytime the rains set in, the fear of losing my crops grips me. Cultivating at the upland areas is also not safe due to menace of Fulani herdsmen. (Male, FGDs, Adidodeke)*

> *There is no way that I can forget what happened to me seven years ago. My house was submerged in the floodwaters and we were forced to relocate after the 2007 floods. The 2010 floods came to destroy our house the second time. Our present location is the third different places we have settled due to floods. We lost in all the flood cases all assets we toiled to accumulate. Each time, we had to start all over. We were traumatised and always worried when we remember it. (Male, FGDs, Debri port)*

> *In the last major floods (referring to 2010), we could not salvage anything. We lost everything you can think of. Though we had some relief items, these were just to cushion us for a short period. I have not been the same since then. I cannot forget about that experience. I am yet to recover fully. (Male, FGDs, Amedzrovi)*

> *Mentally I am always distressed. I tried not to think about it but has not been possible. The footprints or trails of floods in this community are always reminding us of flood damage and what could possibly happen anytime future floods occur. We are not safe and always live in fear…We can't leave too because our sources of livelihood are here. (Female, FGDs Bonyamu)*

The narratives by the urban households are not different from rural ones. Perennial floods have been associated with stress and psychological problems. Worries about damaged property and economic losses, lack of peace anytime the rains set in, persistent inundation of compound and rooms and their apparent defencelessness, lack of money or financial resources to secure alternative flood-free place were recorded during the field interview. A 51-year old tenant at Old Tafo said the following:

> *Each time that rainfall is heavy and never stopping, nobody is at peace. We tremble with fear that the area will flood. You can't sleep because you may not be able to tell what would happen the next second. Last year, a little girl got drowned in the house nearby when their compound got flooded. While the mother was trying to escape with the child, she slipped and lost grips of the little one in the process. The heavy rain and the total darkness in the area made any rescue operation impossible. The body was discovered the following day. We really are not safe here but have no other place to go to. (Male, IDI)*

At Atonso S-line a discussant shared his ordeals in the following excerpts:

> *When the rains start, it only reminds my household of our past losses due to floods. We get worried and wonder what is going to happen again. We don't have any peace of mind until the rain ceases. (Male, FGDs, Atonso)*
>
> *We have not known peace and always sad ever since the Joy school was constructed here. It is the cause of all our woes. I have struggled with the problem of floods for so long but not seeing an end in sight soon. I am not a happy person at all. What should I do to this building, our property? (Male, FGDs, Atonso)*
>
> *The death of one old lady in the next house, a very close friend always traumatised me. She was drowned when she fell into the floodwater that flooded her room. We were told she slipped and fell. Since nobody was around, at the time, she could not be saved. (Female, FGDs, Atonso)*
>
> *…How would you be able to sleep when you have all these children with you while your compound is becoming flooded. You have to be awake and alert because anything can happen. Children you know are vulnerable. As for the children, they would sleep even in the face of trouble but you will even not get the sleep as a parent. When the flood situation persists for days as was the case last year, I always felt tired, worried and frustrated. (Male, IDI, Atonso)*

The narratives from other communities are captured in the following statements:

> *Fetching or scooping floodwater from flooded compound and rooms can be*

arduous and tiring. As and when you think you are almost done then another hours of rain sets in. When floodwater recedes, you have to spend a good part of your time to clean the mess that has been caused. You feel frustrated and weary. You are always under pressure and unable to concentrate to do more serious routine household chores. (Male, FGDs, Breman)

I am hypertensive but my condition has further been aggravated by persistent flooding in this area. Floodwaters do get into our compound anytime it rains heavily. When floodwater gets into your compound and rooms you cannot look on. It gets you busy and worried all the time. You get tired and stressed up for weeks. (Male, FGDs, Breman)

Flood is both economically and emotionally stressful to me and my household. One has to spend the little savings made over the years to carry out repairs of damage caused by floods and to replace lost assets due to floods. Clearing the mess caused by floods is very tasking. I always felt tired and pains all over. You won't be able to have a sound sleep even weeks after everything ends. My pressure always went up because of inadequate sleep and rest. (Male, FGDs, Anwomaso)

A 59-year old lady said:

Quite frankly, my blood pressure always goes up as soon as the rains start because of the worry about floods and the devastation that comes with them. Raining season not only reminds us of our past losses but also makes you to begin to think about what is going to happen the current year. It has not been easy for us here at all. We always live in fear and feel always worthless. (Female, FGDs, Dichemso)

Every year, the occurrence of floods constitutes a major source of drain on our resources. Lost and damaged assets have to be replaced. One has to spend a huge sum of money to construct this flood defence wall. This notwithstanding, you have to spend extra money to put in place other flood abatement measures, money that could have been used for other pressing needs. This gives me headache. (Male, FGDs, Buokrom)

Although I am somehow used to the floods, it is still not easy for me to cope with the amount of work that one has to do during and after flooding almost every year. You are busy during the day and night. I felt always sick during this time. (Male, FGDs, Buokrom)

Part of my house is washed away. It has been undermined by the river anytime it becomes flooded. I do not have the means to stop this stream from eating up the remaining building. It is always worrying me. I need a helper. (Male, FGDs, Ayigya)

My brother! It is very scaring. Anytime the river (referring to Sisa river) gets flooded it also brings along lots of life snakes. Last year when it happened, we *killed about twenty snakes around our compound. (Female, FGDs, Ayigya)*

Flood victims may suffer from psychological health impacts from the stress of the flooding. Floods not only elevate household vulnerability to physical illness, but also mental health (Chae et al., 2005). As Stanke et al. (2012) noted, flooding can pose substantial mental health problems that may continue over extended periods of time. Flood disasters take a heavy toll on the mental health of the people households, most of whom live in developing countries, where there is extremely limited capacity to handle these problems (WHO, 2001). People who have experienced a flood have been shown to have a fourfold higher risk of psychological distress than do those not exposed to flood (Reacher et al., 2004) and a suicide rate 13.8% higher than pre-disaster rates (Du et al., 2010).

It is expected that people who experience a traumatic event will have a severe reaction to it, particularly in the first few days after the event (Tapsell et al., 2002). When victims show symptoms beyond this period there are three possible diagnoses (Rick et al. 1998): adjustment disorder, acute-stress disorder, and post-traumatic-stress disorder. These symptoms may include avoidance of talking or thinking about the flooding, flashbacks, sleep disorders and depression (Tapsell et al., 2002). Bennet's analysis of the 1968 Bristol floods found a significant increase in the number of new psychiatric symptoms reported by women from flooded compared with non-flooded areas, although there was no significant difference for men (Ahern et al., 2005).

Posttraumatic stress disorder (PTSD) comes about after a stressful event such as catastrophic floods and is characterised among other things by intrusive memories, avoidance of circumstances associated with the stressor, sleep disturbances, irritability and anger, lack of concentration and excessive vigilance (WHO, 2001). The nature of the trauma may impinge upon the severity of symptoms (Tapsell et al., 2002). Evidence from northeast England floods suggests that the greater the damage, losses and inconvenience from a flood event, the greater the stresses suffered by flood victims are likely to be (Tapsell et al., 2002). Studies of the 1996 flooding in the Saguenay/Lac St. Jean region of Quebec, Canada, also suggest substantial increases in emotional distress and PTSD among flooded respondents (Ahern et al., 2005). Evidence from Puerto Rico and from work by Norris et al. (2002) suggests that PTSD symptoms are influenced by the extent of flooding, culture, and age. Following a flood, subsequent rainfall can act as a trigger for repeated stress and trauma among those who were flooded, being a factor directly related to the initial flood event (Stanke et al., 2012). Children, young people and older people may be more vulnerable than are adults of working age because they are dependent on adults' responses to the floods that affect families (Stanke et al., 2012).

7.3.2.1 Relationship between perceived psychological health and age of head of household in rural and urban settings

It was hypothesised that there is no significant relationship between age of respondents and their perceived flood-induced psychological health problem. Pearson's Chi-square analysis for rural Gonja records p-value of 0.01 which is less than 0.05 level of significance ($p< 0.05$) (see Table 7.11). It means that there was a significant relationship between age of respondent and flood-induced psychological health problem. In KMA (urban) however, there was no significant relationship between age of respondents and flood-induced psychological health problem since 0.142 which is the p-value here is greater than 0.05 ($P> 0.05$) (see Table 7.14). Tables 7.10 and 7.13 are chi-square contingency tables showing psychological health problems by age in rural Gonja and KMA respectively. Since the decision rule is to reject the null hypothesis if p-value is less than 0.05, one rejects the hypothesis that there is no significant relationship between age of respondent and flood-induced psychological health problem in Central Gonja but unable to reject in the case of KMA.

Since there was a significant relationship between age and psychological health in Central Gonja, further analysis was done using logistic regression to ascertain which age group showed higher level of vulnerability regarding flood-induced psychological health. Results show that older people (60 years and above) show higher level of perceived psychological health than the young age group (20-59 years). In other words, it is significant for older people (P> 0.05) as shown in Table 7.12. This supports the findings of Ngo (2001) and Stanke et al. (2012) that older people show higher level of vulnerability during floods.

Table 7.10: Chi-square contingency table showing psychological health problems by age (Central Gonja)

Age	Frequency	Floods caused psychological health problems		Total
		No	Yes	
20-29	Count	9	14	23
	Expected count	6.9	16.1	23.0
30-39	Count	41	55	96
	Expected count	28.8	67.3	96.0
40-49	Count	17	80	97
	Expected count	29.1	67.9	97.0
50-59	Count	28	51	79
	Expected count	23.7	55.3	79.0
60 and above	Count	15	57	72
	Expected count	21.6	50.4	72.0
Total	Count	110	257	367
	Expected count	110.0	257.0	367.0

Source: Field survey (2017)

Table 7.11: Chi-square Tests (rural)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-square	19.489	4	.001
Likelihood Ratio	19.926	4	.001
Linear-by-linear association	5.652	1	.017
N of valid cases	400		

Source: Field survey (2017)

Table 7.12: Variables in the equation (Logistic regression for age and psychological health), rural Gonja

Age	B	S.E	Wald	df	Sig.	Exp(B)
Young	-1.041	.356	8.551	1	.558	2.459
Old	.214	.394	.294	1	.003	1.171

Source: Field survey (2017)

Table 7.13: Chi-square contingency table showing psychological health problems by age (KMA)

Age	Frequency	Floods caused psychological health problems		Total
		No	Yes	
20-29	Count	3	24	27
	Expected count	5.3	21.7	27.0
30-39	Count	25	65	90
	Expected count	17.6	72.5	90.0
40-49	Count	21	79	100
	Expected count	19.5	80.5	100.0
50-59	Count	17	94	111
	Expected count	21.6	89.4	111.0
60 and above	Count	12	60	72
	Expected count	14.0	58.0	72.0
Total	Count	78	322	400
	Expected count	78.0	322.0	400.0

Source: Field survey (2017)

Table 7.14: Chi-square Tests (KMA)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-square	6.889	4	.142
Likelihood Ratio	6.806	4	.146
Linear-by-linear association	1.522	1	.217
N of valid cases	400		

Source: Field survey (2017)

7.3.2.2 Relationship between sex of respondents and psychological health in rural and urban settings

Using Pearson's Chi-square rest, at $p < 0.05$ as statistically significant, the strength of associations of these categorical variables and the background information has been determined. Chi-square statistical results show p-value of 0.01, well below 0.05 level of significance for Central Gonja (see Table 7.16). It can be concluded that in Central Gonja, there was a significant relationship between sex of respondents and experience of flood-induced psychological health problems. In KMA however, there was no significant relationship between sex and experience of flood-induced psychological health problems. In this case, the p-value (0.629) is greater than the level of significance (0.05) (Table 7.19). Further analysis for Central Gonja was done using logistic regression to show which sex category suffered a higher psychological health during floods. Results show that flood-induced psychological health in relation to sex is significant for females in Central Gonja ($p< 0.05$) (see Table 7.17). The p-values for the rural communities being 0.011 is less than 0.05 level of significance. Tables 7.15 and 7.18 show the relationship between sex and psychological health in Central Gonja and KMA respectively. This is consistent with the findings of Peacock et al. (2000) in which women were found to be more vulnerable to flood disaster than their male counterparts.

Table 7.15: Relationship between sex of respondents and psychological health, rural Central Gonja showing observed and expected frequencies

Sex	Frequency	Floods caused psychological health problems		Total
		No	Yes	
Male	Count	75	216	191
	Expected count	87.2	203.8	291.0
Female	Count	35	41	76
	Expected count	22.8	53.2	76.0
Total	Count	110	257	367
	Expected count	110.0	257.0	367.0

Source: Field survey (2017)

Table 7.16: Chi-square Tests, rural Central Gonja

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-square	11.808	1	.001
Continuity Correction	10.861	1	.001
Likelihood Ratio	11.190	1	.001
Linear-by-linear association	11.775	1	.001
N of valid cases	367		

Source: Field survey (2017)

Table 7.17: Variables in the equation (Logistic regression for sex and psychological health), rural

Age	B	S.E	Wald	df	Sig.	Exp(B)
Female	5.660	.317	7.569	1	.011	2.459
Male	-1.224	.134	2.697	1	.092	1.171

Source: Field survey (2017)

Table 7.18: Relationship between sex of respondents and psychological health, KMA showing observed and expected frequencies

Sex	Frequency	Floods caused psychological health problems		Total
		No	Yes	
Male	Count	33	146	179
	Expected count	34.9	144.1	179.0
Female	Count	45	176	221
	Expected count	43.1	177.9	221.0
Total	Count	78	322	400
	Expected count	78.0	322.0	400.0

Source: Field survey (2017)

Table 7.19: Chi-square Tests, KMA

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-square	.234	1	.629
Continuity Correction	.127	1	.721
Likelihood Ratio	.234	1	.628
Linear-by-linear association	.233	1	.629
N of valid cases	400		

Source: Field survey (2017)

7.4 Summary

The chapter examined rural and urban household vulnerability to floods by focusing on the socio-economic and health effects of floods. In doing so, vulnerability to floods in this chapter is understood as an outcome rather than a process or conditions that lead to increased human exposure, increased susceptibility and reduced resilience to floods. Floods have had both economic and social effects on households in both the rural and urban communities studied, with rural households bearing greater brunt in terms of economic losses and psychological health problems. While a higher economic loss for rural did not support the third proposition, a higher perceived flood-induced psychological health for the rural households supports the related proposition (the fifth proposition). While the urban households saw perennial floods as a curse due to economic losses and associated health problems, it was more of a blessing than a curse to rural Gonja households. In terms of flood-induced mortality and physical health burden, urban households showed a higher level of vulnerability than the rural households, results which fail to validate the fourth proposition. While there was a significant relationship between age of respondent and flood-induced psychological health problem in Central Gonja per the chi-square test, with older people experiencing a higher level of perceived psychological health (rejected null hypothesis), there was no significant relationship between age of respondents and flood-induced psychological health problem in the case of KMA (unable to reject null hypothesis). In terms of sex of respondents, females showed higher levels of psychological health problem in rural Gonja communities but there was no significant relationship between sex and perceived psychological health in KMA. The next chapter addresses household response mechanisms. It looks at the coping and adaptation strategies of the flood-prone study communities as well as the institutional and legal context within which such responses take place.

CHAPTER EIGHT

COPING WITH AND ADAPTING TO FLOODS IN RURAL AND URBAN GHANA

8.0 Introduction

In chapter seven, the study examined household vulnerability to floods, where vulnerability is viewed as an outcome rather than a set of attributes or processes that condition outcomes. Thus, it focused on a comparative analysis of the effects of floods on rural and urban households. Since floods may not be completely prevented, one approach to minimising or mitigating the effects is to cope with and adapt to it. This chapter therefore analyses households' coping and adaptive strategies to floods, whether endogenous (emanating from within) or exogenous (coming from without). The first part of this section examines individual coping mechanisms. The second section addresses household adaptation strategies, including structural and non-structural approaches. The chapter ends with a section that deals with the institutional and legal framework within which flood reduction and management process take place. While the terms adaptation and coping are sometimes used interchangeably in the literature, a distinction between coping and adaption is made in IPCC (2014) this way: coping is short-term response and non-continuous process whereas adaptation practices and results are sustained and the process is continuous; coping is oriented towards survival whereas adaptation is oriented towards long-term livelihood security; coping is motivated by crisis and is usually reactive whereas adaptation involves planning; and coping is often prompted by a lack of alternative whereas adaptation focuses on finding alternatives, including combining old and new strategies and knowledge. It is from this lens that the results of the field study are discussed in this chapter. The chapter also examines the role of institutions in the never-ending flood battle in Ghana.

8.1 Coping with floods in rural and urban Ghana

When hazards, be they natural or of human origin become unstoppable, humankind has to live with them by devising means to cope with them. Whatever method was employed, the ultimate aim has been to limit the hazard incidence, resist better when they occur, and repair efficiently damage when it is over. Unlike adaptation, coping capacities are primarily linked to capacities that help to maintain the current status of the systems under stress (Birkmann et al., 2013).

Different flood coping strategies have been identified in the study communities in both rural Gonja and KMA. Since no single strategy was enough to enable flood victims to cope with floods, a combination of strategies was employed (see Table 8.1). Temporary relocation by flood victims to stay with friends and relatives was one main coping strategy adopted by households that were seriously affected by floods. Usually, they wait for the place to get dry and get back to settle. In Central Gonja, 42% of respondents relocated to stay with friends living upstream the Black and White Volta, who were mostly the Gonjas. Some also created their own camps while others too moved temporarily into available public places, such as church buildings, and classrooms that were located on a higher ground until the water levels receded. This observation supports the study by Nyakundi et al. (2010) that showed that during extreme flood situations, affected families vacated their homes and moved to camps or were accommodated by relatives and friends. In KMA, temporary relocation was not a popular coping mechanism with just 7.6% indicating this as an option (Table 8.1). Where a storey building was involved, occupants of the ground floor moved into the upper floors along with their vulnerable appliances to secure individuals some safety and protect their property from damage. In areas where flood situation was not a serious bother, individuals would normally not vacate rooms.

Bailing of water out of houses to prevent damage to belongings and other personal effects was also a coping strategy employed in both rural Gonja and KMA, though more dominant in KMA than in rural Gonja. This is not strange as the 2007 and 2010 flood disasters that hit Central Gonja district was sudden and unexpected, taking most residents by surprise. Most of the victims, particularly those who were located very close to the river banks did not have the luxury of time to fetch water out of their rooms. From respondents' narratives, what was critical at the time was to salvage few belongings and relocated to safer places. While only 8.5% fetched water out of their rooms in Gonja, 28% did so in KMA. Fetching of water was done when rooms and corridors got flooded in order to limit or prevent losses that would otherwise have been occasioned by the ingress of floodwater into rooms. Bailing water out of the house was done by both men and women with buckets or shallow bowls. This happened alongside cleaning of rooms and their immediate environ. Some wealthier community members in KMA were found using mechanical water pumps to remove water from their homes or compound that got inundated by floodwaters. In the immediate aftermath of floods, a lot of cleaning and fetching out of remaining water had to be done.

Blocking of water inlets to reduce the amount of water coming into the house, and then opening them up after a heavy downpour to allow the water already inside the house to flow out was one of the most helpful individual actions at the household level. Such openings in walls are sealed or blocked with waterproof materials to prevent water from entering individual compounds. In addition, some households put up temporary barriers (e.g. heap of sand, sandbags) at doorsteps against water entry while some residents for instance in Old Tafo and Breman undertook emergency communal work to open up drainage channels. This was not a common coping mechanism in rural Gonja as the nature of their buildings, without foundation and walls, made it practically difficult for such rural households to stop the Black and White Volta floodwater from entering their rooms. The 2010 floods of the Gonja, left most of the rural mud houses destroyed. In KMA, where the nature of floods is perennial, 26.3% blocked entry points of water as opposed to 6.3% in rural Gonja. Besides, individuals place their valuables such as electrical and electronic appliances, books, clothing and other non-waterproof assets above the ground level (e.g. on top of wardrobes, tables etc.) in order to prevent them from damage from floodwaters.

Another coping mechanism adopted by the study communities in KMA was digging of trenches around houses during floods to divert water away from the house. Others too used sandbags (see Plate 8.7) or sand-filled used/old lorry tyres (see Plate 8.8) to prevent the ingress of water into their compound. People build temporary plank bridges between houses across the wetlands to be able to move about during flooding. The role of institutions in households' floods coping process cannot be underestimated. Where it matters most, NADMO, working with other agencies or organisations is able to mobilise and coordinate relief items and deliver same to affected populations.

The findings above were further corroborated by respondents' narratives in the FGDs. The following are some narratives from rural Gonja discussants:

> *…the floods (referring to the 2010 floods) was sudden came unexpected. By the following morning, we were almost surrounded by water. It was so scaring that we had to immediately seek refuge with our Gonja friends up stream. (Male, Bonyamu)*

> *When the rains set in and the water level rose, we did not anticipate that it would get this place. Surprisingly the floods came all the way here and into our rooms. We had to fetch water out of our rooms. But we here were somehow less affected compared to our brothers and sisters in other communities. (Male,*

Kikale No. 4)

When the floods came, my wife was then nursing a three-month baby. It was a difficult moment for us. There was nowhere to relocate to immediately. When we heard that the situation was very bad in some communities and the district capital Buipe, we felt anything could happen anytime. When we saw that the floods were not far from us because of the abnormal rise in the level of water in both the Black and white Volta, we placed a few belongings on a wooden platform above the ground. This did not save us as the floods eventually forced us to relocate into a makeshift shelter. (Male, Debri Port)

In KMA, the following are some extracts from the FGDs.

> *The most traumatic experience to me was this year floods that came when we were all asleep. Unexpectedly, water started entering our rooms. We were all forced to seek temporary refuge upstairs. Thanks to the fact that we live in a storey building. Other people in the community left their rooms to avoid any calamity and sought refuge outside their homes. (Male, Breman)*

> *I am bereft of ideas and at my wits end. I have done what is humanly possible but the floodwater couldn't be stopped in all the previous flood experiences. Look at the thick and tall defence wall. This could not stop the floodwaters from entering my compound and my rooms. My Television set and other valuables were placed on this custom-made table to keep them out of reach of the floodwaters but this could not help the situation. I keep wondering what else to do. (Male, Dechemso)*

> *During periods of heavy and continuous rain showers, the whole of this area becomes seriously flooded. Our compound and rooms sometimes become flooded too. What we did in the past was to place some our assets especially electrical and electronic ones on a table beyond the reach of the floodwaters. You attempt fetching some of the water out and block all possible entry points sometimes without any positive results. When the situation becomes helpless and no help was coming from anybody, we sought temporary refuge around and return when situation normalised. (Female, Atonso S-line)*

> *I am already in talk with my land lord for my rent advance refund. He doesn't stay here with us apparently because of the flood situation. I am just a year and a half old here. My room got inundated when the floods came last year and this year too. I got this room through an agent at the time I was desperately looking for a single room to rent. I came here during the dry season and so did not know the situation here is that bad. The agent too did not disclose this to me. Each time that the place got flooded, I had to send most of my belongings to my landlord's place on the first floor of this storey. Meanwhile I paid a three-year rent advance for the place. It is regrettable. (Male, Kwadaso Estate)*

Interestingly, there were those respondents who claimed they did nothing in during past flood situations. In the Central Gonja, some of these respondents were located a bit uphill and therefore claimed they were not much affected while some simply lacked the capacity to cope and therefore looked on helplessly as the floodwaters destroyed their property. Others too banked their hope on others and institutions for support which did not happen when they expected those helps to come. In rural Gonja, different institutions were mentioned including, the National Disaster Management Organisation (NADMO), NGOs and religious organisations that provided them with emergency relief items including medicine, food, clothing, bedding items and other essentials.

In KMA, those who said they did nothing were those who felt less threatened and unaffected by these floods and trusted the structural defence mechanisms they put in place. The main institution that the urban respondents were aware of is NADMO. However public dissatisfaction about NADMO in both rural and urban communities studied was rife. This was understandable because NADMO, is perceived erroneously by the public as a distributor of relief items. In situations where such items did not accompany their operations and interventions, the public got outraged.

The proportion of respondents in rural Gonja and KMA who did nothing and looked up only to institutions were 5.6% and 6.2% respectively. In sum, the total number of respondents who could not do anything to help themselves and those who sought temporary refuge during the last flood period was 47.6% while that of KMA was 13.8% (see Table 8.1). This implies that respondents in rural Gonja were less able to cope with floods compared with their counterparts in KMA. In a focus group discussion, one discussant in Debri Port said:

When the floods came, it affected most settlements down there. Those of us *located here (high ground) were not affected except part of our farms close to the river. (Male participant)*

This represents one of many harrowing narratives of many rural Gonja residents during field interview. A rather dissenting view was expressed by a participant at Adidodeke this way:

In my case, I was lucky that my house remained intact after the 2010 flood disaster. At the time, I travelled with my family to Battor, for my late father's funeral. Most houses were destroyed but mine was among the few that survived. As you can see, it is not close to the Black Volta. (Male participant)

Similar responses were echoed in KMA by discussants as illustrated below:

For us we are not affected. The floodwater does not get to this place because we are somehow situated on a higher ground. (Male participant, FGDs, Breman)
The floods do not affect us much. We live on the first and second floor of the storey- building. In addition to the fence wall and the slope of the land, we are secured. (Female participant, FGDs, Atonso S-line)

The study in KMA revealed that the age composition of the household partly accounted for inaction on the part of some respondents. Households made up of very old couple (husband and wife) with sometimes young grand children could not do anything by themselves during serious flood situations except where necessary to seek help from neighbours. In Atonso for example, a 71-year old lady had this to say:

I am seventy-one years old and living with my equally aged wife and a grandson, who is sixteen years old. For us, anytime the area got flooded from continuous heavy rains, we were unable to do anything. We could not stop the rains or the floods. We stayed quietly in my room praying to God for the rain to stop. In all cases, God had been faithful. (Male, Atonso S-line)

Table 8.1: Coping mechanisms during and immediate aftermath of floods

Coping mechanisms	Rural		Urban	
	Freq.	%	Freq.	%
Relocated temporarily to stay with friends/relatives/temporary camps till floodwater subsided	302	42.0	95	7.6
Fetched/pumped/bailed water out of room or house/clean room and immediate environment.	61	8.5	350	28.0
Blocked all entry points of floodwater into the house/rooms	45	6.3	329	26.3
Dug trenches around houses to divert water away from the house	64	8.9	79	6.3
Built embankments with sandbags or ridges around the house to prevent ingress of water	17	2.4	64	5.1
Moved things to higher/safer grounds	190	26.4	257	20.5
Looked on helplessly/did nothing	31	4.3	72	5.8
Waited for neighbours and institutions to help/complain to authorities	9	1.3	5	0.4
***Total =Multiple response**	**719**	**100.0**	**1251**	**100.0**

Source: Fieldwork (2017)

Newcomers responses may be quite different from those who have lived in flood-prone communities for years. The experience of newcomers to flood situations as noted by Campion and Venzke (2013) is that of shock and anger. As coping strategies, new comers will attempt to retrieve their rent (that are normally paid 2 or more years in advance), move valuables to safe places, or relocate till the flood situation improves. Older residents on the other hand tend to be more accommodating of the landlords and often show interest in taking part in the construction of new drainage channels, dredging of streams, building of embankments around houses and construction of networks of raised walkways connecting houses. Older residents might have developed strong economic and social ties in the community and are therefore less willing to move out relative to the newcomers.

It was hypothesised that there is no significant relationship between length of stay in flood-prone community and ability to cope with floods. Pearson's Chi-square analysis shows no statistically significant relationship between the length of stay in the community and capacity to cope with future floods in both Central Gonja and KMA. The p-value for rural Gonja (p = .159) and KMA (p = .126) all exceed 0.05 (p> 0.05) (see Tables 8.3 and 8.5). Tables 8.2 and 8.4 are the contingency tables for rural Gonja and KMA respectively. On the basis of the decision rule, one is unable to reject the null hypothesis. The conclusion is that how long one stays in a flood-prone community does not confer on one greater coping ability. It can also be deduced from Table 8.2 that 57% of rural respondents indicated they would not be able to cope with future floods. This is slightly higher than the 55% response in KMA. This implies that rural households were less able to cope with floods compared with the urban households. By extension, it could suggest that the rural households have not been able to adequately adapt to their flood-prone environment compared to the urban households.

Pearson's Chi-square analysis however shows that there is no statistically significant relationship (p= 0.631) between coping ability and settlement type (rural or urban). There was statistically significant relationship between coping ability and age for both rural (p= 0.000) and urban (p= 0.027) but sex showed no statistically significant relationship with household ability to cope with floods in both rural (p= 0.50) and urban (p= 0.671) settings. As the conceptual framework illustrates lack of capacity to cope makes one less resilient and more vulnerable to floods.

Table 8.2: Chi-square contingency table showing length of stay in a community and ability to manage/cope with future floods (Central Gonja)

Age	Frequency	Ability to cope with future floods		Total
		No	Yes	
<5 yrs	Count	5	7	12
	Expected count	6.9	5.1	12.0
5-10 yrs	Count	45	22	67
	Expected count	38.3	28.7	67.0
11-15 yrs	Count	19	21	40
	Expected count	22.9	17.1	40.0
16-20 yrs	Count	24	13	37
	Expected count	21.2	15.8	37.0
> 20 yrs	Count	117	94	211
	Expected count	120.7	90.3	211.0
Total	Count	210	157	367
	Expected count	210.0	157.0	367.0

Source: Field survey (2017)

Table 8.3: Chi-square Tests showing relationship between length of stay in a community and ability to cope with floods (Central Gonja)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-square	6.590	4	.159
Likelihood Ratio	6.645	4	.156
Linear-by-linear association	.373	1	.542
N of valid cases	367		

Source: Field survey (2017)

Table 8.4: Chi-square contingency table showing length of stay in a community and ability to manage/cope with future floods (KMA)

Age	Frequency	Ability to cope with future floods		Total
		No	Yes	
<5 yrs	Count	33	42	75
	Expected count	41.4	33.6	75.0
5-10 yrs	Count	73	54	127
	Expected count	70.2	56.8	127.0
11-15 yrs	Count	35	19	54
	Expected count	29.8	24.2	54.0
16-20 yrs	Count	33	32	65
	Expected count	35.9	29.1	65.0
> 20 yrs	Count	47	32	79
	Expected count	43.7	35.4	79.0
Total	Count	221	179	400
	Expected count	221.0	179.0	400.0

Source: Field survey (2017)

Table 8.5 Chi-square Tests showing relationship between length of stay in a community and ability to cope with floods (KMA)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-square	7.196	4	.126
Likelihood Ratio	7.211	4	.125
Linear-by-linear association	1.603	1	.206
N of valid cases	400		

Source: Field survey (2017)

8.2 Adapting to floods in Rural and Urban Ghana

Adapting IPCC (2014) perspective of adaptation, household adaptation to floods can be viewed as adjustments to ecological, social and economic systems in response to actual or expected floods events and their effects or impacts, which moderates harm or exploits beneficial opportunities. While coping is primarily associated with capacities that help to maintain the current status of the systems under stress, adaptation as a concept implies actions aimed at making more profound change in socio-ecological relations (Birkmann et al., 2013). Diverse adaptation strategies exist and include the use of technical measures to reduce the probability of flooding (e.g. Merz et al., 2010b); the provision of flood protection such as storm surge barriers and dikes (Aerts and Droogers, 2004); the use of insurance to provide compensation, to help recovery, and provide incentives for damage mitigation (Paudel et al., 2012); the use of spatial zoning with increased control over land-use changes and developments of new and existing urban areas (Burby et al., 2000); and the use of damage reduction measures on houses, which are also called flood-proofing measures (Kreibich and Thieken, 2009). Thus, a set of structural measures in interaction with non-structural measures (Minea and Zaharia, 2011) are required to protect flood vulnerable communities. Structural measures refer to any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure (UNISDR, 2004). These are large-scale engineered measures that focus on reducing the probability of a flood hazard itself. Johnson and Priest (2008) describe this as involving ‘hard’ engineering. Non-structural measures concern reducing destruction or damage induced by inundation without hydrotechnical works or structures (Minea and Zaharia, 2011). Unlike structural approaches, non-structural measures reduce exposure or vulnerability and usually rely on human interventions to do so (Harries and Penning-Rowsell, 2011). Non-structural approaches apply what Johnson and Priest (2008) called ‘soft engineering’ solutions in reducing human vulnerability to floods.

The study communities employed different adaptation strategies in order to manage current and future flood damage and risk. Consistent with what was found in the literature, it included both structural and non-structural measures, coming from the household themselves and specific institutions.

8.2.1 Structural adaptation

The research observed different structural defence mechanisms in the communities studied. The type of adaptation method adopted by a household in the study communities is influenced by a plethora of factors including location relative to the flood source, frequency and severity of the floods, economic status of the household, and perceived risk of floods. In the main, the structural approach remains the dominant way by which the rural and urban communities have adapted to flooding.

8.2.1.1 Fence wall as a defence mechanism

The use of fence wall as a protection against floods was not observed in the rural Central Gonja. These were individual mud houses that were not walled. In KMA, the main approach to flood adaptation is structural, involving mainly the use of fortified concrete fence walls as defence against flood onslaught (see Plates 8.1, 8.2, 8.3 and 8.4). About 27.4 % of respondents in KMA relied on the flood defence walls (see Table 8.6). These walls vary in height and thickness, often reinforced by iron rods. In some cases, double walls (inner and outer walls) were built all in an attempt to stop floodwater from entering their homes. The main entrance to the main compound normally have relatively shorter walls to allow uninhibited human entry but difficult for floodwaters to get in. These walls have openings that are sealed off or stuffed with waterproof materials so that floodwater could not find its way in the residence. In the event that floodwaters get into such homes, or when water collect within the compound during heavy downpours these holes are opened to allow the water to drain out quickly. Still some households installed one-way valves on water evacuation pipes to stop the waters from entering the house via the pipes. In the absence of any such defence mechanisms for the rural Gonja communities, they may be exposed to higher level flood risks and vulnerability than the urban communities.

8.2.1.2 Reconstruction of new house on safer ground

In the rural Central Gonja, adaptation principally took the form of rebuilding and reconstruction of houses that were destroyed during the previous devastating floods. Majority of residents in the present locations of Debri Port and Bonyame have had to relocate from the previous sites as their houses were completely destroyed by the 2010 floods. Like those buildings that were destroyed, these new houses were built from essentially local raw materials – clay and grass thatch. As shown in Table 8.6, 68.9% of rural respondents have had to rebuild their houses that were destroyed. Rebuilding a destroyed residential facility in rural Gonja was relatively easier compared to the urban KMA. Not only is land available in a vast form, but that building materials are local raw materials that are acquired at no extra cost. The communal way of living provided a ready source of cheap labour (communal labour) that could be mobilised in the reconstruction process.

In KMA, no respondent said they re-built their houses that were previously destroyed by floods. However, a lot of partially or completely ruined houses were found in the Atonso area while isolated cases were also seen in other study communities including Old Tafo, Breman, Dechemso, Buokrom, and Ayigya Zongo. In the Atonso S-line, the flood situation was so terrible the cost of reconstruction would be outrageously high to attract owners to rebuild. In this respect, owners of these houses had no option but to completely abandon them. While house reconstruction was pretty easy in rural Gonja as explained above, the dynamics in the city are entirely different. Not only is land very costly, the process of acquisition is notoriously cumbersome. The option available on economic grounds therefore for property owners in the flood-prone KMA was to carry out repairs on damaged portions of their facilities.

8.2.1.3 Renovation of buildings and reinforcement of building foundation

In many cases, the intensity of the floods impact was so great that, cracks and structural weaknesses manifest in buildings. Where such buildings are not flattened or badly damaged by floods, owners carried out renovation works and continue to live in them. For respondents in rural Gonja, 26.9% renovated portions of their buildings that suffered some cracks from floods impact. In KMA, 22.5% indicated that they carried out some repairs on their facilities to secure their continuous living in them (see Table 8.6).

In KMA, structural reinforcement to existing buildings were noticeable and involved heavy use of cement with channels created for stormwater. In some cases, building foundations were raised up enough to make it difficult for rising floodwaters to get into rooms. In addition, foundations were in some cases further fortified with massive concrete work at the base of building all round. This was to strengthen such buildings and protect them from collapse (see plates 8.1 and 8.9). While this approach was unpopular in rural Gonja district, where only 1.3% adopted this method, it was the second most important structural methods households (24.9%) used to mitigate flood impacts in KMA (see Table 8.6).

8.2.1.4 Use of upper floor of storey building

Storey buildings offer unique opportunity to some households to escape from the menace of rampaging perennial floods. Where households were unable to contend with the floods, households evacuate from the ground floor to the upper floors of the building (See Plate 8.6). A spectacular and innovative way is to construct a wooden structure on top of original single flat apartment (See Plate 8.5). In this case, occupants move to the top with their belongings during flood season. The original building is either permanently abandoned by the owners or rented out to people who may have no idea about the prevailing flooding problem. From Table 8.6, only 1.1% of respondents in KMA benefitted from the use of storey building by way of adaptation to floods. This however did not apply to rural Gonja. As Table 8.2 shows, no respondent reported the use of this mechanism of adaptation.

8.2.1.5 Filling compounds to a thick depth with gravels

Filling of compounds with laterites was observed in some of the study suburbs in KMA and not in the Central Gonja. From Table 8.6, only 0.5% of the respondents in KMA adopted sand-filling of compounds as a form of structural adaptation. At Atonso S-line for example some households had their walled compounds filled with thick layers of sand. From the perspective of the respondents, it was to raise the ground level within the walled compound higher than the immediate surrounding. This was to make it very difficult for floodwaters to flood such compounds and also allow quick infiltration of floodwater into the thick layer. In most of the observed cases however, this exercise had not been useful in addressing the purpose for which they were done. In the rural communities studied in Central Gonja, no housing unit was walled. Filling of compound as a strategy could not have been an option.

8.2.1.6 Dredging of drainage channels and clearing of choked gutters

Another structural approach involved removal of silt- and waste-choked urban streams and gutters. Again, the method relates to the urban communities and not rural Gonja. In Central Gonja, both the Black and White Volta were not chocked by any waste to warrant any removal. Besides, these rural communities had no storm drains and therefore could not have been chocked. At the individual household levels in KMA, identified choked drains bordering residential units were cleaned, while drainage channels were dredged to increase channel depth so as to reduce their probability of spreading out as when they overflow their banks during a heavy rainfall. Of the total respondents, 4.8% indicated that they on their own have been involved in cleaning and clearing choked drains (from solid waste or sand deposit) that run close to the residence. This they felt obliged to do in order to prevent occurrence of floods (see Table 8.6). To these respondents, they would be the ones to benefit most from such measures. A participant in Old Tafo remarked:

> *If the gutters lying in front of you is choked, do you have to wait for someone or the government to come and clear it for you? If you fail to do it and the floods come, you will bear the brunt. (Male, IDI)*

But the impact of such individual efforts on the overall flood situation was difficult to measure. While such households believed their individual actions in cleaning the gutters in front of them and removing accumulated debris in streams that flow close to their residence have been helpful, lack of support from other community members and institutions according to them often limit the overall benefits. Remarkably, as Table 8.6 reflects, 2.9% and 0.9% of respondents in Gonja and KMA respectively employed no strategy. These respondents were those who claimed that floods came but they were never affected and those without the financial and other resources to undertake structural changes.

Table 8.6: Household structural adaptation strategies

Actions	Rural		Urban	
	Freq.	%	Freq.	%
Clean rooms/environment	158	29.7	351	80.7
Use of concrete flood defence wall and elevated entrance	-	-	383	27.4
Built embankments with sandbags or ridges around house	-	-	250	17.9
Use of upper floor of storey building	-	-	15	1.1
Reconstructed a new house on a raised foundation/upstream	264	68.9	-	-
Renovation of damaged structure	103	26.9	315	22.5
Fortified/reinforced building base or foundation with concrete work	5	1.3	349	24.9
Filling compound with sand	-	-	7	0.5
Dredging/de-silting of drains	-	-	67	4.8
Nothing/Lack resources/not affected	11	2.9	13	0.9
***Total =Multiple response**	383	100.0	1399	100.0

Source: Fieldwork (2017)

Plate 8.1: Massive flood defence wall (Kwadaso)
Source: Fieldwork (2017)

Plate 8.2: Raised concrete entrance with flood defence wall (Kwadaso)
Source: Fieldwork (2017)

Plate 8.3: Flood defence wall (Breman)
Source: Fieldwork (2017)

Plate 8.4: Flood defence wall (Atonso S-line)
Source: Fieldwork (2017)

Plate 8.5: Wooden shack constructed on original self-contained flat (Kwadaso)
Source: Fieldwork (2017)

Plate 8.6: Disserted ground floor due to floods. See the level of flood water on the building (Breman)
Source: Fieldwork (2017)

Plate 8.7: Adaptation with sandbags (Breman)
Source: Fieldwork (2017)

Plate 8.8: Adaptation using used lorry tires, Old Tafo
Source: Fieldwork (2017)

The predominant use of structural techniques in KMA has been influenced by the belief that such structures could offer them protection. Thus, people have developed property in flood-prone areas believing that structural techniques they put in place for flood management would provide them greater protection than they actually do. In the presence of these defence walls and related structures, many tend to behave less responsibly. This has not helped the course of these flood-prone inhabitants in Kumasi Metropolis including those with the perception that they were protected by such structures. This absolute trust in such structures is evident in the following quotations from discussants:

> *We used to suffer from floods but with the construction of this storm drain about a year or two ago, we no longer experience floods. We are free now except those living at the other end bordering the Sisa stream. (Female, FGDs, Ayigya Zongo)*

> *Since I constructed this defence wall, the flood problem has reduced significantly. Though floodwater still gets into the compound, it is better than before. (Male, FGDs, Breman)*

> *This flood problem has been due to the poor condition of the main bridge...that is yet to be fixed. It is too narrow and almost giving way. If the authorities fix this problem, it would stop the floods. (Female, IDI, Kwadaso)*

> *We did not create the flood problem here. It is the institutions and the assemblies to be precise which have failed us. The city is expanding very fast but the storm drains are still the old narrow ones. Besides, the drains are not enough. If the government tackles the issues surrounding these drains, the problem would be over. (Male, FGDs, Old Tafo)*

As Lave and Lave (1991) noted, no engineering structure can guarantee protection for people living in a flood plain. It is partly in response to this trend that emphasis now is shifting from structural mitigation strategies to those that rely on land management to make room for some flooding to occur (Wood et al., 2012). Generally, respondents have not been able to adapt adequately to the flood condition in which they found themselves. This is evident in the rising levels of losses sustained by victims each time that floods occurred. The use of structural methods must therefore be used to supplement the non-structural approaches. Faisal et al. (1999) noted that a well-coordinated and balanced combination of both structural and non-structural measures is required as part of the long-term flood mitigation strategies.

8.2.2 Non-Structural adaptation to floods

In recent years, the emphasis within the public discourse on flood risk management has witnessed a shift away from large-scale engineering measures and towards the promotion of a broader range of adaptation measures (Johnson et al., 2005). The recognition that conventional means of reducing flood risk had become insufficient in relation to the scale and nature of the problem (Harries and Penning-Rowsell, 2011), has led to a change in policy direction. As Harries and Penning-Rowsell (2011) noted, structural defences alone could never protect communities against the most extreme floods. Non-structural measures are therefore an alternative complementary to structural measures that may reduce the loss of human life and economic activities. These non-structural measures as Minea and Zaharia (2011) indicated include legislation, catchment managements, land and administrative urban planning, public education, insurances, hydrologic forecasting and warning.

8.2.2.1 Migration as an adaptive strategy

In the rural Central Gonja, the study found that residents either permanently or seasonally migrated from their original communities to other places. In rural Gonja, migration was reported as an adaptation strategy. During field interviews, discussants indicated migration as a livelihood strategy. Those who had left the communities due to past negative flood impact were not there at the time of the research to speak for themselves. Fortunately, we met their close friends and relatives who told their stories. There were people with institutional memories including traditional leaders who could recount past events. Scores of ruined and abandoned houses belonging to people who once lived in these communities but are no more there were found in Agege, Nigeria Camp, Debri Port, Bonyamu, Kopedeke, Kikale No.4, Adododeke and Amedyrovi.

As indicated in chapter six, the seeming abatement of floods in rural Gonja has been a source of worry for the rural farmers and fisher folks. Annual river floods came with economic benefits to the farmers and fishermen. The rich alluvial deposits at the banks of the Black and White Volta which were associated with past annual floods were particularly attractive to the rural population for arable farming. A rise in water levels of the Black and White Volta, according to the respondents came with heavy fish catch. When floods do not come, livelihood activities are adversely affected. This situation makes seasonal migration an alternative livelihood strategy. During the prolonged dry season, when fishing becomes economically less-rewarding due to low water level in the Black and White Volta, fishermen migrated downstream to Yeji and other areas to do fishing. Some also migrated to urban Buipe and Kumasi for different livelihood activities. They returned to their various communities when conditions back home improved. This was what a respondent said in a FGDS at Adidodeke, a view that epitomises those expressed by many others:

> *When the floods don't come, we encourage our young men to move to other towns where things are better. This helps us to make extra income to support our families. We encourage our young men to migrate. Even though some women have joined these days, they are in minority. (Male, 62 years, FGD, Adidodeke)*

Those fisher men who did not travel, normally the older folks, adopted farming both along the Black and White Volta (see Plate 8.9) and areas away from these rivers as supplementary economic activity. But farming away from the river banks (upland) has become unattractive to the people for two principal reasons: First, the soil is not as fertile compared with the rich alluvial deposits along the Black and White Volta and second the destruction to crops by the cattle left uncontrolled by Fulani herdsmen. Besides, these farmers often had to go through the arduous task of fencing large tracks of cultivated crops in the hope that they would be safe from the grazing cattle of the

Fulanis. This, in most instances had not been effective. Still others engage in charcoal burning as a supplementary livelihood strategy. Because of uncertainties about when floods would occur, farming along the river banks normally took place much earlier in the year, often supported with irrigation in the dry season. This affords the farmers the opportunity to harvest earlier before the rains set in.

Indeed, migration as a post-flood livelihood adaptation strategy has been widely documented in the literature (Afriyie et al, 2017; Codjoe et al., 2012; Sultana, 2010). Similar to the current findings, these reports also indicate that younger men were found to be more likely to migrate than their older folks. Although younger females were also reported to occasionally migrate during flooding events, women were generally reported as having lower propensities to migrate compared with their male counterparts. Unlike the findings of Afriyie et al. (2017), the seasonal migrations reported in the current work were not occasioned by flood-related disruptions but hydrological changes in the two major rivers that manifest in the low water level and absence of annual floods.

Plate 8.9: Irrigated area along the White Volta, Amedzrovi

Source: Fieldwork (2017)

In KMA, there were also cases of permanent relocation of people. This was evident in the number of buildings especially in Atonso S-lines left either in ruins or standing abandoned, but whose owners were nowhere to be found. Unlike rural Gonja, there was no recorded case of seasonal migration in KMA by the study. It was the case that property owners in wetland areas in KMA would normally not readily abandon their houses in the face of flood threats. They do so only when the flood situation becomes so critical as to threaten their very survival. In situations where owners of such property decided eventually to relocate, they either abandoned them or rented these houses out through their agents to newcomers who may have little or no idea about the prevailing flood conditions in the area. But whether temporal or permanent relocation, is a decision influenced by the interplay of plethora of factors including severity of floods, one's economic status, individual's perceived risk and social networks. Where social capital is weak and non-existent, and economic circumstance makes it impossible to relocate, households have had to put up with or endure years of inconvenience created by perennial floods. A discussant had this to say in a focus group discussion:

> *Look at those buildings standing in the bush there. They belong to people who once lived here. The community extended all the way there but due to floods, they all abandoned their buildings and left the community. Is it not sad? Look at the building next to where we are… It is ours but is now overtaken by weeds. You cannot even rent it out (Male, Atonso S-line)*

8.2.2.2 Social capital an adaptive strategy

Both informal and formal social networks are essential components of 'social capital', a resource produced when people cooperate for mutual benefit (Cattell, 2001). For Putnam, social capital encompasses "…features of social life-networks, norms (including reciprocity) and trust - that enable participants to act together more effectively…" (Putnam, 1995, p. 664). Coleman defines social capital in terms of its structural, relational and functional elements, (Coleman, 1990), while for Jacobs (1960), it refers to networks which provide a basis for trust, co-operation and perceptions of safety. At the core, social capital theory provides an explanation for how individuals use their relationships to other actors in societies for their own and for the collective good. This collective good, or welfare, has both material elements and wider spiritual and social dimensions (Adger et al., 2003).

As indicated in chapter six (see Table 6.4), overwhelming majority of respondents in rural Gonja district belong to informal social network group and benefitted from them. Neighbourhood friends and relations were clearly safety valves for these rural folks in times of trouble as was the case in 2007 and 2010 when destructive floods hit these communities. There was the general feeling among the respondents that everyone has someone close by that could be relied on when in trouble. This situation inspired hope and made people have a sense of belonging and security. The following extracts from the field interviews further lent credence to the above observations:

> *I have benefitted a lot from being in this community. I could not have raised my new building without the support I received from relatives and friends. (Male, FGDs Debri Port)*

> *What I particularly love here is the communal self-help spirit. We are each other's keeper. You have a problem and everybody in the community comes around to support. This is what keeps us going. (Male, FGDs, Bonyamu)*

> *The institutions and the government were unable to fix our past flood problems. We believed our problems could be solved by ourselves…Seeing ourselves as one big family, we make merry together when the occasion demands it and mourn and solve problems together when they arise. (Male, FGDs, Agege)*

As was indicated earlier, communal spirit disintegrates with urbanisation. This explains why familial ties and self-help spirit were lacking in metropolitan Kumasi. Religious organisations, professional associations and the like tend to be safety valves for urban dwellers. While these associations see to the welfare of members based on their rule of engagement and common principle, the proportion of respondents who actually relied on or benefitted from social network groups as means of adaptation in KMA is small (37.5%) (see Table 6.4). As respondents themselves indicated, the supports from these groups were often not connected to flood issues. The following views from respondents amplify this:

> *As a teacher, I belong to the Ghana National Association of Teachers (GNAT). But GNAT does not have resources meant for flood victims support. The association cannot help you to recover losses incurred during floods. A few friends might come to your aid but such assistance would not get you back your lost items. (Male, FGDs, Dichemso)*

> *I do not belong to any association and I have never received any help or benefitted from such associations. I have no helper that is why I am still living here. (Female, FGDs, Boukrom)*

But when she was quizzed further whether she did not belong to any religious association, she admitted being a Roman Catholic church. On whether the church had never come to her aid, she noted:

> *I have never received any financial or material benefits from the church where I fellowship. It only serves my spiritual needs and other social need. (Female, FGDs, Atonso S-line)*

Another discussant added:

> *Yes, the church would support you when you are bereaved, during wedding and outdooring ceremonies. It would not come to your aid because floods have destroyed your property. (Female, FGDs, Atonso S-line)*

8.2.2.3 Flood insurance as a form of adaptation

Flood insurance is critical in adaptation by recovering insured losses in the event of catastrophic flooding. It is a key factor for reducing the financial risk for individuals, enterprises, societies at large in the event of natural hazards (Kron, 2005). Flood insurance can be a worthy supplement to official disaster relief schemes and serve as a foundation for economic resilience. Since the risk of flooding can be spread across time and space, the uncertainties associated with extreme weather events can be attenuated (Lo, 2013).

In both the rural and urban communities studied, no respondent had his or her property insured against unforeseen disaster. The only form of insurance the study found was National Health Insurance Scheme (NHIS) and third-party motor insurance cover. While taking insurance policy to cover property like personal buildings may not be common in the Ghanaian context, the low financial power of these flood-prone communities would make it practically impossible for them to contemplate let alone to actualise insuring their houses. Unless a legal regime makes it mandatory for the insurance cover, voluntarily adopting flood insurance in this context would be a mirage. As Lo (2013) opined, this voluntary move is a function of risk perception that is shaped by social norms.

8.2.2.4 Sale of assets

In situations where victims did not lose all livelihood assets, some sold a bit of these assets to cushion the economic hardships they have had to endure as a result of floods. In the rural Central Gonja, victims sold some surviving cattle and domestic animals to mitigate the effects of floods. Unlike their male counterparts, females were somehow disadvantaged. Since most of them lacked or do not own valuable assets to sell in order to reduce the ills visited on them by floods, they had to rely on assistance from relatives, friends and other institutions. This is consistent with the findings of Aboagye et al. (2013) who noted that lack of ownership of assets by females limits sales of assets as an option to mitigate the effects of floods.

In terms of households' adaptation to floods, whether structural and non-structural, urban households have shown greater capacity than the rural households. This explains why rural households of Central Gonja showed a generally higher level of vulnerability compared to urban households of KMA.

8.3 The role of institutions in flood mitigation and management

8.3.1 Introduction

The section highlights the significance of risk governance as captured in the MOVE conceptual framework. Many societies around the world have institutions that are tasked to protect citizens from the effects of environmental risk events, including those associated with extreme climatic events. Institutional responses take the form of either structural and non-structural. Structural approaches take the following forms: Construction of barriers, barrages, dams and river regulation; building of dykes, levées and embankments; forestation to abate floods; flood proofing/mitigating measures. Non-structural measures on the other hand include: Flood forecasting and early warning; land use planning, regulation and management; public education and awareness raising; and flood preparedness, planning, evacuation and compensation (Harries and Penning-Rowsell, 2011).

8.3.2 Institutional and legal framework for managing floods in Ghana

8.3.2.1 Institutional stakeholders for managing floods

In Ghana, institutional interventions are critical in flood control and management as well as in minimising the negative effects of floods on vulnerable populations. Traditionally flood risks have been managed through a combination of structural defence measures, warnings and emergency measures. More recently they have included development controls and land zoning policies. Since 1988, local government has become the development agent at the local level in Ghana. Through the Local Government Act 1993, (ACT 462), local governments exercise deliberative, legislative and executive functions for the purpose of engendering sustainable development at the local and community level. Thus, the local government is a planning and implementing authority of programmes and strategies meant to minimise the vulnerability of communities. The responsibilities of basic infrastructure provision and ensuring improvement and management of human settlements and the environment rest with the local government. These responsibilities give local governments the mandate to address flood risk issues and socio-economic vulnerability (ILGS and IWMI, 2012).

While there are many other institutions that one can say are involved either directly or indirectly in the flood management process, the key ones are: Central Gonja District Assembly (CGDA), Kumasi Metropolitan Assembly (KMA), Town and Country Planning Department (T&CPD) and National Disaster Management Organisation (NADMO).

i. Central Gonja District Assembly and Kumasi Metropolitan Assembly

The CGDA and KMA are the local authorities of the district and metropolis respectively. They are responsible for the overall development of their respective districts including planning, infrastructural development and social service provision. Flood issues are integral part of the development plans of the assemblies. These are captured in the form of mitigating strategies such as construction of drains, drains de-silting, clearing of choked gutters and public education. Metropolitan, Municipal and District Assemblies (MMDAs) have the responsibility of ensuring the provision of adequate and consistently functioning drainage systems in order to minimise the impacts of flood hazards (MLGRD, 2010). Other key roles of the MMDAs include enforcement of bye-laws, budgeting for the purpose of flood management, forging partnership with private entities and other stakeholders in addressing problems of floods, mobilising community members for the purpose of flood management by offering them training programmes. The study found that the major flood management strategy of the KMA is the engineering approach involving construction of storm drains, bridges and other flood control barriers.

ii. Town and Country Planning Department

As a government agency, T&CPD is responsible for the planning and managing growth and development of settlements in the country. It is the mandate of the department to promote sustainable human settlements development anchored on the principles of efficiency, orderliness, safety and healthy growth of communities. In terms of flood management and control, its role is not in doubt. Being an institution in charge of land use planning, it makes recommendations for water courses to be protected so that floodwaters are allowed to flow through. It also offers assistance in programmes meant to educate and sensitise the public while serving on NADMO board which is responsible for the control and management of floods.

iii. The National Disaster Management Organisation (NADMO)

By the Act establishing it, (Act 517 of 1996) NADMO has the responsibility for managing disasters and related emergencies. It is responsible for coordinating material and human resources of various institutions and agencies in order that emergency response in times disaster and management of disaster in general in the country are carried out in the most effective and efficient way (ILGS and IWMI, 2012). It is also to ensure the country's preparedness to avert disasters and ensure their proper management when they occur.

NADMO also offers material and other support services in the form of first aid to victims of flood disaster while it sorts things out with other stakeholders. Relief or support items may include but not limited to clothing, medications, food items, temporary housing, tents, building materials depending on the intensity of the flood disaster, mattresses, and cooking utensils. Where private individuals, organisations or agencies want to assist in times of disaster, NADMO is the conduit to get to the affected communities.

As part of their programmes, they also educate the public about flood mitigation, management and reporting through the most accessible mass media. Through the publication of their quarterly newsletter, NADMO educates people and also share information on flooding. Furthermore, NADMO collaborates with other stakeholders in managing flooding through the rapid response team for effective communication by inviting ministries, departments and agencies that have a stake in flood management to deliberate and take decisions on flood prevention and management.

In order to play its role meaningfully, NADMO offices have been established from the national through the district to the zonal level throughout the country. NADMO officers carry out field visits to assess the extent to which residents have put in measures to prevent disaster. As a community mobilisation strategy, Disaster Volunteer Groups (DVGs) are placed in the various communities, who provide immediate response to flood disasters before reports are delivered to their various district offices and to regional or the headquarters where necessary. Thus, DVGs serve as early warning elements, conduits of community awareness creation and first responders to disasters in their respective communities.

8.3.2.2 Legal regime for managing floods in Ghana

Legal support for reducing the risks of flooding by the Government of Ghana is captured in the National Water Policy (2007), Environmental Sanitation Policy (2010), National Urban Policy (2012), and Land Use and Spatial Planning Act (Act 925), 2016. In the National Water Policy (2007) under Focus Area 6, Government aims to:

- construct flood protection structures at appropriate locations;
- apply appropriate technologies to provide the necessary information for detection and early warning systems for floods and drought;
- establish and enforce appropriate buffer zones along river banks including measures to compensate for loss of lands;
- ensure that land use planning/building regulations are adequate and enforced in respect of waterways and flood-prone areas;
- ensure rainwater harvesting techniques are incorporated into the building code and enforced; and
- ensure implementation of mitigation strategies in consultation with affected communities (MWRWH, 2007 p. 21; *ILGS and IWMI, 2012 pp. 12-14)*

The Environmental Sanitation Policy (2010: 5) reflects the following strategies by the government that could have a direct or indirect bearing on floods:

- restricting the formation of new slums;
- ensuring efficient and effective management of flood control and drainage systems; and
- promoting private sector participation in flood control and coastal protection (*(ILGS and IWMI, 2012 pp. 12-14).*

The Environmental Sanitation Policy (2010) mandates District Assemblies to ensure that communities are provided with adequate and consistently functioning drainage works in accordance with nationally defined design standards in order to limit sanitary nuisances, vector breeding and the physical hazards of flooding.

In the May 2012 Ghana National Urban Policy, some initiatives for achieving objective four (4) of 'improving environmental quality of urban life' directly and indirectly relate to flood control. These are:

- Develop and manage infrastructure systems with the appropriate technology needed to provide basic hygienic conditions in towns and cities;
- Generate environmental awareness by increasing mass media public education programmes on sanitation in schools and public places;
- Protect open spaces, green belts, forest reserves, water bodies, wetlands, water catchment areas and other ecologically sensitive areas from physical development and urban encroachment;
- Develop and implement a systematic programme of flood control measures in urban communities;
- Pursue rigorous public education and law enforcement against reprehensive public attitudes and conduct that induce environmental degradation; and
- Establish adequate measures against natural hazards in urban areas (GOG, 2012 p. 24).

In 2016, the Land Use and Spatial Planning Act (Act 925) came into force. The purpose of the bill was to provide a comprehensive legal framework that will consolidate, revise and harmonise existing legislation on land use and spatial planning and provide for sustainable development of land and human settlements through a decentralised planning system. It is to ensure judicious use of land in order to improve quality of life, promote health and safety in respect of human settlements, regulate national, regional, district and local spatial planning and generally provide for spatial aspects of socio economic development. The bill was passed due to the concerns about the absence of a comprehensive legal framework for land use and spatial planning, which has led to multiplicity of legislations conferring land use, planning and management functions to institutions other than the T&CPD (Kyei, 2016; MESTI, 2015).

8.3.3 Structural approach to flood control by institutions

The institutional structural approach to flood control does not apply to rural Gonja. No such structures were observed in the study of rural Gonja district. In Kumasi Metropolis, these include first and foremost construction of drainage channels, storm drains and bridges in the neighbourhood. There are countless number of them in the Metropolis except that they are either too narrow or often choked with solid waste thus undermining their capacity to carry surface water runoff and streams that run through them. There are also ongoing projects such as the storm drain on the Aboabo River spanning through Anloga through Asokwa and Ahensan to Atonsu.

Another structural approach that the study found is dredging of river or stream channels that flow through the Metropolis. This is done to increase their depths which help reduce their chances of over-flowing their banks to cause flooding. One of the main causes of floods in the Metropolis as noted in chapter five has been poor solid waste management. In order to address this, the KMA in collaboration with other agencies carry out routine clearing of choked river channels, tertiary and roadside drains (choked gutters), sometimes with the involvement of local communities. NADMO also organises de-silting of drainage systems through community mobilisation using their DVGs at the various sub-Metros. The objective of this exercise is to ensure that the drainage systems remain uninterrupted or their flows are improved. In most of these flood prone suburbs, the chiefs and assemblymen also harness local labour and capacity into clearing drains of filth, building walkways, footbridges, drains among others. Regrettably, waste clearing only provides a short-term relief as the city gets back into the same mess on yearly basis due mainly to the rapidly growing and lawless urban population, resource constraint and institutional inertia in the enforcement of relevant laws.

KMA also organises demolition where necessary of buildings located in environmentally precarious locations or in waterways to allow streams to flow smoothly and save the larger community from risks of floods. This approach has never worked in a desired way because of its reactive rather proactive nature. Besides, its selective nature leaves some buildings in waterways untouched while others are cleared. This selective process often degenerates into unnecessary confrontations which sometimes attract the interventions of some influential public figures. It also comes with protracted legal tussles at the court making the demolishing exercise ineffective.

8.3.4 Non-structural

8.3.4.1 Flood forecasting and early warning

Forecasting and warning systems must advance information allowing the population preparedness for the flood occurrence. Weather forecast and hydrological warning at the national level come from Ghana Meteorological Agency (Gmet) and disseminated through the mass media. Through the engagements with other institutions, NADMO is able to gather relevant information in order to share with communities to prepare for potential flooding incidents. Prior to rainy seasons, NADMO normally sent warnings about floods through community mobilisation using Disaster Volunteer Groups (DVGs) at the various sub-Metros. In rural Central Gonja, information about the extreme weather events, opening of the Bagre dam and potential flooding is normally communicated to the communities by NADMO mainly through their zonal coordinators and DVGs and sometimes through their local radio station. Since they did not have an Early Warning System in place, information gets to the district from the regional NADMO office. But as the District coordinator of NADMO recounted, financial constraints limit the use of radio as a source of information dissemination. In KMA, awareness creation and sensitisation programmes are organised by NADMO through the radio, television as well as the use of information vans of the Information Services Department, as well as other collaborative agencies. On early warning system, the operations officer of NADMO, KMA explained it this way:

> *Yes, we have early warning system in place that helps us get information about weather changes. This was made possible through the CREW project. When we get this information, we relay it to the communities through our sub-metro and district directors and the DVGs in the various communities. (IDI, NADMO, Kumasi)*

The Community Resilience through Early Warning (CREW) Project according to the key informant was established in 2013 under the partnership of UNDP and Government of Ghana through the National Disaster Management Organisation with funding support from Norwegian Government to deliver some of the key components of the Ghana Plan of Action for Disaster Risk Reduction (DRR) and Climate Change Adaptation programme (CCA) 2005-2015. Through the implementation of hazard mapping, early warning, and vulnerability assessment and reduction, the project aims first to reduce economic and human losses and damage from priority disasters, and second, to establish an effective early warning and communication for priority hazards to reduce disaster risks in the 10 pilot sites including Kumasi by 2016. Through this intervention, Early Warning communication equipment have been procured and installed at the NADMO Headquarters and in twenty sub-national offices.

The Community Resilience through Early Warning system (CREW EWS) uses open free of charge satellite based meteorological data and provides a basic flood and drought forecast for all the pilot areas. The CREW EWS exists of two systems: an expert system that collects data, calculates forecasts and presents all relevant data and a web dissemination tool called "Dashboard" that visualises specific warnings and flood hazard information through a dedicated website. With the aid of these systems, the skill required for estimating the intensity of rainfall is expected to improve while providing reasonably accurate rainfall forecasts for issuing early warning necessary to protect vulnerable communities from flood hazards.

8.3.4.2 Land use planning, regulation and management

One of the reasons amplifying the negative effects of floods is human settlements exposure due to their location in the floodplains. Urban planning policy, as an instrument for reducing associated effects of hydric risk is expressed by flood areas zoning, discouraging constructions in floodplains and offering of technical advice regarding land use. The role of local public administration as Minea and Zaharia (2011) noted is to restrict approvals of new construction in flooding areas and resettlement. In Ghana, and for that matter KMA, this is never the case. There are good policies in place that if implemented, could stem the perennial flood situation in the Metropolis. It was evident from the public interviews (as also indicated in chapter five) that there are big and influential players in the whole land sales arrangement. The land business is a complex transaction involving a number of actors from KMA, Land Commission and the Traditional Authority. A key informant from the Water Resources Commission in Kumasi Metropolis explained:

> *The perennial flooding in the Metropolis is really worrying. As a commission, we have clear policy guidelines (referring to the Riparian Buffer Zone Policy) that seek to protect water bodies from encroachment by developers. There is a limit to which we can go. We don't have the power to stop people from building in wetlands. We don't sell nor allocate lands. The institutions mandated to do this are simply not helping. They together with chiefs are are to blame. (Female, IDI)*

Another key informant from the Hydrological Services Department noted:

> *We design and supervise construction of drains. We do not construct them by ourselves. It is normally given to contractors. In Ghana, it isn't the case that we don't know what the right thing is but we simply refuse to do the right thing. We would offer the right technical advice but may not be followed strictly due to funds unavailability when the implementation comes. The failure of people to do the right thing including the planners is what is causing the flooding issue. (Male, IDI)*

An officer at T&CPD, KMA was unhappy about the perennial floods in the Metropolis. He remarked:

> *The citizens are to blame. Why do I say so? Why should anybody in the first place pay for land located in a place that you know is uninhabitable? It would interest you to know that most of those who develop their property in waterways and in other flood-prone areas do not have the requisite permit to do so. They are unauthorised buildings. KMA pulls these buildings down today and tomorrow new buildings spring up. In most cases, we don't have any idea about these developments. (Male, IDI)*

Similar blaming of others was recorded in an interaction with an officer at the Lands Commission (the Land Registration Division and the Public and Vested Land) and the Department of Parks and Gardens, in Kumasi Metropolis. This may also simply be a defence mechanism or an attempt to deny that they themselves are part of the problem. In other words, they may simply be engaging in a psychological mind game to create the impression that they played no role as an institution in the flood problem.

8.3.4.3 Raising public awareness/ Public education

In Central Gonja, NADMO with the support of the District Assembly is involved in public education and awareness creation about floods and mitigation measures through the local radio station and the DVGs. As the District Director noted, their main focus has been public sensitisation on how to prevent losses resulting from floods. There are however some constraints. The main operational challenges as noted by the NADMO officer were lack of funds and other logistics including means of transport. Inaccessibility of the remote rural communities limits effective operations of NADMO. The District NADMO Director in Central Gonja had this to say:

> *We have a lot of problems including finance and means of transport to the remote flood-prone rural communities. (Male, NADMO-Central Gonja)*

Raising public awareness on floods in KMA is one area that NADMO, working with other institutions focuses on. The KMA and NADMO mostly carry out their public education on floods through the radio, television or use of information vans of the Information Services Department. NADMO publishes a quarterly newsletter to educate people and also share information on flooding. Like in Central Gonja, inadequate funds undermined effective and efficient delivery of services by NADMO in KMA as noted by the operations officer of NADMO.

> *Our main constraints are inadequate logistics and funding. We normally receive some financial support from KMA, usually from the disaster fund to carry out our educational programmes. Our success largely depends on the support we receive from stakeholder institutions. (Male, NADMO-KMA)*

8.3.4.4 Flood preparedness, planning, evacuation and compensation

In the National Disaster Management Organisation Act, 1996 (ACT 517), NADMO is given the mandate for preparing, monitoring and evaluating disaster plans as well as provision of facilities for public awareness, warning systems and general preparedness for staff and communities. The National Disaster Management Organisation (NADMO) working with other institutions like the Police, fire service and the like help in evacuation of victims to safe places. It is the institution mandated to co-ordinate the supply of relief items in the form of food, medicine, clothing, bedding and temporary shelter (tents). But as Campion and Venzke (2013) noted, the provision of such relief items will depend on the availability of funds and number of people who have been affected.

8.3.5 Evaluation of the role of NADMO and other institutions

It has to be noted that, several institutions are involved in reducing the risks of flooding in Ghana. NADMO works with other institutions like, the Police Service, Ghana Fire Service, the Army, aid workers, volunteers and paramedics to protect lives and property whenever floods occur. In Central Gonja, Non-Governmental Organisations (NGOs) like Care International and Action Aid International have been particularly helpful. Notwithstanding the institutional, legal or policy frameworks, Ghana is yet to witness an end to perennial floods. The situation is even more serious in the urban centres where rapidly growing populations and inadequate spatial planning have combined to increase vulnerability of the urban poor to flood risks.

To many of the respondents, NADMO is the only institution they knew and looked up to. Respondents were therefore asked whether they were satisfied generally with the kind of support or services they received from NADMO using 5-point scale responses ranging from not at all satisfied (1) to extremely satisfied (5). It is clear from Table 8.7 that most respondents were not that satisfied with the kind of support they received. In rural Gonja, majority (82%) of the respondents were slightly satisfied, with 6.3% not satisfied at all. In KMA, 50.3% were slightly satisfied while as high as 43.8%

were not satisfied at all. These responses were not strange because of the generally wrong public perception about the actual mandate of NADMO. Viewed largely as an organisation set up to distribute relief items, public disaffection for NADMO has grown over the years because such expectations have not been met.

Several reasons were given for these responses. Respondents who showed some level of satisfaction indicated that at least they got something to cushion their problems. While the majority (59.9%) in rural Gonja said institutional interventions helped to alleviate their sufferings, 59.6% of respondents in KMA said the information and other non-material benefits prepared them to cope with floods when they occurred. The distributions of other related reasons for rural and urban respondents are captured in Table 8.8.

Those who said they were not satisfied gave reasons such as delays in the responses of these institutions especially when it comes to relief items, inadequate relief items, failed or unfulfilled promises and the fact that they still live with the floods (see Table 8.9). In Central Gonja their main concern had to do with the quantum and timely distribution of relief items. A middle-aged man at Debri Port captured it vividly in the following statement:

> *When the floods came we had to resettle. It took some time before the compensation came. The items were simply not enough compared to what we lost. They were basically food and water. Some people did not get anything. We still need some help. (Male, FGDs)*

In KMA, not even a single respondent said they ever received relief items from NADMO or other institutions that NADMO works with. As the respondents indicated, these institutions are not visible and they do not come to them in times of trouble. This is the narrative of a discussant in Atonso S-line, a view that reflects the general feelings of participants:

For us here, nobody comes to us. We've lost items due to flooding but have never been compensated for. It is only our Assemblyman who came here around elections time. They sometimes organise dredging and de-silting of drains in the community when they need our votes. (Male, FGDs)

Table 8.7: Respondents' level of satisfaction with institutional support by locality

Scale	Level of satisfaction	Rural		Urban	
		Freq.	%	Freq.	%
5	Extremely satisfied	-	-	-	-
4	Very satisfied	11	3.0	5	1.3
3	Moderately satisfied	32	8.7	19	4.8
2	Slightly satisfied	301	82.0	201	50.3
1	Not at all satisfied	23	6.3	175	43.8
	Total	**367**	**100.0**	**400**	**100.0**

Source: Fieldwork (2017)

Table 8.8 Respondents' reasons for satisfaction with institutional support by locality

Reasons	**Rural**		**Urban**	
	Freq.	%	Freq.	%
Was better than nothing	33	9.6	20	8.8
Able to get back some lost items	55	16.0	-	-
We got what we were even not expecting	11	3.2	-	-
They help to lessen our burden, stress, pains	206	59.9	33	14.7
Items were shared fairly	5	1.5	-	-
Can't depend on government/institutions for everything	15	4.4	-	-
Information they share with us help us to prepare and cope better	9	2.6	134	59.6
They show they care for us	-	-	38	16.9
Always responded in times of disaster	10	2.9	-	
Total	**344**	**100.0**	**225**	**100.0**

Source: Fieldwork (2017)

Table 8.9: Respondents' reasons for dissatisfaction with institutional support by locality

Reasons	Rural		Urban	
	Freq.	**%**	**Freq.**	**%**
Inadequate relief items/not enough/did not match lost items	7	30.4	-	-
Support came late/not timely	8	34.8	22	12.6
Floods still persist/floods still affect us	2	8.7	28	16.0
Failed promises/demand for financial contribution	-		53	30.3
Received only food and used clothing	4	17.4	-	-
Items not fairly distributed/items went to wrong people/not every affected person got relief items	2	8.7	-	-
They are less visible/little action/We don't see them	-	-	72	41.1
Total	**23**	**100.0**	**175**	100.0

Source: Fieldwork (2017)

8.4 Summary

The chapter dealt with how rural and urban households in Ghana have coped with and adapted to floods. Households were found to have adopted different coping strategies during floods. The dominant coping strategy adopted by rural Gonja respondents was temporary relocation. In KMA, blocking of floodwater entry points, fetching of water out of rooms and compound and moving valuables to safer grounds were the dominant coping mechanisms. In general, the urban study communities of KMA were better able to cope with floods than the rural Gonja communities. The hypothesis that there is no significant relationship between length of stay in flood-prone community and ability to cope with floods was validated using Pearson's Chi-square test. Pearson's Chi-square analysis showed no statistically significant relationship between coping ability and settlement type (rural or urban). There was however statistically significant relationship between coping ability and age for both rural and urban. Sex showed no statistically significant relationship with household ability to cope with floods in both rural and urban settings.

Unlike the short-term reactive individual household response to floods, they also employed varied adaptation strategies in order to manage current and future flood risk. In terms of adaptation, both structural and non-structural measures were employed. The study found that structural measures were the dominant ways by which the rural and urban households have adapted to flooding. The non-structural approaches included migration, use of social capital, and sales of assets. In both the rural and urban communities covered in this study, no evidence of flood insurance policy cover was found.

The study found that many institutions were involved in the control and management of floods in both the rural and urban communities that were covered in this study. Institutional responses like the individual household responses took the form of non-structural response in the form of public education in rural Central Gonja. In KMA, it has been a combination of both structural and non-structural responses. The effectiveness of these institutions to carry out their mandate has been compromised by plethora of factors including constraint of funds, weak laws, ineffective coordination among the institutions and unnecessary interference from politicians and traditional leaders. In spite of the institutional and policy framework, the flood situation in Ghana appears to be worsening year by year. While the agencies think that they were doing well in the face of financial and logistic constraints, the respondents thought otherwise. The following chapter, the last one, summarises all the preceding chapters, draws conclusion and gives recommendations for policy and for further research.

CHAPTER NINE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

9.0 Introduction

This chapter presents a summary of key findings, conclusions and recommendations of the study. The chapter summarises the problem investigated, the objectives, methods and key findings. Conclusions were drawn and appropriate recommendations provided as well as the contributions to knowledge and literature, limitations and areas for further research

9.1 Summary

9.1.1 Problem and objectives

Floods remain one of the most endangering sources of disaster risk, posing danger to particularly vulnerable human systems. While the global picture shows that immediate loss of life from flooding is increasing more slowly, reflecting the successful implementation of flood risk management measures, fatalities still remain high in underdeveloped countries where floods have a disproportionate impact on the poor and socially disadvantaged, particularly women and children.

Rural and urban Ghana are scenes for perennial floods, with rising loss of property including household productive assets for every successive floods. The 2010 floods, one of the many flood disasters that have devastated the Central Gonja District, submerged several communities and destroyed household economic assets. In Kumasi Metropolis, perennial floods with increasing intensity and widening spatial extent continue to cause human vulnerability. The number of people affected by floods and associated losses keep rising from year to year. In Ghana, reports on floods in terms of their causes and effects have largely been left to the media. Scientific studies of household vulnerability and adaptation to floods in rural and urban Ghana are limited. The current study tried to fill these lacunae. The general objective of the study was to examine households' vulnerability and adaptation to floods in rural and urban Ghana. Specifically, the study

1. described the different physical and human contexts within which floods occur in rural and urban Ghana.
2. analysed the relative vulnerability of rural and urban flood-prone households to floods.
3. assessed how rural and urban households have been affected by floods.
4. examined the coping strategies of rural and urban Ghanaian households to floods.
5. examined the adaptation strategies of rural and urban Ghanaian households to floods.
6. evaluated how the institutional and legal context affects vulnerability of households to floods.

9.1.2 Empirical and conceptual perspectives of vulnerability and adaptation to floods

Floods refer to the condition that occurs when water overflows the natural or artificial confines of a stream, river, or other body of water, or accumulates by drainage over low-lying areas. Floods have been classified as the most common of disastrous acts of nature among all catastrophes leading to economic losses and deaths. Floods can have negative economic, social and environmental consequences. Catastrophic floods can drown people and livestock, sweep away bridges, vehicles and buildings, force the survivors to abandon their homes and cause extensive morbidity and mortality throughout the world.

Human population continues to be vulnerable to floods. Vulnerability has been defined as the degree of loss resulting from a potentially damaging phenomenon or the degree to which a system or unit (such as a human group or a place) is likely to experience harm due to exposure to perturbations or stresses. Disentangling the components of vulnerability has been the subject of vigorous academic debate. However, there is a simple and widely accepted approach that is broad enough to capture the essence of the different concepts of vulnerability detailed in the literature. The framework defines vulnerability as a function of exposure, sensitivity, and adaptive or coping capacity.

Many factors contribute to vulnerability. These factors act to undermine capacity for self-protection, blocks or diminish access to social protection, delays or complicate recovery, or expose some groups to greater or more frequent hazards than other groups. They include rapid population growth, poverty and hunger, poor health, low levels of education, gender inequality, fragile and hazardous location, and lack of access to resources and services, including knowledge and technological means, disintegration of social patterns. It also includes lack of access to information and knowledge, lack of public awareness, limited access to political power and representation (Aysan,1993 cited in Philip and Rayhan, 2004).

Vulnerability of human populations to floods has been studied from different theoretical and conceptual perspectives. Key among these are: Sustainable Livelihood framework (DFID; 1999); the double structure perspective of vulnerability (Bohle, 2001); vulnerability as one of four components of disaster risk (Davidson's, 1997); Bollin et al., 2003); UN/ISDR framework (UN/ISDR, 2004); Turner et al. (2003)

framework; pressure and release model (Füssel, 2007); the holistic conceptual framework (Cardona and Barbat, 2000; Carreño et al., 2005); Onion framework (Bogardi and Birkmann, 2004); BBC conceptual framework (Bogardi and Birkmann, 2004; Cardona, 1999) and the MOVE framework (Birkmann et al., 2012). The current work used the MOVE (adapted) framework for analytical purpose.

9.1.3 Summary of main findings

9.1.3.1 Natural and human contexts of floods in rural and urban Ghana

As one of the objectives, the study analysed the natural and human factors that give rise to floods in rural and urban Ghana. The study did not find rainfall as a principal factor causing flood disasters in both Central Gonja and Kumasi Metropolis. Indeed, annual rainfall has witnessed a decreasing albeit insignificant trend in the Central Gonja but showed an insignificant increasing trend for the month June. In KMA, the trend has been an insignificantly increasing annual rainfall trend, but a decreasing trend for June. From the available evidence, the study has also not been able to establish a strong case for topography, geology and soil as flood triggers. The study found that anthropogenic factors rather than physical-environmental factors are mainly responsible for the past flood cases in both rural Central Gonja and Kumasi Metropolis. While the Opening of the Bagre dam in the neighbouring Burkina Faso is a key factor for past flood cases in Central Gonja, poor spatial planning and land use management as well as poor solid waste management underlie the perennial flooding in Kumasi Metropolis. These findings confirm the proposition that human factors were responsible for the past floods in the study communities.

9.1.3.2 Household characteristics and flood vulnerability analysis in rural and urban Ghana

The study also examined rural and urban household vulnerability in relation to their background information. Majority of the respondents were engaged in informal sector employment with fishing and farming being the dominant occupation in rural Gonja and commercial activity being the main economic activity in KMA. Economic returns from these various activities were generally low. Thus, majority of the respondents fell within the low-income group, making them vulnerable to floods. In terms of financial capital base of the households, it was generally low in both the rural and urban study communities. With generally low educational background and limited vocational skills human capital base was equally low particularly in rural Gonja. Not only were asset categories limited, but livelihood opportunities were equally limited in these flood-prone communities. These characteristics among others increase the vulnerability of the study population to floods. In general, the rural households in Central Gonja showed a higher level of vulnerability to floods than the urban households of KMA in terms of the vulnerability indicators used.

9.1.3.3 Effects of floods in rural and urban households

Floods affected both the rural and urban communities studied from economic, social and health perspectives, with rural households bearing the greatest brunt in terms of economic losses and psychological health problems. Paradoxically, the rural folks that suffered the most and still potentially more vulnerable to future floods perceived perennial floods as more of a blessing than a curse. While there was a significant relationship between age of respondent and flood-induced psychological health problem in Central Gonja from Pearson's chi-square results, there was no significant relationship between age of respondents and flood-induced psychological health problem in the case of KMA. In the study, older people showed higher level of perceived psychological health. From sex perspective, females showed higher levels of psychological health problem in both rural and urban study communities.

9.1.3.4 Coping with and adapting to floods by rural and urban households

Households were found to have adopted different coping strategies during floods. These included among other measures temporary and permanent relocation, fetching of water out of flooded compound and rooms, blocking of entry points of floodwater into compound, and moving things to higher/safer grounds. In some cases, the study found that respondents could not help the situation but looked on helplessly as they waited for neighbours and institutions to come to their aid.

In terms of adaptation, both structural and non-structural measures were employed. The study found that structural measures were the dominant ways by which the rural and urban communities have adapted to flooding. Some of the specific structural measures included: Fence wall as a defence mechanism; elevating entrance through concrete works; reconstruction of new house on a raised foundation or upstream; renovation of buildings; building embankments with sandbags or ridges around house; Use of upper floor of storey building; and reinforcing building base or foundation through massive concrete works. There were however some respondents who had no measures in place by way of adaptation due to lack of capacity to do so. The non-structural approaches included migration, use of social capital, and sales of assets. In both the rural and urban communities studied, no evidence of flood insurance policy cover by households was found.

The study found that many institutions were involved in the control and management of floods in both the rural and urban study communities but the effectiveness of these institutions however has been undermined by a number of challenges but most prominent being weak legal regime, resource/logistic constraints and non-enforcement of land use regulations. While the institutional respondents thought that they have done well in the face of logistic constraints, the households thought otherwise.

9.2 Conclusions

Analyses of rainfall and other natural physical factors revealed that they cannot be blamed for the past flood situation in both Central Gonja and KMA. With diminished role of climate and other physical factors, the study concluded that anthropogenic factors rather than climatic or physical factors have been the main causes of floods in both rural and urban Ghana. While the opening of the Bagre dam in Burkina Faso has been the main trigger of floods in Central Gonja, that of KMA has been driven by urban sprawl and growth processes accompanied with inadequate drainage infrastructure and poor waste management. The proposition that anthropogenic factors account for increasing floods in both rural and urban Ghana was thus validated. The MOVE framework used emphasises coupling relations between environmental and societal dimensions. This means that floods are given form and meaning by the interaction with social systems and social systems also influenced by their actual and perceived hazard context and environmental conditions. Findings reflect that floods in both rural and urban Ghana result from the interplay of both human and natural factors which justifies the conceptual framework.

In relation to the selected vulnerability indicators which measure exposure, susceptibility and resilience categories and captured in the MOVE analytical framework, majority of both the rural and urban study communities were found to be highly vulnerable to floods with rural Gonja communities showing a higher level of vulnerability. Not only were they more exposed and susceptible, they also demonstrated lower capacity to cope and adapt. The proposition that rural households reflect a higher level of vulnerability to floods than the urban households in terms of their characteristics was thus validated (proposition two).

Defining vulnerability as an outcome, the study found the rural and urban flood-prone communities reflecting different levels of vulnerability socio-economically. Floods have had both economic and social effects on households in both the rural and urban communities studied, with rural households bearing greater brunt in terms of economic losses and psychological health problems. While a higher economic loss for rural households did not support the third proposition, a higher perceived flood-induced psychological health for the rural households supports the fifth proposition. As regards flood-induced mortality and physical health burden, urban households showed a higher level of vulnerability than the rural households, thus failing to validate the fourth proposition. While there was a significant relationship between age of respondent and flood-induced psychological health problem in Central Gonja per the chi-square test, with older people experiencing a higher level of perceived psychological health (rejected null hypothesis), there was no significant relationship between age of respondents and flood-induced psychological health problem in the case of KMA (unable to reject null hypothesis). In terms of sex, females showed higher levels of psychological health problem in rural Gonja communities but there was no significant relationship between sex and perceived psychological health in KMA.

Different strategies were adopted by the rural and urban households to cope and adapt to floods. Aside the short-term reactive responses employed mainly during floods to floods, households also adopted different adaptation strategies to enable them reduce the ills of floods. In both rural and urban households, structural approaches were the norm. The non-structural measures of adapting to floods were however limited. Over-reliance on the structural defence mechanisms has not helped to mitigate the sufferings of these flood-prone communities. In terms of coping and adapting to floods, rural households of Central Gonja showed a lower capacity compared with the urban flood-prone communities of KMA. It was therefore not surprising that rural households showed a higher level of vulnerability to floods than their urban counterparts.

Institutional interventions in flood risk mitigation have not been effective due to non-enforcement of land use regulations and financial constraints. The combined effect is that the study communities had low capacity to cope with and adapt to floods, thereby increasing their vulnerability. Results however suggest a higher capacity of coping and adaptation among urban households than rural households. The hypothesis that there is no significant relationship between length of stay in flood-prone community and ability to cope with floods was validated. There was statistically significant relationship between coping ability and age in both rural and urban settings but sex showed no statistically significant relationship with household ability to cope with floods in both rural and urban areas. As illustrated in the conceptual framework, household vulnerability to floods would be reduced if they can anticipate flood occurrence, cope with it when it occurs and can recover easily after its occurrence. Lack of these only implies increased vulnerability. The findings in general justify pragmatism, the philosophy that underpins the study.

9.3 Recommendations

9.3.1 Recommendations for policy

1. Drainage systems must be expanded to increase their capacity for detaining and conveying high stream flows. This must be supplemented with feeder channels to channel water into the main drainage system. KMA must play a key role in this regard.
2. A key requirement for addressing the flood menace is regular dredging and de-silting of urban stream/river channels by the KMA in collaboration with other stakeholders.
3. In KMA, a review of the waste management system is needed. Provision of adequate and accessible waste bins is good but if these are not lifted regularly, waste littering is inevitable. Regular emptying of waste receptacles by waste collection companies is of cardinal importance. Regular cleaning of choked gutters through mobilisation of community labour would help stem incidence of floods linked with choked drains. Waste re-use and recycling must be given a priority attention. Importantly, sustained public education, through the most accessible media on the ills of indiscriminate waste disposal and the need to avoid deliberate dumping of waste into drains would go a long way to solve the waste problem. Here again, KMA working with the various waste management companies must play a lead role.
4. Sustained education and community sensitisation on the need to avoid building in waterways, wetlands as well as building too close to large waterbodies as in the case of rural Gonja is a matter of necessity. This must involve all key institutional stakeholders such as NADMO, the assemblies and traditional leaders.

5. In the case of KMA, there is the need to adopt smart growth principle to stem the phenomenon of urban sprawl. This principle has been embraced and applied in a number of countries mainly in the developed world as a reaction to a sprawling city. The concept demands that future urban growth is focused on existing built-up areas to establish a compact, efficient and environmentally sensitive pattern of urban development that provides people with various transportation systems and a range of housing and employment choices. Smart growth does not imply cessation of growth; rather, it emphasises revitalisation of the already-built-up environment and, to the extent necessary, fostering compact urban development.
6. Maintaining urban green spaces and conserving vegetative cover can be a useful intervention in controlling floods. In areas where the trees have been removed, planned tree replanting must be undertaken through the assemblies with support from all other relevant stakeholders. For the streets and other key public places, a close collaboration between civil engineers and landscape architects from a very early stage is required in order to integrate tree planting into the design of such places. This however requires the development of a green plan or strategy by KMA to guide the development of green spaces.
7. Of overriding importance is the need for enforcement of relevant laws on planning and urban design. Kumasi Metropolitan Assembly for example is too lax in enforcing removal of illegal structures that give rise to worsening flood situation.
8. One major reason for the never-ending flood situation is week institutions. Institutional strengthening then becomes absolutely critical. Adequate funding to NADMO and other institutions from the central government is necessary. The problem of floods is such that the Government alone may not be able to provide

all the needed resources. NGOs and corporate organisations must join in the crusade on the fight to rid our rural and urban communities of destructive floods. To succeed, these institutions must wake up to their responsibilities in the enforcement of policies relating to land use. They must be allowed to work devoid of undue interference from the politicians, traditional leaders and other so called 'big people'. The various institutions must also work hand-in-hand. In other words, institutional coordination is paramount. We also need a new generation of citizens ready to support these institutions to ensure a more sustainable use of the rural and urban environment.

9. In the short-term, an effective international collaboration and agreements with Burkina Faso on the share use of the Volta River Basin is key in ending the periodic floods from the Bagre dam water spillage. A transboundary water resource management with cooperation from the riparian states is recommended. This will succeed if a multi-scale participatory governance framework for joint management of water resources and improvement of livelihoods through riverbank protection schemes is given practical relevance. A broad-based inter-ministerial task force from the Ministry of Local Government and Rural Development, Water Resources Commission, Ministry of Interior, Ministry of defence among others may be required for intervention. In the long-term however, these communities may have to be relocated away from their present location through the district assembly, with the support from other stakeholders. Such a decision must however involve the stakeholder riparian communities.

9.3.2 Areas for further research

1. An in-depth study of the role of flood risk communication in disaster risk reduction in Ghana.
2. An exploration of objective measurement or assessment of vulnerability using indicators developed in this study.
3. Flood risk perception in rural and urban flood-prone communities.

9.4 Limitations of the study

Despite the novel contributions of this study, a few limitations are notable. The first relates to lack of institutional flood data for Central Gonja beyond 2010. Even for KMA, flood data earlier than 2012 were unavailable. This limited how far back and forward in time (temporal analysis) one could make analysis. This did not however compromise the results of this study. As regards household flood-induced economic losses and psychological health problems, information provided was entirely based on self-reporting rather than clinical measures. While this may raise questions about the authenticity of the information provided, cross-checking with other community members helped to address this concern.

9.5 Contributions to knowledge and literature

9.5.1 Contribution to knowledge

To the best of our knowledge, this is the first study that examines the health effects of floods within the Ghanaian context. In particular, investigating the long-term (psychological) health effects of floods in both rural and urban Ghana using a simplified 10-point Kessler and others screening questions for assessing psychological distress of respondents is novel. The comparative, holistic and eclectic use of different methodological approaches and research techniques based on pragmatic philosophical stance in assessing household vulnerability and adaptation is a methodological contribution.

Conceptually, the study has made some contributions. The use of the adapted MOVE conceptual framework, which was developed and applied in Europe, in evaluating households' vulnerability and adaptation is the first of its kind in the context of Ghana. The key elements in the framework and the set of vulnerability indicators developed and their applications in measuring vulnerability levels of respondents are useful additions to the theoretical and conceptual perspectives of vulnerability.

9.5.2 Contribution literature

The study provides contributions to the literature on flood vulnerability, coping and adaptation in rural and urban contexts. While several papers from this thesis are being worked on, the following for now represent those published or under review:

Abass, K., Adanu, S. K., & Agyemang, S. (2018). Peri-urbanisation and loss of arable land in Kumasi Metropolis in three decades: Evidence from remote sensing image analysis. *Land Use Policy*, *72*, 470-479.
https://doi.org/10.1016/j.landusepol.2018.01.013

Abass, K., Afriyie, K. & Gyasi, R. (2018). From green to grey: The dynamics of land use/land cover change in urban Ghana. *Land Scape Research (in press)*

Abass, K., Bour, D. & Aboagye, D. (Under review) Floods in Urban Ghana: Attribution to rainfall variability? *International Journal of Urban Sustainable Development.*

Abass, K. (under review). Household vulnerability and adaptation to fluvial floods in rural Ghana. *Journal of Risk Research.*

Abass, K., Afriyie, K. & Acheampong, B. (under review). Land use and land cover change: Implications for flood risk management in urban Ghana. *Journal of Environmental Planning and Management.*

REFERENCES

Abass, K. (2009). *A regional geography of Ghana for senior high schools and undergraduates*. Pictis, Accra.

Aboagye, D. (2012). The Political Ecology of Environmental Hazards in Accra, Ghana. *Journal of Environment and Earth Science* Vol. 2(10) pp.157-172.

Aboagye, D., Dari, T. and Koomson, J. (2013). Risk Perception and Disaster Management in the Savannah Region of Ghana. *International Journal of Humanities and social Science*, 3(3): 85-96.

Addo-Fordwuor, D. (2014). Green Space Depletion in Ghana's Urban Settlements: A Case of Kumasi. A Masters' Thesis Submitted to the School of Graduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi.

Addo, K.A, Larbi, L., Amisigo, B., and Ofori-Danson, P. K. (2011). Impacts of coastal inundation due to climate change in a cluster of urban coastal communities in Ghana, West Africa. *Remote Sensing*, *3*(9), 2029-2050.

Adger, W. N. (1999): Social Vulnerability to Climate Change and Extremes in Coastal Vietnam. *World Development*, vol. 27 no 2, pp. 249-269.

Adger, W.N. (2003). Social capital, collective action, and adaptation to climate change. Economic Geography, 79(4), 387– 404.

Adger, W.N. (2006). Vulnerability. *Global Environmental Change 16(3)*, 268-281.

Adger, W. N., Huq, S., Brown, K., Conway, D., and Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in development studies*, *3*(3), 179-195.

Adjei-Gyapong, T., and Asiamah, R. D. (2002). The interim Ghana soil classification system and its relation with the world reference base for soil resources. *Rapport sur les Ressources en Sols du Monde (FAO)*.

Adjei Mensah, C. (2014a). Destruction of urban green spaces: A problem beyond urbanisation in Kumasi city. *American Journal of Environmental Protection, 3*(1), 1-9.

Adjei Mensah, C. (2014b). Is Kumasi Still a Garden City? Land Use Analysis between 1980-2010. *Journal of Environment and Ecology,* 5(2), 89-107.

Aerts, J. C. J. H. and Droogers, P. (2004). Climate Change in contrasting river basins, Adaptation strategies for water for food and water for the environment, CABI, Wallingfort,

Afrane, S. and Amoako, C. (2011). Peri-Urban development in Kumasi. In: Adarkwa KK, editor. Future of the tree: towards growth and development of Kumasi, pp. 92–110, Kumasi: University Printing Press.

Afriyie, K., Abass, K. and Adomako, J.A.A. (2014). Urbanisation of Rural Landscape: Assessing the Effects in Peri-Urban Kumasi. *International Journal of Urban Sustainable development,* 6(1): 1-19.

Afriyie, K., Ganle, J. K., and Santos, E. (2017). 'The floods came and we lost everything': weather extremes and households' asset vulnerability and adaptation in rural Ghana. *Climate and Development,* 1-16. Retrieved from fhttps://doi.org/10.1080/17565529.2017.1291403 (28/01/2018)

Ahadzie, D. K., and Proverbs, D. G. (2011). Emerging issues in the management of floods in Ghana. *International Journal of Safety and Security Engineering, 1*(2), 182-192.

Ahern M., and Kovat S. (2005). The Health Impacts of Floods. In: Few R., Matthies F. (eds): Floods Hazards and Health. Trowbridge: Cromwell Press, 2005, pp 28–53.

Ahern, M., Kovats, R. S., Wilkinson, P., Few, R., and Matthies, F. (2005). Global health impacts of floods: epidemiologic evidence. *Epidemiologic reviews*, 27(1), 36-46.

Ahmed, S.M. and Ahmed, H.S. editors (1999): Experiences of deluge: flood 1998.

BRAC Research Monograph Series 15.

Alcamo, J., Flörke, M. and Märker, M., (2007). Future long-term changes in global water resources driven by socio-economic and climatic change. *Hydrological Sciences Journal*, 52 (2), 247–275.

Alcantara-Ayala, I. (2002). Geomorphology, natural hazards, vulnerability and prevention of natural disasters in developing countries. *Geomorphology*, *47*(2-4), 107-124.

Alexander, D. (1993): Natural disasters. New York: Chapman & Hall.

Alexander, D. (2002): *Principles of Emergency Planning and Management*, Oxford University Press, New York

Alwang, Jeffrey, and Paul B. Siegel. (2000). Towards Operational Definitions and Measures of Vulnerability: A Review of the Literature from Different Disciplines. Draft.

Amoako, C. and Adom-Asamoah, G. (2017). From open spaces to adapted spaces – The politics of managing green areas in Kumasi, Ghana. In the proceedings of the 6th International Conference on Infrastructure Development in Africa, 12th April, 2017, KNUST, Ghana. Retrieved from http://ir.knust.edu.gh/xmlui/handle/123456789/10855, 15/12/17.

Amoako, C., and Boamah, E.F. (2015). The three-dimensional causes of flooding in Accra, Ghana. *International Journal of Urban Sustainable Development*, *7*(1), 109-129.

Amoateng, P. (2016). *The changing spatial extent of rivers and floodplains and its implications for flooding: The case of Kumasi, Ghana.* (PhD Thesis), School of Environmental Sciences, Charles Sturt University.

Amoateng, P. Finlayson, C.M., Howard, J. and Wilson, B. (2017). *International Journal of Disaster Risk Reduction.* http://dx.doi.org/10.1016/j.ijdrr.2017.09.044

Antwi-Agyei, P., Dougill, A. J., Fraser, E. D., and Stringer, L. C. (2013). Characterising the nature of household vulnerability to climate variability: empirical evidence from two regions of Ghana. *Environment, development and sustainability*, *15*(4), 903-926.

Appiah, D.O. (2012). The Dilemma of Poverty and Safety: The Case of Urban Flooding in the Aboabo River Basin, In Jha, A. Lamond, J., and Bloch, R. Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century, Washington, GFDRR/World Bank.

Appiah, D.O. (2016). Geoinformation modelling of peri-urban land use and land cover dynamics for climate variability and climate change in the Bosontww District, Ghana. Doctoral thesis submitted to the Department of Civil Engineering, College of Engineering, KNUST.

Appleton, B. (ed) (2002). Climate Changes the water Rules, dialogue on water and Climate, Printfine Ltd., Liverpool, UK.

Asumadu-Sarkodie, S. Rufangura, R., Jayaweera, H.M.P.C. and Owusu, P.A. (2015). Situational Analysis of Flood and Drought in Rwanda, *International Journal of Scientific and Engineering Research*, 6 (8):1960-1970.

Aysan, Y. F. (1993). “Keynote Paper: Vulnerability Assessment.” In: P. Merriman and C.

Browitt, eds., *Natural Disasters: Protecting Vulnerable Communities*, pp. 1- 14.

Babbie, E. (1989). *The Practice of Social Research* (7 th edn.) Belmont, CA: Wadsworth.

Backstrom, C. H., and Hursch, G. D. (1963). *Survey research*. Evanston, IL: Northwestern University Press.

Balica, S. F., Douben, N., and Wright, N. G. (2009). Flood vulnerability indices at varying spatial scales. *Water science and technology*, *60*(10), 2571-2580.

Balica, S.F.; Wright, N.G. and Vander Meulen, F. (2012): A flood vulnerability index for coastal cities and its use in assessing climate change impacts, Nat Hazards 64:73–105 DOI 10.1007/s11069-012-0234-1

Bawa, J.A.K., Seidu, A. and Abukari, W. (2015). Community based initiative and strategies for adapting to annual floods along the Black and White Volta Rivers in the Central Gonja District of Northern Region, Ghana. *Journal of Environment and Earth Science, 5*(8): 33-42.

Berg, B. L. (2001) Qualitative Research Methods for the Social Sciences, 4th edn, Boston Allyn and Bacon. Available at: https://www.amazon.com/Qualitative-Research-Methods-Social-Sciences/dp/0205318479 (accessed 20/12/16).

Biesta, G. (2010). Pragmatism and the Philosophical Foundation of Mixed Methods Research. In: A. Tashakkori and E. Teddlie (Eds.), *SAGE handbook of mixed methods in social and behavioral research* (2nd ed.) (pp. 69-94). Thousand Oaks, CA: Sage.

Birkmann, J. (2006): Measuring vulnerability to promote disaster-resilient societies: Conceptual frameworks and definitions. In: J. Birkmann, Measuring vulnerability to natural hazards. Towards disaster resilient societies. United Nations University Press, Tokyo/New York/Paris, pp 9-54.

Birkmann J. (2011a): Regulation and coupling of society and nature in the context of natural hazards. In: Brauch HG, Oswald-Spring U, Mesjasz C, Grin J, Kameri-Mbote P, Chourou B, Birkmann J (eds), Coping with global environmental change, disasters and security. Springer, Berlin, pp 1103–1127.

Birkmann, J. (2011b). First- and second-order adaptation to natural hazards and extreme events in the context of climate change. *Nat Hazards* 58:811–840 DOI 10.1007/s11069-011-9806-8.

Birkmann J, Buckle P, Jaeger J, Pelling M, Setiadi N, Garschagen M, Fernando N, Kropp J (2010). Extreme events and disasters: a window of opportunity for change? Analysis of organizational, institutional and political changes, formal and informal responses after mega-disasters. Nat Hazards 55(3): 637–655

Birkmann, J., Cardona, O. D., Carreño, M. L., Barbat, A. H., Pelling, M., Schneiderbauer, S., ... and Welle, T. (2013). Framing vulnerability, risk and societal responses: the MOVE framework. *Natural hazards*, *67*(2), 193-211.

Birkmann, J., Garschagen, M., Tuan, V.V., and Binh, N.T. (2012). Vulnerability, Coping and Adaptation to Water Related Hazards in the Vietnamese Mekong Delta. In: Renaud F.G. and Kuenzer, C (eds) The Mekong Delta System Interdisciplinary Analyses of a River Delta. Springer, Dordrecht, pp 245–289.

Birkmann J, von Teichman K, Aldunce P, Bach C, Binh NT, Garschagen M, Kanwar S, Setiadi N, Thach L.N. (2009). Addressing the challenge: recommendations and quality criteria for linking disaster risk reduction and adaptation to climate change. In: Birkmann J, Tetzlaff G, Zentel KO (eds) DKKV publication series, No. 38, Bonn.

Blaikie, P., Cannon, T., Davis, I., Wisner, B., (1994). At Risk: Natural Hazards, People's Vulnerability and Disasters. Routledge, London.

Bogardi, J. and J. Birkmann (2004) ''Vulnerability Assessment. The First Step Towards Sustainable Risk Reduction'', in Malzahn, D. and T. Plapp, eds, Disaster and Society – From Hazard Assessment to Risk Reduction, Berlin: Logos Verlag Berlin, pp. 75–82.

Bohle, H.G. (2001). Vulnerability and criticality: perspectives from social geography. IHDP Update 2(2001):1–7.

Bokszczanin A. (2002). Long-term negative psychological effects of a flood on adolescents. Pol Psychol Bull, 33:55–61.

Bollin, C., C. Ca´rdenas, H. Hahn and K.S. Vatsa (2003). Natural Disaster Network; Disaster Risk Management by Communities and Local Governments, Washington, D.C.: Inter-American Development Bank, available at http:// www.iadb.org/sds/doc/GTZ%2DStudyFinal.pdf.

Booij, M. J. (2005). Impact of climate change on river flooding assessed with different spatial model resolutions. *Journal of hydrology*, *303*(1-4), 176-198.

Botchway, E., Afram, S.O., and Ankrah, J. (2014). Building permit acquisition in Ghana: The situation in Kumasi. Developing Country Studies, *4*(20), 11-22.

Braun, V. and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3: 77–101. doi:10.1191/ 1478088706qp063oa

Brewer, J., and Hunter, A. (1989). *Multimethod research: A synthesis of styles*. Newbury Park, NJ: Sage.

Burby, R. J., Deyle, R. E., Godschalk, D. R., and Olshansky, R. B. (2000). Creating hazard resilient communities through land-use planning. *Natural hazards review*, *1*(2), 99-106.

Burton I, Kates R.W., White G.F. (1993). The environment as hazard. Oxford University Press, New York.

Burton, I., Smith, J.B. and Lenhart, S. (1998). Adaptation to Climate Change: Theory and Assessment. In: J.F. Feenstra, I. Burton, J.B. Smith and R.S.J. Tol (eds.), *Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies*, United Nations Environment Program (UNEP) and Institute for Environmental Studies (IES), Nairobi and Amsterdam.

Cairncross, S. and Ouano, E.A.R. (1990). Surface water drainage in urban areas. In Hardoy, J.E., Cairncross, S. and Satterthwaite, D., (eds.), *The poor die young: housing and health in Third World cities*. London: Earthscan, 158–68.

Campion, B.B. and Venzke, J. (2013). Rainfall variability, floods and adaptations of the urban poor to flooding in Kumasi, Ghana. *Nat Hazards* 65:1895–1911 DOI 10.1007/s11069-012-0452-6

Cardona, O.D. (1999). ‘‘Environmental Management and Disaster Prevention: Two Related Topics: A Holistic Risk Assessment and Management Approach’’, in J. Ingleton, ed., Natural Disaster Management, London: Tudor Rose.

Cardona, O.D. and A.H. Barbat (2000). El Riesgo S´ısmico y su Prevencio´n, Cuaderno Te´cnico 5, Madrid: Calidad Sideru´rgica.

Cardona, O. (2003). The need for rethinking the concepts of vulnerability and risk from a holistic perspective: A necessary review and criticism for the effective risk management. In *Mapping Vulnerability: Disasters, Development and People.* Edited by G. Bankoff, G. Frerks and D. Hilhorst, London: Earthscan.

Carreño, M.L, O.D. Cardona and A.H. Barbat (2005). ‘‘Urban Seismic Risk Evaluation: A Holistic Approach’’, 250th Anniversary of Lisbon Earthquake, Lisbon.

Carlson, R. V., Boyd, K. M., and Webb, D. J. (2004). The revision of the Declaration of Helsinki: past, present and future. *British journal of clinical pharmacology*, *57*(6), 695-713.

Casteel, M. J., Sobsey, M. D., and Mueller, J. P. (2006). Faecal contamination of agricultural soils before and after hurricane-associated flooding in North Carolina. *Journal of Environmental Science and Health A*, *41*(2), 173-184.

Cattell, V. (2001). Poor people, poor places, and poor health: the mediating role of social networks and social capital. *Social science & medicine*, *52*(10), 1501-1516.

Central Gonja Community Water and Sanitation Agency (2015). Report on community water and sanitation provision, Central Gonja District.

Chae EH, Tong Won Kim, Rhee SJ, Henderson TD (2005). Impact of flooding on the mental health of affected people in South Korea. Community Ment Health J., 41(6):633–645.

Chambers, R. and Conway, G.R. (1992). ‘Sustainable Rural Livelihoods: Practical Concepts for the 21st Century’, IDS Discussion Paper 296. Brighton, UK: Institute of Development Studies.

Chan, N.W. and Parker, D.J. (1996). Response to dynamic flood hazard factors in peninsular Malaysia. The Geographical Journal 162(3), 313–25.

Chen, J., Tsai, H., Hsu, P. and Shen, C. (2007). Estimation of waste generation from floods, *Waste Management*. **27(12):** p. 1717-1724.

Cherniack E.P. (2008). The impact of natural disasters on the elderly. Am J Disaster Med 3(3):133–139.

Choudhury, W.A., Quraishi, F.A., Haque, Z. (2006). Mental health and psychosocial aspects of disaster preparedness in Bangladesh. International Review of Psychiatry (Abingdon, England), 18(6):529–535.

Christie, F. and Hanlon, J. (2001). *Mozambique and the Great Flood of 2000*. Oxford: James Currey.

Cobbinah, P.B. and Amoako, C. (2012). Urban Sprawl and the Loss of Peri-Urban Land in Kumasi, Ghana. *International Journal of Social and Human Sciences*, 6, 388-397.

Codjoe, S. N. A., Atidoh, L. K., and Burkett, V. (2012). Gender and occupational perspectives on adaptation to climate extremes in the Afram Plains of Ghana. Climatic Change, 110(1–2), 431–454.

Coleman, J. S. (1990). Foundations of social theory. Harvard: Harvard University Press.

Coppola D.P. (2007). Introduction to International Disaster Management. Amsterdam, Boston: Butterworth Heinemann, pp xxiii, 547.

Correia, M. (2002). Gender dimensions of vulnerability to exogenous shocks: The case of Ecuador. In: P. Beckerman and A. Solimano (eds.) Crisis and Dollarization in Ecuador: Stability, Growth, and Social Equity. pp: 177-215. Washington D.C.: World Bank.

CRED - Center for Research on the Epidemiology of Disasters (2005). EM-DAT: the OFDA/CRED International Disasters Data Base. Brussels, Belgium: School of Public Health, Universite´ Catholique de Louvain (http://www.em-dat.net/).

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., and Hanson, W. E. (2003). Advanced mixed methods research designs. In: Tashakkori, A. and Teddlie, C. (Eds.). In: *Handbook of mixed methods in social and behavioral research* (pp. 209-240). Thousand Oaks, CA: SAGE.

Cunningham, W. (2001). "Breadwinner Versus Caregiver: Labor Force Participation and Sectoral Choice over the Mexican Business Cycle." In E. Katz and M. Correia, eds., *The Economics of Gender in Mexico: Work, Family, State and Market*. Washington, D.C.: World Bank.

Curry MD, Larsen PG, Mansfield CJ, Leonardo KD (2001). Impacts of a Flood Disaster on an ambulatory pediatric clinic population. Clin Pediatr (Phila) 40(10):571–574.

Dasgupta, A., and Baschieri, A. (2010). Vulnerability to climate change in rural Ghana: Mainstreaming climate change in poverty-reduction strategies. *Journal of International Development*, *22*(6), 803-820.

Davis, I. and Hall, N. (1999). Ways to measure community vulnerability. In Ingleton, J., editor, Natural disaster management. Leicester: Tudor Rose, 87-89.

Davidson, R. (1997). An Urban Earthquake Disaster Risk Index, The John A. Blume Earthquake Engineering Center, Department of Civil Engineering, Re- port No. 121, Stanford: Stanford University.

Dayour, F., Yendaw, E. and Jasaw, G.S. (2014). "Local residents' perception and adaptation/coping strategies to climate-induced disasters in Bankpama, Wa West District, Ghana", *International Journal of Development and Sustainability*, Vol. 3 No. 12, pp. 2186-2205.

Dari, T., Aboagye, D. and Koomson, J. (2013). Coping with Floods in the Savannah Region of Ghana, *Arts and Social Sciences Journal*, 61:1-12.

Dawes, J. (2008). "Do data characteristics change according to the number of scale points used?" International Journal of Market Research, 50 (1): 61-77.

Delamonthe, T. and Smith, R. (2004). Open access publishing takes off. Br Med J, 328: 1–3.

del Mar López, T., Aide, T. M., and Thomlinson, J. R. (2001). Urban expansion and the loss of prime agricultural lands in Puerto Rico. *Ambio: A Journal of the Human environment*, *30*(1), 49-54**.**

DFID (1999). *Sustainable livelihoods guidance sheets* 1-4. Department of international Development: London. http://www.nssd.net/pdf/sectiono.pdf. Accessed 19 August, 2016.

Diaz, J.H. (2007). The impact of hurricanes and flooding disasters on hymenopterid-inflicted injuries. Am J Disaster Med 2007;2(5):257–269.

Donner, W., and Rodríguez, H. (2011). Disaster risk and vulnerability: The role and impact of population and society. Population Reference Bureau.

Donner, W. and Rodríguez, H. (2008). "Population Composition, Migration, and Inequality: The Influence of Demographic Changes on Disaster Risk and Vulnerability," *Social Forces*, 87(2): 1089-1114.

Douglas, I., Alam, K., Maghenda, M., Mcdonnell, Y., McLean, L., and Campbell, J. (2008). Unjust waters: climate change, flooding and the urban poor in Africa. *Environment and urbanisation*, *20*(1), 187-205.

Downing, T.E., Olsthoorm, A.A. and Tol, R.S.J., editors, (1999). Climate, change and risk. London, Routledge.

Dulal, H. B., Brodnig, G., Onoriose, G. C., and Thakur, K. H. (2010). Capitalizing on assets: Vulnerability and adaptation to climate change in Nepal. Social development papers: Social dimensions of climate change (Paper No. 121). Washington: The World Bank.

Du, W., FitzGerald, G. J., Clark, M., and Hou, X. Y. (2010). Health impacts of floods. Prehospital and disaster medicine, 25(3), 265-272.

Dumenu, W. K., and Obeng, E. A. (2016). Climate change and rural communities in Ghana: Social vulnerability, impacts, adaptations and policy implications. *Environmental Science & Policy*, *55*, 208-217.

Duodu, S. (July 27, 2017). Death toll in Tamale flood disaster rises to four. Retrieved from https://www.graphic.com.gh/news/general-news/death-toll-in-tamale-flood-disaster-rises-to-four.html, accessed 16/11/2017.

El Sayed, B. B., Arnot, D. E., Mukhtar, M. M., Baraka, O. Z., Dafalla, A. A., Elnaiem, D. E. A., & Nugud, A. H. D. (2000). A study of the urban malaria transmission problem in Khartoum. *Acta tropica*, *75*(2), 163-171.

Ellis, F. (2000). *Rural Livelihood Diversity in Developing Countries*, Oxford University Press, New York, NY.

Enarson, E. and Morrow, B.H. (1998). "Why Gender? Why Women? An Introduction to Women and Disaster." In: The Gendered Terrain of Disaster: Through Women's Eyes, eds. Elaine Enarson and Betty Hearn Morrow. Westport: Praeger Publishers, 1-8.

Faisal, I. M., Kabir, M. R., and Nishat, A. (1999). Non-structural flood mitigation measures for Dhaka City. *Urban Water*, *1*(2), 145-153.

Fay, M. and Ebinger, J. (2010). A Framework for Developing Adaptation Plans. In: Fay, M., Block, R.I and Ebinger, J. (eds.), Adapting to Climate Change in Eastern Europe and Central Asia. World Bank, Washington DC, USA.

Fenton DM, Kelly G, Vella K, Innes JM (Eds) (2007). 'Climate Change and the Great Barrier Reef: Industries and Communities.' (Great Barrier Reef Marine Park Authority and the Green house Office, Australia).

Few, R (2003). Flooding, vulnerability and coping strategies: local responses to global threat. Progress in Development Studies Vol.3, pp 43-58.

FitzRoy, F. R., and Papyrakis, E. (2010). An introduction to climate change economics and policy. London: Earthscan.

FLOODsite-Consortium (2005). Language of Flood Risk. www.floodsite.net.

Forkuo, E. K., (2010). "Digital Elevation Modelling Using ASTER Stereo Imagery", Journal of Environmental Science and Engineering, 52(2), pp 81-92.

Fothergill, A. (2001). Women in crisis: An ethnographic study of gender and class in a natural disaster., Dissertation. University of Colorado at Boulder: United States – Colorado.

Fraenkel, J. R. and Wallen, N. E. (1996). How to design and evaluate research. USA: Mc. Fraw-Hill Inc

Fuchs S, Kuhlicke C, Meyer V (2011). Editorial for the special issue: vulnerability to natural hazards - the challenge of integration. Nat Hazards 58(2):609-619.

Füssel, H. M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global environmental change*, *17*(2), 155-167.

Ghanaian Times (2008, Monday, April 14). Red Cross assists flood victims to rebuild houses. P.18

GhanaWeb (2010, October 16). Central Gonja floods displace 25,000. Retrieved from https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Central-Gonja-floods-displace-25-000-195318?channel=D1, accessed 15/03/2017.

Ghana Statistical Service (GSS) (2014a). *2010 Population and Housing Census, District Analytical Report (KMA*). GSS, Accra.

Ghana Statistical Service (2014b). (*2010). Population and Housing Census*, *District Analytical Report (Central Gonja District*). GSS, Accra.

Ghana Statistical Service. (2015). Ghana poverty mapping report. GSS, Accra

Gilbert RO (1987). Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold, New York

Gill, S. E., Handley, J.F., Ennos, A. R., and Pauleit, S. (2007). Adapting cities for climate change: the role of the green infrastructure. *Built environment*, *33*(1), 115-133.

Ginexi EM, Weihs K, Simmens SJ, et al. (2000). Natural disaster and depression: a prospective investigation of reactions to the 1993 midwest floods. Am J Community Psychol, 28: 495–518.

Gough, K. and Yankson, P. (2000). "Land Markets in African Cities: The Case of Peri-Urban Accra, Ghana," *Urban Studies*, 37(13), 2485–2500.

Government of Ghana (2001). Town and Country Planning Department, Flood and Drainage in Accra: A situational Analysis of the June 27, 2001 Floods. Accra, Ghana.

Government of Ghana (2003). Accra Metropolitan Assembly, Greater Accra Metropolitan Area Anti Flood Committee, Operational Plans, Accra, Ghana.

Government of Ghana (GoG) (2012). *National Urban Policy Framework*. Ministry of Local Government and Rural Development, Accra.

Graphic Online (2015, June 5). Flood disaster profile of Ghana since (1968). Available at:http://www.graphic.com.gh/news/general-news/flood-disaster-profile-of-ghana.html (accessed 2/02/17).

Green C., van der Veen A., Wierstra E. and Penning-Rowsell E. (1994). Vulnerability refined: analysing full flood impacts. In: Penning-Rowsell E. and Fordham M. (eds.) Floods across Europe – Flood hazard assessment, modelling and management. Middlesex University Press, London.

Greene, J. (2000). Understanding social programs through evaluation. In N. K. Denzin and Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 981–1000). Thousand Oaks, CA: Sage.

Greene, J. C., Caracelli, V. J. and Graham, W. F. (1989). Toward a conceptual framework for mixed- method evaluation designs. *Educational Evaluation and Policy Analysis* 11: 255–274.

Greene, J. C. and Caracelli, V. J. (eds) (1997). *Advances in Mixed-Method Evaluation: The Challenges and Benefits of Integrating Diverse Paradigms*. San Francisco: Jossey-Bass Publishers.

Grewal I, and Ritchie J. (2006). 'Ethical and Language Matching of the Researcher and Research Group During Design, Fieldwork and Analysis'. In: Y.N. James (Ed.), *Health and Social Research in Multi-ethnic societies*. London and New York: Routledge, pp. 65–81.

Guba, E. G., and Lincoln, Y. S. (1989). *Fourth generation evaluation.* Thousand Oaks, CA: Sage.

Gunderson L (2000). Ecological Resilience - In Theory and Application. Annual Review of Ecological Systems 31, 425-439.

Gyekye, K. A. (2011). 'Geomorphic Assessment of Floods Within the Urban Environment of Gbawe-Mallam, Accra'. *Ghana Journal of Geography*, 3, 199-229.

Haines, A., and Patz, J.A. (2004). Health effects of climate change. JAMA, 291(1):99–103.

Hajat, S., Ebi, K. L., Kovats, S., Menne, B., Edwards, S., and Haines, A. (2003). The human health consequences of flooding in Europe and the implications for public health: a review of the evidence. Applied Environmental Science and Public Health, 1(1): 13-21.

Hamza M. and Zetter, R. (1998). Structural Adjustment, Urban Systems and Disaster Vulnerability in Developing Countries. *Cities,* vol. 15, pp. 219-229.

Handmer, J., Penning-Rowsell, E., and Tapsell, S. (1999). Flooding in a warmer world: The view from Europe. In T. E. Downing, A. A. Olsthoorn, and R. S. J. Tol (Eds.), *Climate, change and risk* (pp. 125-161). London: Routledge.

Hanson, W. E., Creswell, J. W., Clark, V. L. P., Petska, K. S., and Creswell, J. D. (2005). Mixed methods research designs in counseling psychology. *Journal of counseling psychology*, *52*(2), 224.

Harries, T., and Penning-Rowsell, E. (2011). Victim pressure, institutional inertia and climate change adaptation: The case of flood risk. *Global Environmental Change*, *21*(1), 188-197.

He, Z. X. (1998). A suicide belt in China: The Yangtze basin. Archives of Suicide Research, 4(3), 287-289.

Heller L, Colosimo E.A., and Antunes C.M. (2003). Environmental sanitation conditions and health impact: a case-control study. Rev Soc Bras Med Trop, 36:41–50.

Hewitt, K., (1997). Regions of Risk: A Geographical Introduction to Disasters. Longman, Harlow.

Heyman B.N., Davis C. and Krumpe P.F. (1991). An assessment of worldwide disaster vulnerability. *Disaster Management* 4, 3-36.

Hilhorst, D. and G. Bankoff (2004). ‘‘Introduction: Mapping Vulnerability’’, in G. Bankoff, G. Frerks and D. Hilhorst, eds, Mapping Vulnerability: Disasters, Development and People, London: Earthscan.

Holling C.S. (1973). Resilience and stability of ecological systems. Annual Review of Ecological Systems 4, 1-23.

Hufschmidt G (2011). A comparative analysis of several vulnerability concepts. Nat Hazards 58(2):621–643.

IFI (International Flood Initiative), (2010). The fourth international flood initiative and international conference of flood management. http://www.ifi-home.info/e-Meetings-and- Workshops.html (Accessed 15 August 2016).

IFRC) (International Federation of Red Cross and Red Crescent Societies) (2001). World Disasters Report 2001. Geneva: IFRC.

ILGS & IWMI - Institute of Local Government Studies and International Water Management Institute (2012). Community Adaptation to Flood Risk and Vulnerability, Final Report.

IPCC (Intergovernmental Panel on Climate Change) (*2001). Climate Change 2001-Impacts, Adaptation, and Vulnerability: Summary for Policy makers and Technical Summary of the Working Group II Report*, IPCC, Geneva.

IPCC (Intergovernmental Panel on Climate Change) (2007a). Summary for policymakers. *In*: S. Solomon *et al*., eds., *Climate change 2007: The physical science basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 1–18, http://www.ipcc.ch/ pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf [Accessed 10 March 2010].

IPCC (Intergovernmental Panel on Climate Change) (2007b). Summary for policymakers. *In*: M.L. Parry *et al*., eds., *Climate change 2007: Impacts, adaptation and vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 7–22, http://www. ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf [Accessed 10 March 2010].

IPCC (Intergovernmental Panel on Climate Change) (2011). Human settlement, water, energy and transport Infrastructure – mitigation and adaptation strategies. Expert Meeting of WGII and WGII, 22–24 March 2011, Calcutta, India.

IPCC (Intergovernmental Panel on Climate Change) (2012). Managing the risks of extreme events and disasters to advance climate change adaptation. In: A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (eds CB Field, V Barros, TF Stocker et al.), Cambridge University Press, Cambridge, NY, USA.

IPCC (Intergovernmental Panel on Climate Change) (2014). Climate change 2014: Impacts, vulnerability and adaptation. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University.

Israel, M. and Hay, I. (2006). Research Ethics for Social Scientists: Between Ethical Conduct and Regulatory Compliance. Pine Forge Press, SAGE Publications Ltd, UK.

ITC - International Institute for Geo-Information Science and Earth Observation (2004). Application 1. http://www.itc.nl/ilwis/applications/application01.asp.

Jacobs, J. (1960). The death and life of great American cities. New York: Vintage.

Jacobs, P., Blom, G., Linden, G. van der, (2000). Climatological changes in storm surges and river discharges: the impact on flood protection and salt intrusion in the Rhine-Meuse delta. Proceedings of the ECLAT-2 KNMI Workshop. Climatic Research Unit, Norwich, pp. 35–48.

Jensen, R.R. and Shumway, J.M. (2010). Sampling our world. In: Gomez, B. and Jones III P.J.(eds.) Research methods in Geography: A critical introduction. Willey-Blackwell. John Willey and Sons, pp77-90.

Jha, A.K., Bloch, R., and Lamond J. (2012). *Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Centur*y, The World Bank, Washington D.C.

Johnson, B., and Gray, R. (2010). A history of philosophical and theoretical issues for mixed methods research. In: A. Tashakkori and E. Teddlie (Eds.), *SAGE handbook of mixed methods in social & behavioral research* (2nd ed.) (pp. 69-94). Thousand Oaks, CA: Sage.

Johnson, C., Tunstall, S. and Penning-Rowsell, E. (2005). Floods as catalysts for policy change: Historical lessons from England and Wales. *Water Resour Dev* 21(4), 561–575.

Johnson, C. L., and Priest, S. J. (2008). Flood risk management in England: a changing landscape of risk responsibility? *International Journal of Water Resources Development*, *24*(4), 513-525.

Jones R and Boer R (2003). Assessing current climate risks, Adaptation Policy Framework: A Guide for Policies to Facilitate Adaptation to Climate change, UNDP, in Review

Jonkman, S. N. (2005). Global perspectives on loss of human life caused by floods. Natural hazards, 34(2), 151-175.

Jonkman, S. and Kelman, I. (2005). An analysis of causes and circumstances of flood disaster deaths. Disasters, 29: 75–97.

Jonkman, S.N. and Vrijling, J.K. (2008). Loss of life due to floods. *Journal of Flood Risk Management 1(1):* 43-56.

Joyce S. (2000). The dead zones: Oxygen-starved coastal waters. Environ Health Perspect,108(3): A120–125.

Kaboub, F. (2008). Positivist paradigm. *Leong, Encyclopedia of Counselling, Thousand Oaks*, 786-787.

Karley, N.K. (2009). Flooding and Physical Planning in Urban Areas in West Africa: Situational Analysis of Accra, Ghana. *Theoretical and Empirical Researches in Urban Management*, 4(13) 25-41.

Kasperson JX, Kasperson RE, and Turner BL (2010). Vulnerability of coupled human-ecological systems. In: Rosa EA, Dieckmann A, Dietz T, Jaeger CC (eds.) Human footprints on the global environment MIT Press, Cambridge.

Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., Kasperson, J. X., and Ratick, S. (1988). The social amplification of risk: A conceptual framework. Risk Analysis, 8(2), 177-187.

Kelly, M. and Adger, N. (2000). Theory and Practice in Assessing Vulnerability to Climate Change and Facilitating Adaptation, *Climatic Change* 47, 325-352.

Kessler, R.C., Andrews, G., Colpe, L.J., Hiripi, E., Mroczek, D.K., Normand, S.-L.T., Walters, E.E., Zaslavsky, A.M., 2002. Short screening scales to monitor population prevalence and trends in non-specific psychological distress. Psychological Medicine, 32: 959-956. DOI: 10.1017}S0033291702006074.

Kolsky, P. (1999). Performance-based evaluation of surface-water drainage for low income communities: a case study in Indore, Madhya Pradesh. Ph.D. Thesis, University of London.

Kondo, H., Seo, N., Yasuda, T., Hasizume, M., Koido, Y., Ninomiya, N., and Yamamoto, Y. (2002). Post-flood—infectious diseases in Mozambique. Prehospital and disaster medicine, 17(3), 126-133.

Konrad, C. P. (2003). Effects of urban development on floods. United States Geological Survey Fact Sheet 076–03, Tacoma, Washington.

Korah, P. I., and Cobbinah, P. B. (2017). Juggling through Ghanaian urbanisation: flood hazard mapping of Kumasi. *Geo Journal*, *82*(6), 1195-1212.

Korboe, D. (2001). Historical development and present structure of Kumasi. In: Adarkwa, K. K., and Post, S. (eds.), Fate of the tree: planning and managing the development of Kumasi, Ghana (pp. 41-58). Accra: Woeli Publishing Services.

Kreibich, H. and Thieken, A. H. (2009). Coping with floods in the city of Dresden, Germany, Nat Hazards, 51, 423–436.

Krimsky, S. and Golding, D. (Eds) (1992): *Social theories of risk*. Praeger Publications, CT

Kron, W. (2005). Flood risk= hazard• values• vulnerability. *Water International*, *30*(1), 58-68.

Krug EG, Kresnow MJ, Peddicord JP, Dahlberg, L. L., Powell, K. E., Crosby, A. E., and Annest, J. L. (1999). Retraction: suicide after natural disasters. New England Journal of Medicine, 340: 148–9.

Kumar, R. (2011). Research Methodologies: a step-by-step guide for beginners, 3rd. edn., Thousand Oaks, CA: SAGE.

Kundzewicz, Z. W., Mata, L. J., Arnell, N. W., Döll, P., Jimenez, B., Miller, K., Oki, T., Şen, Z. and Shiklomanov, I. (2008). The implications of projected climate change for freshwater resources and their management. *Hydrol. Sci. J.* **53**(1), 3–10.

Kundzewicz, Z. W., Kanae, S., Seneviratne, S. I., Handmer, J., Nicholls, N., Peduzzi, P., ... Sherstyukov, B. (2014). Flood risk and climate change: Global and regional perspectives. Hydrological Sciences Journal, 59(1), 1–28.

Kunii O., Nakamura S., Abdur R., and S Wakai, S. (2002). The impact on health and risk factors of the diarrhoea epidemics in the 1998 Bangladesh floods. Public Health 116:68–74.

Kyei, Y. (2016). Land Use, Spatial Planning Bill passed. Available at http://www.ghanaiantimes.com.gh/land-use-spatial-planning-bill-passed/, accessed 4/08/2017.

Lamond, J., Bhattacharya, N., and Bloch, R. (2012). The role of solid waste management as a response to urban flood risk in developing countries, a case study analysis. *WIT Transactions on Ecology and the Environment*, *159*, 193-204.

Lave, T. R., and Lave, L. B. (1991). Public perception of the risks of floods: Implications for communication. *Risk analysis*, *11*(2), 255-267.

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, *22*(140), 1-55.

Liu, A., Tan, H., Zhou, J., Li, S., Yang, T., Wang, J., Liu, J., Tang, X., Sun, Z., and Wen S.W. (2006). An epidemiologic study of post-traumatic stress disorder in flood victims in Hunan China. Can J Psychiatry, 51(6):350–354.

Levin, K. A. (2006). Study design III: Cross-sectional studies. *Evidence-based dentistry*, *7*(1), 24-25.

Lewis, J. (1999). Development in disaster-prone places: studies of vulnerability. London: Intermediate Technology Publications.

Lo, A. Y. (2013). The role of social norms in climate adaptation: Mediating risk perception and flood insurance purchase. *Global Environmental Change*, *23*(5), 1249-1257.

Lu, S., Lu, X., Zhao, W., Liu, Y., Wang, Z. and Omasa, K. (2015). Comparing vegetation indices for remote chlorophyll measurement of white poplar and Chinese elm leaves with different adaxial and abaxial surfaces. *Journal of Experimental Botany*, Vol. 66, No. 18 pp. 5625–5637.

Mann, H.B., (1945). Nonparametric tests against trend. *Econometrica* 13, 245-259.

Manzanas, R., Amekudzi, L. K., Preko, K., Herrera, S., and Gutiérrez, J. M. (2014). Precipitation variability and trends in Ghana: An intercomparison of observational and reanalysis products. *Climatic Change*, 124(4), 805–819.

Marfai, M.A. (2011). *Urban coastal flooding and risk management (an overview of Jakarta and Semarang City.* Presentation in the consultation workshop *Preparation of a Global Handbook for Urban Flood Risk Management*, Jakarta, May 25-6.

Marshall, N. A., P. A. Marshall, J. Tamelander, D. Obura, D. Malleret-King, and J. E. Cinner. (2009). *A framework for social adaptation to climate change: sustaining tropical coastal communities and industries*. International Union for Conservation of Nature (IUCN), Gland, Switzerland. [online] URL: http://www.iucn.org/about/work/programmes/marine/marine_resources/ marine_publications/?4943/A-Framework-for-Social-Adaptation- to-Climate-Change

Maxwell J.A. and Mittapalli, K. (2010). Realism as a stance for mixed methods research. In: A. Tashakkori and E. Teddlie (Eds.), *SAGE handbook of mixed methods in social and behavioral research* (2nd ed.). Thousand Oaks, CA: Sage.

McCarthy, J. J., Canziani, O., Leary, N, Kokken, D. and White, K. (2001). "Climate Change

2001: Impacts, Adaptation and Vulnerability", Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, New York.

McDougall, K., Liu, x., Basnet, B., and Apan, A., (2008). "Evaluation of current DEM Accuracy for Condamine Catchment", Proceedings of the 8th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences Shanghai, P. R. China, June 25-27, 2008, pp 71-78.

McGranahan, G, D Balk and Anderson, A (2007). "The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones", *Environment and Urbanisation* Vol 19, No 1, April, pages 17–37.

McMillen C, North C, Mosley M, et al. (2002). Untangling the psychiatric comorbidity of posttraumatic stress disorder in a sample of flood survivors. *Compr Psychiatry* 43: 478–85.

Merz, B., Hall J., Disse, M., and Schumann A (2010a): Fluvial flood risk management in a changing world. *Nat Hazards Earth Syst Sci* 10:509–527.

Merz, B., Kreibich, H., Schwarze, R., and Thieken, A. (2010b). Review article "Assessment of economic flood damage", Nat. Hazards Earth Syst. Sci., 10, 1697–1724, doi:10.5194/nhess-10-1697- 2010.

Messner, F. and Meyer, V. (2006). Flood Damage, Vulnerability and Risk Perception – Challenges for Flood Damage Research In: J. Schanze, E. Zeman, and J. Marsalek (eds.), Flood Risk Management: Hazards, Vulnerability and Mitigation Measures. Springer, Dordrecht, The Netherlands.

MESTI (Ministry for Environment, Science, Technology and Innovation) (2015). *Land Use and Spatial Planning Bill, 2016*, MESTI Accra. Available at https://s3.amazonaws.com/ndpc-static/CACHES/PUBLICATIONS/2016/08/05/Land+Use+And+Spatial+Planning+Bill+2015.pdf, accessed 4/08/2017.

Miezah, K., Obiri-Danso, K., Kádár, Z., Fei-Baffoe, B., and Mensah, M. Y. (2015). Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. *Waste Management*, *46*, 15-27.

Miles, M. B., and Huberman, M. (1994). Qualitative data analysis: A sourcebook of new methods (2nd ed.). Beverly Hills, CA: Sage.

Milly P, Betancourt J, Falkenmak M, Hirsch R, Kundzewicz Z, Lettenmaier DP, Stouffer RJ (2008). Stationarity is dead: whither water management? Science 319:573–574

Milojevic, A., Armstrong, B., Hashizume, M., McAllister, K., Faruque, A., Yunus, M., ... and Wilkinson, P. (2012). Health effects of flooding in rural Bangladesh. Epidemiology, 23(1), 107-115.

Minea, G., and Zaharia, L. (2011). Structural and Non-Structural Measures for Flood Risk Mitigation in the Bâsca River Catchment (Romania). *Forum geografic*, 10(1): 157-166.

Ministry of Local Government and Rural Development (MLGRD) (2010): "Environmental Sanitation Policy (Revised 2010)". MLGRD, Accra

Mirza, M.M.Q (2004). Vulnerability to the Ganges water diversion: Adaptation and coping mechanisms. In: M.M.Q. Mirza (ed.), *The Ganged water diversion: Environmental effects and implications*, Kluwer Academic Publishers, Dordrecht, the Netherlands. Accessed 20th November, 2015 at http://www.springeronline.com

Mitchell, J.K., Devine, N., Jagger, K., (1989). A contextual model of natural hazard. Geographical Review 794 (4), 391 - 409.

Mogammad A.B. (2008). Analysing urban flood risk in low-cost settlements of George South Africa: Investigating physical and social dimensions. A thesis submitted to the Department of Environmental and Geographical Science, University of Cape Town in partial fulfilment of the requirements for the award of Masters in Social Science.

Morgan, D. L. (2007). Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods. *Journal of mixed methods research*, *1*(1), 48-76.

Morgan, D. L. (2013). *Integrating qualitative and quantitative methods: A pragmatic approach*. Thousand Oaks, CA: SAGE.

Morgan, D. L. (2014). Pragmatism as a paradigm for social research. *Qualitative Inquiry*, *20*, 1045–1053. doi:10.1177/1077800413513733

Munang, R., Thiaw, I., Alverson, K., Mumba, M., Liu, J. and Rivington, M., (2013). Climate change and ecosystem-based adaptation: a new pragmatic approach to buffering climate change impacts. *Current Opinion in Environmental Sustainability*, *5*(1), 67-71.

Muñoz-Cadena, C.E., Arenas-Huertero, F.J. and Ramón-Gallegos, E. (2009). Comparative analysis of the street generation of inorganic urban solid waste (IUSW) in two neighborhoods of Mexico City, *Waste Management*, 29(3): p.1167-1175.

Mukhopadhyay, S. (2010). A geo-environmental assessment of flood dynamics in lower Ajoy River inducing sand splay problem in Eastern India. *Ethiopian Journal of Environmental Studies and Management, 3*(2):1-15.

Munich Re (1997). Flooding and insurance. Munich.

Murray, V., Caldin, H., Amlot, R., Stanke, C., Lock, S., Rowlatt, H., and Williams, R. (2011). The effects of flooding on mental health. Health Protection Agency, London, UK.

Musah, B.N.A, Mumuni, E., Abayomi, O. and Jibrel, B.M. (2013). Effects of floods on the livelihoods and food security of households in the Tolon Kumbumgum District of the Northern Region of Ghana. *American Journal of Research Communication*, 1(8):1-12

MWRWH (Ministry of Water Resources, Works and Housing) (2007). "National Water Policy". MWRWH, Accra.

Myjoyonline.com (2017). Victims of Tamale floods yet to receive relief. Retrieved from https://www.myjoyonline.com/news/2017/july-29th/victims-of-tamale-floods-yet-to-receive-relief.php, accessed 16/11/2017.

NADMO (2010). Central Gonja 2010 flood disaster report, Central Gonja District.

NADMO (2017). Kumasi Metropolis floods situational report, KMA.

Nethengwe, N.S. (2007). Integrating participatory GIS and political ecology to study flood vulnerability in the Limpopo Province of South Africa. [PhD thesis]. Morgantown: West Virginia University, Department of Geology and Geography.

Nelson DR, Adger WN, Brown K (2007). Adaptation to Environmental Change: Contributions of a Resilience Framework. Annual Review of Environment and Resources 32, 395-419.

Ngo, E. B. (2001). ‘‘When Disasters and Age Collide: Reviewing Vulnerability of the Elderly.’’ Natural Hazards Review 2(2):80–89.

Nobre, G. G., Jongman, B., Aerts, J. and Ward, P. J. (2017). The role of climate variability in extreme floods in Europe. *Environmental Research Letters*, *12*(8): 1-11.

Norris FH, Kaniasty K, Conrad ML, et al. (2002). Placing age differences in cultural context: a comparison of the effects of age on PTSD after disasters in the United States, Mexico, and Poland. J Clin Geropsychol, 8:153–73.

Nowell L.S., Norris J.M., White D.E. and Moules N.J. (2017) Thematic Analysis: Striving to Meet the Trustworthiness Criteria. *International Journal of Qualitative Methods* 16(1):1-13. DOI: 10.1177/1609406917733847

Nyakundi, H., Mogere, S., Mwanzo, I., Yitambe, A., (2010). Community perceptions and Response to flood risks in Nyando District, Western Kenya. Journal of Disaster Risk Studies, 3(1): 346-366.

Obeng, H. (2000). Soil classification in Ghana. *Selected Economic Issues*, (3), 1-35. CEPA

Obour, S.K. (2015, June 5). Accra floods: Cause of deadly Goil filling station. Accra: Graphic Communications Group, Graphic Online. Available at: http://www.graphic.com.gh/news/general-news/accra-floods-cause-of-deadly-goil-filling-station-fire-revealed.html (accessed 2/02/17).

Oduro-Ofori, E, Braimah, I. and Agyeman, O.K. (2014). 'Promoting Green Infrastructure in Kumasi: Challenges and Strategies'. *Research on Humanities and Social Sciences*. 4(26), 110 - 118.

Okyere, C. Y., Yacouba, Y., and Gilgenbach, D. (2012). *The Problem of annual occurrences of floods in Accra: An Integration of Hydrological, Economic and Political Perspectives*. Interdisplinary Term Paper, ZEF Doctoral Studies Programme. Boon: Centre for Development Research, Boon University.

Oteng-Ababio, M. (2011). Missing links in solid waste management in the Greater Accra Metropolitan Area in Ghana. *GeoJournal*, *76*(5), 551-560.

Otukei, J. R., and Blaschke, T. (2010). Land cover change assessment using decision trees, support vector machines and maximum likelihood classification algorithms. *International Journal of Applied Earth Observation and Geoinformation*, *12(Supplement 1)*, S27-S31.

Ouellet, C., Saint-Laurent, D., and Normand, F. (2012). Flood events and flood risk assessment in relation to climate and land-use changes: Saint-François River, southern Québec, Canada. *Hydrological Sciences Journal*, *57*(2), 313-325.

Owusu-Ansah, J. K. (2015). The influences of land use and sanitation infrastructure on flooding in Kumasi, Ghana. *GeoJournal*, *81*, 555–570.

Owusu, K., and Waylen, P. R. (2009). Trends in spatio-temporal variability in annual rainfall in Ghana (1951–2000). Weather, 64(5), 115–120.

Owusu, K., and Waylen, P. R. (2013). The changing rainy season climatology of mid-Ghana. *Theoretical and Applied Climatology*, 112(3–4), 419–430.

Owusu-Sekyere E., Osumanu, I.K. and Yaro, J.A. (2013). Dompoase Landfill in the Kumasi Metropolitan Area of Ghana: A 'Blessing' or a 'Curse'? *International Journal of Current Trends in Research*, 2 (1):87-96.

Oyinloye, M. A. And Kufoniyi O. (2011): Analysis of Land use, Land cover Change and Urban Expansion in Akure, Nigeria. Journal of Innovative Research in Engineering and Sciences, 2(4), 234-248.

Parker, D.J. (1999). *Flood*, In Ingleton, J. (Ed.), *Natural Disaster Management*, Tudor Rose, Leicester, pp. 38-40.

Parker, D. J., Green, C. H., and Thompson, P. M. (1987). Urban flood protection benefits: A project appraisal guide, Gower Technical Press, Aldershot.

Parkinson, J (2002), "Urban drainage in developing countries – challenges and opportunities", *Waterlines* Vol 20, No 4.

Parkinson, J. (2003). Drainage and stormwater management strategies for low-income urban communities. *Environment and Urbanization*, *15*(2), 115-126.

Patton, M. Q. (2002). Qualitative Research and Evaluation Methods, pp.209-339. Thousand Oaks, CA: Sage.

Paudel, Y., Aerts, J., and Botzen, W. (2012). Public private catastrophe insurance, Geneva Pap. Risk. Ins., 37, 257-285.

Peacock, W., B. H. Morrow, and H. Gladwin, eds. (2000). *Hurricane Andrew and the Reshaping of Miami: Ethnicity, Gender, and the Socio-Political Ecology of Disasters*. Miami, Fla.: Florida International University, International Hurricane Center.

Pelling, M., (1999). The political ecology of flood hazard in urban Guyana. *Geoforum 30*, 249-261.

Pelling, M. (2003). *The Vulnerability* of *Cities: Natural Disasters and Social Resilience.* Earthscan: London.

Penning-Rowsell E., Floyd P., Ramsbottom D., Surendran S. (2005). Estimating injury and loss of life in floods: a deterministic framework. Natural Hazards 36(1–2):43–64.

Penning-Rowsell, E. C. and Green, C. H. (2000). New insights into the appraisal of flood alleviation benefits. I. Flood damage and flood loss information. J. Inst. Water Environ. Manag. 14, 347–353.

Penning-Rowsell E. and Peerbolte B. (1994). Concepts, Policies and Research. Penning- Rowsell E. and Fordham M. (eds.) Floods across Europe. Flood Hazard Assessment, Modelling and Management. Middlesex University Press, London, 1-17.

Perrow, C. (2007). The Next Catastrophe. Princeton, NJ: Princeton University Press

Philip, D., and Rayhan, M. I. (2004). Vulnerability and Poverty: What are the causes and how are they related? *ZEF Bonn, center for Development Research, University of Bonn*.

Poole J, Hogan D.E. (2007): Floods). In: Hogan DE, Burstein JL (eds): Disaster Medicine. Philadelphia: Lippincott Williams and Wilkins, pp 214–224.

Prowse, M., and Scott, L. (2008). Assets and adaptation: An emerging debate. IDS Bulletin, 39(4), 42–52.

Putnam, R. D. (1995). Tuning in, tuning out: The strange disappearance of social capital in America. *PS: Political science* and *politics*, *28*(4), 664-683.

Pyle, D.M. (2006). Severe Convective Storm Risk in the Eastern Cape Province of South Africa. Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy at Rhodes University.

Quagraine, V.K. (2011). Urban Landscape Depletion in Kumasi Metropolis. In: Adarkwa KK, editor. Future of the tree: towards growth and development of Kumasi, pp. 212 – 233, Kumasi: University Printing Press.

Quartey, J.D., (2013). An economic assessment of the deforestation of Ghana's garden city of West Africa. In: Simpson, R., Zimmermann, M. (Eds), The economy of green cities: a world compendium on green urban economy. Local Sustainability, vol. 3, Springer Science and Business Media, Dordrech.

Rain, D., Engstrom, R., Ludlow, C., and Antos, S. (2011). Accra Ghana: A city vulnerable to flooding and drought-induced migration. Case study prepared for Cities and Climate Change: Global Report on Human Settlements. Available from http://www.unhabitat.org/grhs/2011, accessed 2/10/2017.

Ramachandra, T.V., Bharath, A.H., Sowmyashree, M.V. (2015). Monitoring urbanisation and its implications in a mega city from space: Spatiotemporal patterns and its indicators. *Journal of environmental management*, *148*, 67-81.

Ramlal, B., and Baban, S. M. (2008). Developing a GIS based integrated approach to flood management in Trinidad, West Indies. *Journal of environmental management*, *88*(4), 1131-1140.

Rasid, H., and Haider, W. (2002). Floodplain residents' preferences for non-structural flood alleviation measures in the Red River basin, Manitoba, Canada. *Water international*, *27*(1), 132-151.

Reacher M., McKenzie K., Lane C, Nichols T, Kedge I, Iversen A, Hepple P, Walter T, Laxton C., Simpson J. and Lewes Flood Action Recovery Team (2004). Health impacts of flooding in Lewes: a comparison of reported gastrointestinal and other illness and mental health in flooded and non-flooded households. Communicable Disease and Public Health, 7(1):39–46.

Renn, O. (2008). Risk governance – coping with uncertainty in a complex world. Earthscan, London

Rick, J., Perryman, S., Young, K., Guppy, A. and Hillage, J. (1998). Workplace trauma and its management: review of the literature. Report for the Health and Safety Executive. Institute for Employment Studies, University of Sussex, Brighton.

Sáenz, R., Bissell, R. A., and Paniagua, F. (1995). Post-disaster malaria in Costa Rica. Prehospital and disaster medicine, 10(3), 154-160.

Sanderson, D. (2000). Cities, disasters and livelihoods. *Environment and Urbanisation* 12(2), 93–102.

Sarantakos, S. (2013). Social research. 4th edition. Hampshire: Palgrave Macmillan.

Sarewitz, D., Pielke, R., Keykhah, M., (2003). Vulnerability and risk: some thoughts from a political and policy perspective. *Risk Analysis* 23(4): 805–810.

Sarkar, U., Nascimento, S. F., Barbosa, R., Martins, R., Nuevo, H., Kalofonos, I., Grunstein, I., Flannery, B., Dias, J., Riley, L. W., Reis, M.G., and Ko, A.I. (2002). Population-based case-control investigation of risk factors for leptospirosis during an urban epidemic. The American Journal of Tropical Medicine and Hygiene, 66(5), 605-610.

Schanze, J. (2006). Flood Risk Management – A Basic Framework In: J. Schanze, E. Zeman, and J. Marsalek (eds.), Flood Risk Management: Hazards, Vulnerability and Mitigation Measures. Springer, Dordrecht, The Netherlands.

Schatz J.J. (2008). Floods hamper health-care delivery in southern Africa. Lancet, 371(9615):799–800.

Schiller, Bradley R. (1995). *The Economics of Poverty and Discrimination*. Englewood Cliffs, NJ: Prentice Hall.

Schneiderbauer, S. and Ehrlich, D. (2004). Risk, Hazard and People's Vulnerability to Natural Hazards: A Review of Definitions, Concepts and Data, Brussels: European Commission–Joint Research Centre (EC-JRC).

Sharma, V., and Priya, T., (2001). Development strategies for flood prone areas, case study. Disaster Prevention and Management, Patna, India vol. 10 (2) pp. 101–109.

Sidley, P. (2000). Malaria epidemic expected in Mozambique. BMJ: British Medical Journal, 320(7236), 669.

Smit B, and Wandel J (2006). Adaptation, capacity and vulnerability. Global Environ Change 16:282–292

Smith, J.B., Huq, S., Rahman, A. and Mirza, M.M.Q. (1998). *Considering Adaptation to Climate Change in the Sustainable Development in Bangladesh* (prepared for the South Asia Region, World Bank, Washington, D.C.), Stratus Consulting Inc., Boulder, Colorado, USA.

Smith, K. (2001). *Environmental Hazards: Assessing risk and reducing disasters* (3rd edition) London: Routledge.

Smith, K. (2004). *Environmental Hazards: Assessing Risk and Reducing Disaster*.

Smith K. and Ward R. (1998). Floods – Physical processes and human impacts. Chichester.

Staes, C., Orengo, J. C., Malilay, J., Rullán, J., and Noji, E. (1994). Deaths due to flash floods in Puerto Rico, January 1992: implications for prevention. International journal of epidemiology, 23(5), 968-975.

Stanke, C., Murray, V., Amlôt, R., Nurse, J., and Williams, R. (2012). The effects of flooding on mental health: Outcomes and recommendations from a review of the literature. PLoS Currents, 4, e4f9f1fa9c3cae. http://doi.org/10.1371/4f9f1fa9c3cae

Stanturf, A. J., Warren, L. M., Charnley, S., Polasky, C. S., Goodrick, L. S., Armah, F., and Nyako, A. Y. (2011). Ghana climate change vulnerability and adaptation assessment. New York, NY: USDA Forest Services International Program.

Stefanov, L. W.; Ramsey, S. M., and Christensen, R. (2001). Monitoring Urban Land Cover Change: An Expert System Approach to Land Cover Classification of Semi-arid to AridUrban Centres, Department of Geological Sciences, Arizona State University, Tempe, AZ 85287 USA; Centre for Environmental Studies, Arizona State University, Tempe, AZ 85287 USA, Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA, USA, Remote Sensing of Environment. doi: 10.1016/S0034-4257(01)00204-8.

Stimpson J. (2004). Disaster, well-being, and sense of control: Testing a reciprocal path in the stress process model., The University of Nebraska-Lincoln: United States—Nebraska.

Stoltman, J. P., Lidstone, J., and Dechano, L. M. (2004). *International perspectives on natural disasters: Occurrence, mitigation, and consequences*. New York, NY: Springer.

Stow, D.A., Weeks, J.R., Shih, H.-C., Coulter, L.L., Johnson, H., Tsai, Y.-T., Kerr, B.A.,

Benza, M. and Mensah, F. (2016). Inter-regional pattern of urbanisation in southern Ghana in the first decade of the new millennium. *Applied Geography*, *71*, 32-43.

Sultana, F. (2010). Living in hazardous waterscapes: Gendered vulnerabilities and experiences of floods and disasters. Environmental Hazards, 9(2010), 43–53.

Sur, D., Dutta, P., Nair, G. B., and Bhattacharya, S. K. (2000). Severe cholera outbreak following floods in a northern disrict of West Bengal. *Indian Journal of Medical Research*, *112*, 178-182.

Tao, H., Gemmer, M., Bai, Y., Su, B., and Mao, W. (2011). Trends of streamflow in the Tarim River Basin during the past 50 years: Human impact or climate change? *Journal of hydrology*, *400*(1-2), 1-9.

Tapsell, S. M., Penning-Rowsell, E. C., Tunstall, S. M., and Wilson, T. L. (2002). Vulnerability to flooding: health and social dimensions, Phil. Trans. R. Soc. A, 360, 1511–1525. doi: 10.1098/rsta.2002.1013

Tapsell, S.M., and Tunstall S.M. (2008). "I wish I'd never heard of Banbury": The relationship between 'place' and the health impacts from flooding. Health & Place, 14(2):133–154.

Tashakkori, A., and Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.

Teddlie, C., and Tashakkori, A. (Eds.). (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences*. Thousand Oaks, CA: SAGE.

Thornton, P. K., Ericksen, P. J., Herrero, M., and Challinor, A. J. (2014). Climate variability and vulnerability to climate change: a review. *Global change biology*, *20*(11), 3313-3328.

Turner, B.L., II, Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., and Schiller, A. (2003). A Framework for Vulnerability Analysis in Sustainability Science. Proceedings of the National Academy of Sciences of the United States of America 100 (14):8074-8079.

Ubink, J. M. (2008). Struggles for land in peri-urban Kumasi and their effects on popular perception of chiefs and chieftaincy. In J. M. Ubink and K. Amanor (Eds.), Contesting land and custom in Ghana: State, chief, and the citizen. pp. 155-182 Leiden: Leiden University Press.

Ubink, J.M., and Quan, J.F. (2008). How to combine tradition and modernity? Regulating customary land management in Ghana. *Land Use Policy*, *25*(2), 198-213.

United Nations, Department of Humanitarian Affairs (1992). Internationally agreed glossary of basic terms related to disaster management (DNA/93/36). United Nations, Geneva

UN–HABITAT (2003), *Water and Sanitation in the World's Cities – Local Action for Global Goals*, published in association with United Nations Human Settlement Programme (UN–HABITAT), Earthscan, London, UK.

UN HABITAT (2010). The State of African Cities (2010). Governance, Inequality and Urban Land Markets. Nairobi, UN Habitat.

UN International Strategy for Disaster Reduction (UNISDR) (2002). Living with risk: a global view of disaster reduction initiatives (preliminary version). UNISDR, Geneva.

UN International Strategy for Disaster Reduction (UNISDR) (2004). Living with risk: a global review of disaster risk reduction initiatives, Vol.1, UNISDR, Geneva Accessed from: http://www.unisdr.org/we/inform/publications/65 on 28 October, 2016.

UNISDR (2009). Terminology: Basic terms of disaster risk reduction: United Nation International Strategy for Disaster Reduction (UNISDR). Accessed on 14 July 2017 from http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm..

Varis, O. (2005). Are floods growing? *Ambio 34(6)*, 478-480.

Vollaard, A. M., Ali, S., van Asten, H. A., Widjaja, S., Visser, L. G., Surjadi, C., and van Dissel, J. T. (2004). Risk factors for typhoid and paratyphoid fever in Jakarta, Indonesia. Jama, 291(21), 2607-2615.

Wade, T. J., Sandhu, S. K., Levy, D., Lee, S., LeChevallier, M. W., Katz, L. and Colford Jr, J. M. (2004). Did a severe flood in the Midwest cause an increase in the incidence of gastrointestinal symptoms? American Journal of Epidemiology, 159(4), 398-405.

Waelde LC, Koopman C, Rierdan J, et al. (2001). Symptoms of acute stress disorder and posttraumatic stress disorder following exposure to disastrous flooding. J Trauma Dissoc, 2: 37–52.

Waring, S. C., Reynolds, K. M., D'Souza, G., and Arafat, R. R. (2002). Rapid assessment of household needs in the Houston area after Tropical Storm Allison. *Disaster management & response: DMR: an official publication of the Emergency Nurses Association*, 3-9.

Watts M.J. and Bohle H.G. (1993). The space of vulnerability: the causal structure of hunger and famine. *Progress in Human Geography* 17, 43-67.

WDR (2010). Urbanisation and climate change risk, 114-137. In *Focus on Urban Risk.* (World Disaster Report Series). Geneva: United Nation International Strategy for Disaster Reduction.

Willroth P, Diez, JR, and Arunotai N (2011). Modelling the economic vulnerability of households in the Phang-Nga Province (Thailand) to natural disasters. Nat Hazards 58(2):753–769.

Wissmar, R.C. and Timm, R.K., (2004). Effects of changing forest and impervious land covers on discharge characteristics of watersheds. *Environmental Management*, 34 (1),91–98.

Wisner, B., Blaikie, P., Cannon, T. and Davis, I. (2004). At Risk: Natural Hazards, People's *Vulnerability and Disasters, 2nd edition*. London: Routledge.

WMO-UNESCO (2007). Concept Paper on International Flood Initiative (IFI). Geneva: World Meteorological Organisation. 21 pp.

WHO (World Health Organization) (2001). The world health report 2001— mental health: new understanding, new hope. Geneva, Switzerland: World Health Organization.

Wood, M., Kovacs, D., Bostrom, A., Bridges, T. and Linkov, I., (2012). Flood risk management: US Army Corps of Engineers and layperson perceptions. *Risk analysis*, **32**(8), 1349-1368.

Woodruff BA, Toole JM, Rodriguez DC, et al (1990). Disease surveillance and control after a flood in Khartoum, Sudan, 1988. Disasters, 14:151–63.

World Bank (2002). *World Development Report*, World Bank, Washington, D.C.

World Medical Association (1964). Declaration of Helsinki. General Assembly Helsinki, Finland.

Yeboah, I. (2003). "Demographic and Housing Aspect of Structural Adjustment and Emerging Urban Form in Accra, Ghana," *Africa Today*, 50(1), 107-119.

Yeboah, I. (2006). "Subaltern strategies and development practice: Urban water privatisation in Ghana," *The Geographical Journal* 172 (1), 50-65.

Yeboah, E. and Obeng-Odoom, F. (2010). "We are not the only ones to blame": District Assemblies' perspectives on the state of planning in Ghana. Commonw. J. Local Gov. (7). 78-98.

Yusof, A., Siddique, A. K., Baqui, A. H., Eusof, A., and Zaman, K. (1991). 1988 floods in Bangladesh: pattern of illness and causes of death. *Journal of diarrhoeal diseases research*, 310-314.

Zakour, M. J., and Swager, C. M. (2018). Vulnerability-plus theory: The integration of community disaster vulnerability and resiliency theories. In *Creating Katrina, Rebuilding Resilience* (pp. 45-78).

Zevenbergen, C., Veerbeek, W., Gersonius B. and van Herk, S. (2008). Challenges in urban flood management: Travelling across spatial and temporal scales. *Flood Risk Management 1*, 81-88.

Zhou, X. and Wang, Y.C. (2011). Spatial–temporal dynamics of urban green space in response to rapid urbanisation and greening policies. *Landscape and Urban Planning*, 100(3): 268-277.

APPENDICES

APPENDIX 1

Household Interview Schedule
Survey on Household vulnerability and adaptation to Floods: a comparative study of rural and urban Ghana

Dear Sir/Madam,

My name is Kabila Abass, a PhD candidate in Geography and Rural Development, Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi. I am currently embarking on a survey that covers household flood vulnerability and its coping and adaptive strategies. For a successful execution of this project, it is necessary that I collect household data in selected flood-prone communities in rural and urban Ghana.

I am delighted you offered to participate in this interview and want to assure you of my absolute commitment to secure your privacy and confidentiality in as far as your responses or information you provided are concerned. The information collected will be for academic purposes only and your name will not be mentioned.

If you have any issues or concerns regarding this survey, do not hesitate to contact me at +233244580883. You may also contact my Advisers, Professor Dr. Dr. Daniel Bour and Dr. Dacosta Aboagye, Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi.

Thank you,

Abass Kabila
Department of Geography and Rural Development, KNUST.
Phone: **0244580883**

Location ID
Latitude:……………………………………………
Longitude:…………………………………….

Interviewer's Name:………………………………………

Interviewer's contact………………………………..……

A: Background information
A1: Locality and living environment

101. How long have you been living in this community? (Tick) Please indicate length of stay in the box

a. < 5yrs [ ]
b. 5-10 yrs [ ]
c. 11-15yrs [ ]

d. 16-20yrs [ ]
e. > 20yrs [ ]

102. Which of these applies to you? (Tick)
a. Native/indigenous [ ]
b. Settler/migrant [ ] (state place of origin)……………….

103. Name of Community……………….…………

104. Settlement type (Tick)
a. Urban [ ]
b. Rural [ ]

105. Proximity to a major stream/river? (Tick)
a. No [ ]
b. Yes [ ] Indicate approximate distance in metres …………………………

106. Located within wetland/waterlogged area wetland: (Tick)
a. No [ ]
b. Yes [ ]

107. Where is the dwelling unit sited? (Tick)
a. In a valley [ ]
b. Hill top [ ]
c. Plain [ ]
d. Other (specify)…………………………………

108. Is residence close to stormwater outlet? (Tick)
a. No [ ]
b. Yes [ ]

109. What is the nature of topography? (Tick)
a. steep slope [ ]
b. gentle slope [ ]
c. flat [ ]
d. undulating [ ]
e. Other (specify)…………………………………………..

110. How accessible is the place of residence (road links etc.)? (Tick)
a. Accessible [ ]
b. Inaccessible [ ]

A2: Socio-Demographic characteristics

111. Sex (Tick)
a. Male [ ]
b. Female [ ]

112. Religious affiliation (Tick)
a. Christianity [ ]
b. Islam [ ]

c. Traditional [ ]
d. No religion [ ]
e. Other (specify)……………………………………………

113. What is the highest level of education attained? (Tick)
   a. No formal education [ ]
   b. Basic education [ ]
   c. Secondary/Technical/Vocational education [ ]
   d. Tertiary education [ ]
   e. Other (specify)…………………………………………….

114. What is your current marital status? (Tick)
   a. Never married [ ]
   b. Cohabiting [ ]
   c. Married [ ]
   d. Widowed [ ]
   e. Divorced/separated [ ]

115. Ethnicity of household (Tick)
   a. Akan [ ]
   b. Gonja [ ]
   c. Dagomba [ ]
   d. Mamprusi [ ]
   e. Dagarbas [ ]
   f. Konkomba [ ]
   g. Ewes [ ]
   h. Other (specify) ………………………………………………………………..

116. Age of head of household (Tick) *Please, state the actual age in this box*
   a. <20 [ ]
   b. 20-29 [ ]
   c. 30-39 [ ]
   d. 40-49 [ ]
   e. 50-59 [ ]
   f. 60 and above [ ]

117. What is the size of your household? *Please, state the actual household size in this box*
   a. 1-3 [ ]
   b. 4-6 [ ]
   c. 7-9 [ ]
   d. *≥10* [ ]

118. Number of dependants...

A3: Financial and Human Capital Asset Base

119. Current employment status of household head (Tick)
   a. Employed (government/large companies) [ ]
   b. Employed by relatives/SMEs [ ]

c. Self employed [ ]
d. Unemployed [ ]

120. What is your main current occupation? (Tick)
a. Farming [ ]
b. Fishing [ ]
c. Trading/business/driving [ ]
d. Civil/Public Service [ ]
e. Artisanal work [ ]
f. Other (specify) ……………………………………………..

121. What is your estimated total monthly income (formal and informal sources) ? (Tick)

Please state the actual income in this box

a. Less than GH¢100 [ ]
b. GH¢100 -GH¢ 300 [ ]
c. GH¢301- GH¢500 [ ]
d. GH¢501- GH¢700 [ ]
e. GH¢701- GH¢900 [ ]
f. Above GH¢900 [ ]

122. How many other household members are working for income? ………………

123. What is the estimated total monthly income of other household members?
Please state the actual total income in this box

a. GH¢0 -GH¢100 [ ]
b. GH¢1001-GH¢ 300 [ ]
c. GH¢301- GH¢500 [ ]
d. GH¢501- GH¢700 [ ]
e. GH¢701- GH¢900 [ ]
f. Above GH¢900 [ ]

124. Do you have any family members who work(s) away from home? (Tick)
a. No [ ] If No, proceed to Q 127
b. Yes [ ] If yes, (specify number)……………………………………………

125. Do they remit or send money back home? (Tick)
a. No [ ]
b. Yes [ ] if yes, (specify the amount)……………………………………………

126. If yes in (Q126), how often are you remitted? (Tick)
a. Monthly [ ]
b. Yearly [ ]
c. Irregular [ ]
d. Other (specify)……………………………..……………………………………..

127. Which of these applies to the property you live in? (Tick)
a. Own house [ ] (Specify value of property)…………………………
b. Family house [ ]
c. Rented apartment [ ] (specify monthly rent)…………..…………………

d. State-owned [ ]
e. Squatter [ ]
f. Other (Specify)……………………………………………………………..

128. Do you have access to credit facilities? (Tick)
a. No [ ]
b. Yes [ ]

129. If yes in Q128, indicate your source of credit (Tick all that apply to you).
a. Micro-lending sources [ ]
b. Banks [ ]
c. Credit union [ ]
d. Susu agents [ ]
e. Other (specify)…………………………………………

130. Do you have any insurance cover? (Tick)
a. No [ ]
b. Yes [ ]

131. If yes, indicate the type of insurance cover (Tick)
a. House [ ]
b. Vehicle [ ]
c. Medical (NHIS) [ ]
d. Life Assurance [ ]
e. Other (specify)……………………………………….....

132. Do you save money? (Tick)
a. No [ ] If No, proceed to question Q 134
b. Yes [ ]

133. How much money on average do you save monthly?
………………………………………………………………………………………………

134. Is any member of the household physically challenged?
a. No [ ] If No, proceed to question Q 137.
b. Yes [ ]

135. If yes in Q 134, how many are physically challenged? …………………….

136. State the specific physical disability condition (cripple, Deaf and dumb etc.)
………………………………………………………………………………………………

137. Complete the following table in respect of household asset base

Physical Assets possessed	NO	YES	Commercial use	Non-commercial Use	Present condition (spoilt or not)
Radio					
Television					
*Telephone/Cell phone					
*Vehicle					
*House					
*Sewing machine					
*Bicycle/motor bike					
* Canoe/engine boat					
*Computer					
Other (specify)					

** Indicate whether commercial or non-commercial use*

138. Indicate Yes or No (**by ticking**) against each of the following statements regarding household access to critical assets/resources.

S/N	**Statement**	**NO**	**YES**
a	Household has access to electricity for domestic use		
b	Household uses wood fuel as the main energy source for domestic use		
c	Household has access to adequate health services		
d	Household has access to waste disposal system		
e	Household has in-house water supply		
f	Household has in-house toilet facility		
g	Household has access to water/river for irrigation		
h	Household has access to land for farming		
i	Other (specify)		

A5: Social Capital

139. Do you belong to any social network group? (Tick)

a. No [ ]
b. Yes [ ] Name of social group ……………………………

140. If yes in (**139**), how do you benefit from the social networking?......................
……………………………………………………………………………………………

141. Which community-based organisations/institutions does your household benefit from? (Tick)

a. NGOs [ ]
b. Religious organization [ ]
c. Local government departments/ services [ ]
d. Other (specify)………………………………………

142. Can you always count on the support of Neighbours in the event of floods occurring in the community (Tick)

a. No [ ]
b. Yes [ ]

B. Type and Quality of Housing/building/dwelling unit

201. Type of dwelling unit in which you live (Tick)

a. Single apartment [ ]
b. Flat/single storey/two/three/multiple storey [ ]
c. Compound house [ ]
d. Informal structure [ ]
e. Others (specify)...

202. What material is used predominantly for the building? (Tick)

a. Mud [ ]
b. Stone [ ]
c. Wooden frame [ ]
d. plastic sheets [ ]
e. Metallic sheet [ ]
f. Bricks/cement blocks [ ]
g. Others (specify)……………………………………………

203. What material is used for roofing of your house/dwelling unit? (Tick)

a. Plastics sheets [ ]
b. Grass thatch [ ]
c. Metallic sheets [ ]
d. Roofing Tiles [ ]
e. Bamboo [ ]
f. Sticks with mud [ ]
g. Other (specify)…………………………………………………

204. What material is used for the floor (nature of the floor of rooms)? (Tick)
a. Not cemented/bare ground/ clay [ ]
b. Not cemented but covered with plastic sheets/linoleum [ ]
c. Tiled (non-wooden) [ ]
d. Wooden tiles [ ]
e. Cemented [ ]
f. Other (specify)……………..………………………………

205. Is the building having foundation?
a. No [ ]
b. Yes [ ]

Section C: Flood Incidence and Causes

301. How many times have you experienced flooding within the last ten years?.............
……………………………………………………………………………………………

302. How often have you experienced flooding? (Tick)
a. Yearly [ ]
b. Every two years [ ]
c. Every three years [ ]
d. Every four years [ ]
e. Every five years [ ]
f. Irregular [ ]
g. Other (specify)…………………………………………………………

303. In which year did you experience the most damaging floods?..................................

304. How many days did it take the damaging floodwaters to recede?............................

305. Was the flood associated with rainfall? (Tick)
a. No [ ]
b. Yes [ ]

306. How many days did it take the rain to stop?..

307. What was the pattern or nature of the rain? (Tick)
a. Little showers for about a month [ ]
b. Once but heavy rainfall [ ]
c. Heavy rains for several days [ ]
d. Intermittent heavy rains for several days [ ]

308. What in your view are the main flood-inducing factors in the community? (Tick all that apply)
a. Building in waterways [ ]
b. Building in waterlogged areas [ ]
c. Building too close to river bank [ ]
d. Choked gutters/storm drains [ ]
e. Inadequate storm drains [ ]
f. Prolonged heavy rainfall [ ]

g. Opening of the Bagre dam [ ]
h. Siltation of river channel [ ]
i. Urbanisation [ ]
j. Other (specify) ………………………………………………………..

Section D: Flood risk information and communication

401. Would you on your own be able to predict whether there is going to be floods or not? (Tick)
a. No [ ]
b. Yes [ ]

402. If yes in Q 401, explain…………………………………………………………

403. Do your household members have access to any specific information which you can use to protect your house and household against floods? (Tick)
a. No [ ]
b. Yes [ ]

404. If yes in Q403, from which source (s) do you normally obtain information about floods? (Tick)
a. Radio [ ]
b. Television [ ]
c. Mobile van [ ]
d. Gong-gong beater/town crier [ ]
e. Books and print documents [ ]
f. Community meetings [ ]
g. Friends [ ]
h. Other (specify)…………………………………………………….

405. Is there a way by which flood risk is communicated to you? (Tick)
a. No [ ]
b. Yes [ ]

406. If yes in Q 405, how is flood risk communicated to you? (Tick all that apply)
a. Radio [ ]
b. Television [ ]
c. Mobile van [ ]
d. Gong-gong beater/town crier [ ]
e. Books and print documents [ ]
f. Community meetings [ ]
g. Friends [ ]
h. Other (specify)…………………………………….…………….

407. What kind of information about flood is normally communicated to you? (Tick)
a. Information on building safer houses [ ]
b. Information on risks of building in waterways [ ]
c. Information on extreme weather conditions (windy storms, heavy rainfall) [ ]
d. Information on safer behavioural practices [ ]
e. Other (specify)…………………………………………………….

408. Which agency or agencies is/are responsible for information dissemination about floods and associated risks in your community? (Tick all that apply)

a. NADMO [ ]
b. The Red Cross [ ]
c. Meteorological Services Department [ ]
d. Metropolitan/District Assembly [ ]
e. NGOs [ ]
f. Other (Specify)……………………………………………………………

409. Do you have any local/indigenous ways of predicting floods occurrence? (Tick)

a. No [ ]
b. Yes [ ]

410. If yes in Q 409, specify (Tick)

a. Level of water in the river [ ]
b. Peculiar cry of a river bird [ ]
c. Warning from spiritualists [ ]
d. Consult oracles [ ]
e. Movement of large number of special type of snails [ ]
f. When python is seen climbing a tree [ ]
g. Other (specify)………………………..………………………………………

411. Is there an early warning signal that floods would occur at a particular time or day? (Tick)

a. No [ ]
b. Yes [ ]

412. Comment on the reliability of the various channels of flood risk communication (Tick)

a. Highly reliable [ ]
b. Reliable [ ]
c. Somehow reliable [ ]
d. Less reliable [ ]
e. Unreliable [ ]

Section E: Flood effects and Mitigation

501**.** The following seeks to assess the impact of floods on household and community infrastructure. Indicate by **ticking** the appropriate response to the following statements.

	Effects	**NO (Tick)**	**YES (Tick)**
a	Household ever registered human life loss from floods		
b	Floods caused destruction/damage to household building		
c	Floods caused damage to household electrical and electronic appliances – radio, TV, computer, refrigerator, etc.		
d	Floods destroyed other household property e.g. books, documents, beds & bedding, furniture, clothing etc.		
e	Floods caused disruption of household business		
f	Floods caused damage to farm/crops		
g	Floods caused destruction to livestock/domestic birds		
h	Floods caused damage to fishing nets		
i	Floods caused damage to fishing boats		
j	Floods caused health problems		
k	Floods caused psychological trauma, stress, sleep disorders etc.		
l	Floods led to pollution/contamination of water supply		
m	Floods disconnected household from water supply/ disrupted water supply		
n	Floods disrupted power supply		

502. What in your view should be done to reduce harmful impact of floods at the household and community levels?

(a) Household level..

(b) Community level……………………………………………

503. Where applicable indicate the actual number and wealth of items lost or damaged to floods.

Loss/destruction	**Specify number lost due to floods if applicable**	**Estimated wealth of items lost (Gh. Cedis)**
Loss of life due to floods		
destruction to farm/crops		
destruction to livestock		
destruction to canoes/motors/nets		
Destruction to household property		

504. Did any household suffer from flood-related health problem in recent time? (Tick)

a. No [ ]
b. Yes [ ]

505. If yes, which of these diseases/ailments did you suffer from? (Tick all that apply)

a. Diarrhoea [ ]
b. Cholera [ ]
c. Typhoid [ ]
d. Hepatitis A [ ]
e. Malaria [ ]
f. Skin infections [ ]
g. Other (specify)………………..……………………

506. Floods caused increased stress and anxiety-related health problems (Tick)

a. No [ ]
c. Yes [ ]

507. What in your view should be done to reduce vulnerability/exposure to floods at the household and community levels?

(a) Household level……………………………………………………….

(b) Community level……………………………………………………..

508. These questions concern how you have been feeling over the period you experience flooding. Tick a box below each question that best represents how you have been.

Questions (K-10 Items)	None of the time (1)	Little of the time (2)	Some of the time (3)	Most of the time (4)	All of the time (5)
During the period of flooding about how often did you feel tired out for no good reason?					
During the period of flooding about how often did you have thoughts of killing yourself?					
During the period of flooding about how often did you feel so nervous that nothing could calm you down?					
During the period of flooding about how often did you feel hopeless?					
During the period of flooding, about how often did you feel restless or fidgety?					
During the period of flooding, about how often did you feel upset by little things?					
During the period of flooding, about how often did you feel depressed?					
During the period of flooding, about how often did you feel that everything was finished?					
During the period of flooding, about how often did you feel so sad that nothing could cheer you up?					
During the period of flooding, about how often did you feel worthless?					

Section F: Coping with and Adapting to Floods

F1: Actions taken before floods

601. In all your past flood experiences, did you have fore knowledge of their occurrence?

(Tick)

a. No [ ] If No, proceed to Q604
b. Yes [ ]

602. If yes to Q601, what specific actions did the household take to prevent or mitigate flood damage or losses? (Tick all that apply)

a. Constructed drainage channels in the neighbourhood [ ]
b. Dredged river/stream channel [ ]
c. Built embankments with sand bags or ridges around house [ ]
d. Removed silt and waste materials from choked gutters [ ]
e. Did nothing [ ]
f. Other (specify)………………………………………

603. Would you say that the actions you took were effective? (Tick)

a. No [ ]
b. Yes [ ]

604. Does your household have any flood preparedness plan in place to respond to or prepare for future floods? (Tick)

a. No [ ]
b. Yes [ ]

605. If Yes to Q 604, explain ………………………………………………

606. Does the community have any measures in place to reduce future household vulnerability to floods? (Tick)

a. No [ ]
b. Yes [ ]

607. If yes to Q 606, what kind of measures have been put in place by the community to reduce your exposure to flood impacts? ……………………………………………

608. Does the Assembly have any measures in place to reduce future house vulnerability to floods? (Tick)

a. No [ ]
b. Yes [ ]

609. If Yes to Q 608, what kind of measures have been put in place by the Assembly to reduce community exposure to potential flood impacts?
…………………………………………………………………………………………

610. Would your household be able to manage/cope with future floods when it occurs? (Tick)

a. No [ ] Why? ………………………………………………
b. Yes [ ] Explain:……………………………………………

611. Are there legislations or community rules in place that regulate the behaviour/conduct of people to reduce flood risk? (Tick)

a. No [ ] Why?……………………………………….
b. Yes [ ] Explain………………………………………

612. Are there special measures in place that ensure the protection of children, women, the elderly and the disabled? (Tick)

a. No [ ]
b. Yes [ ] Explain……………………………………………………

F2: Coping strategies during floods

613. What actions did you take during the last flood event? (Tick all that apply)

a. Relocated to stay with friends till water subsided [ ]
b. Relocated to stay with relatives till water subsided [ ]
c. Blocked all entry points of floodwater into the house/rooms [ ]
d. Fetched/pumped water out of room or house [ ]
e. Built embankments with sandbags or ridges around room or house [ ]
f. Moved things to higher grounds [ ]
g. Dug trenches around houses to divert water away from the house [ ]
h. Looked on helplessly [ ]
i. Waited for neighbours and institutions to help [ ]
j. Other (specify)…………………………………………………………………….

614. Did your actions yield the desired positive results? (Tick)

a. No [ ]
b. Yes [ ]

615. What were the consequences of these actions? (Tick)

a. No damage to household electrical gadgets [ ]
b. No damage to building [ ]
c. No damage to fence wall [ ]
d. No loss of life [ ]
e. Yielded no positive results/loss off property [ ]
f. Other (specify)……………………………………………………………………

616. How did you handle or manage (if applicable) the specific cases of children, the elderly and the disabled during floods (most vulnerable group)?………………………

F3: Actions taken after floods

617. What actions did you take after the last flood event? (Tick all that apply)

a. Clean rooms/environment [ ]
b. Sought assistance from friends and relatives [ ]
c. Collected rent paid for the remaining years and relocated [ ]
d. Move residence to new location after the expiration of rent advance [ ]
e. Reconstructed residence on a raised foundation/stilt [ ]
f. Complain to authorities [ ]
g. Other (specify)……………………………………………………………………

618. Did social networking (friends etc.) help you during and after past flood events? (Tick)

a. No [ ]

b. Yes [ ]

619. Did you receive any support from any institutions/organisations? (Tick)
   a. No [ ] If No, proceed to Q 625
   b. Yes [ ]

620. If Yes to Q 619, which institutions/organisations supported you during floods? (Tick all that apply)
   a. NADMO [ ]
   b. The Red Cross [ ]
   c. Meteorological Services Department [ ]
   d. Metropolitan/District Assembly [ ]
   e. NGOs [ ]
   f. Religious organization [ ]
   g. Other (Specify)………………………………………………………………

621. What kind of support were received from the institutions/organisations? (Tick)
   a. Food items [ ]
   b. Medicines [ ]
   c. Clothes [ ]
   d. Supply of shelter [ ]
   e. Money [ ]
   f. Other (Specify)………………………………………………………………

622. How were the relief items distributed? (Tick)
   a. Via community leaders [ ]
   b. Via heads of households [ ]
   c. Directly to the individual victims [ ]
   d. Other (Specify)………………………………………………………………

623. Were you satisfied with the kind of support received from these institutions? (Tick)
   a. No [ ]
   b. Yes [ ]

624. Explain your response………………………………………………………………

625. What long-term measures (non-structural) have you adopted to reduce household vulnerability to floods? (Tick all that apply)
   a. Seasonal migration [ ]
   b. Depend of friends and relatives and institutions (social capital) [ ]
   c. Flood insurance policy cover [ ]
   d. Sales of assets [ ]
   e. Other (Specify)………………………………………………………………

626. What long-term defence mechanisms (structural) have you adopted to reduce the impact of floods? (Tick all that apply)
   a. Use of fence wall [ ]
   b. Raised/reinforced building foundation [ ]
   c. Reconstructed building on a higher/safer place [ ]

d. Use of upper stored [ ]
e. Built house on stilts/concrete pillars above the ground [ ]
f. Other (Specify)……………………………………………………………

627. Would you say that your household well adapted to face future floods? (Tick)
a. No [ ]
b. Yes [ ]

628. Explain your response……………………………………………………….

APPENDIX 2

Household Interview Guide for FGDs and household In-depth Interviews

Survey on Household vulnerability and adaptation to Floods: a comparative study of rural and urban Ghana

Dear Sir/Madam,
My name is Kabila Abass, a PhD candidate in Geography and Rural Development, Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi.

I am currently embarking on a survey that covers household flood vulnerability and its coping and adaptive strategies. For a successful execution of this project, it is necessary that I collect household data in selected flood-prone communities in rural and urban Ghana.

I am delighted you ofered to participate in this interview and want to assure you of my absolute commitment to secure your privacy and confidentiality in as far as your responses or information you provided are concerned. The information collected will be for academic purposes only and your name will not be mentioned.

If you have any issues or concerns regarding this survey, do not hesitate to contact me at +233244580883. You may also contact my Advisers, Professor Dr. Dr. Daniel Bour and Dr. Dacosta Aboagye, Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi.

Thank you,

Abass Kabila
Department of Geography and Rural Development, KNUST.
Phone: **0244580883**

A. Choice of present settlement location
- What reasons account for your choice of this place for settlement?
- *Do you have any intention of relocating? and why?*

B. Causes of floods
- Frequency of floods: *How often do you experience floods in this community?*
- *When was the last time that floods hit this community?*
- In which year did you experience damaging floods in this community?
- How many days did it take the damaging floodwaters to recede?
- Was the flood associated with rainfall?
- How many days did it take the rain to stop?
- What was the pattern or nature of the rain?
- What in your view was the main cause of the floods?
- Punishment from the gods?

C. Flood experience and effects
- *What is the main livelihood activity of the community?*
- *How long have you been doing this work?*

- *Has flooding affected economic/livelihood activities? Probe*
- *Has the community incurred any losses in the most destructive past flood event? Property or human loss*
- *What was the biggest loss?*
- *Psychosocial, mental health problems; post-traumatic stress disorder etc.*
- *Could you have prevented or averted such losses? Explanation.*
- *How has floods (recent and past) affected your health? Probe*

D. Flood risk perceptions and communication

- *Would you say that flooding in this community results from purely natural processes?*
- *Do you think that the location of this settlement predisposes you to risks of floods?*
- *Do you think that the nature of your buildings could make your community vulnerable to floods?*
- *Do you think that throwing/disposing of waste indiscriminately can increase household's risk to floods?*
- *Do you think building houses in waterway could increase community vulnerability to floods?*
- *Do you think building houses close to a major river bank increases community vulnerability to floods?*
- *Would you say that floods pose potential danger to human life and property?*
- *How is flood risk communicated to you?*
- *If you have the opportunity to be relocated would you oblige? Reasons*
- *Can floods affect human health and how? Ask discussants specific flood-related health risks – diarrhoea, cholera, typhoid, stress, and other psychological health problems.*

E. Coping with flood disaster/flood mitigation

- *What did the community do during the most serious flooding when it last occurred?*
- *Did you receive support? **Source of support** (e.g. family members, friends, NADMO, Red-Cross,* religious organization, Metropolitan and District Assembles, *NGOs); relocation)*
- *What form of support did you receive?*
- *Were you satisfied? Probe*
- *Would the community have been able to cope without any external support?*
- *In the event of any future flood, would you be able to cope without any support?*

F. Flood adaptation (long term, planned, proactive)

- *Have you as a community put in any long-term measures to reduce damage from floods?*
- *What specific measures have you put in place to reduce the impact or negative effects of floods?*
- *How effective have these been? Time-tested?*
- *Have these measures yielded positive results?*

- *Knowledge/existence of legislations or community rules that regulate human activities that intensify flooding?*

APPENDIX 3

Interview Guide for Key informants (NADMO, RED-CROSS etc.) – In-depth interviews Survey on Household vulnerability and adaptation to Floods: A comparative study of rural and urban Ghana

Dear Sir/Madam,
My name is Kabila Abass, a PhD candidate in Geography and Rural Development, Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi.

I am currently embarking on a survey that covers household flood vulnerability and its coping and adaptive strategies. For a successful execution of this project, it is necessary that I collect household data in selected flood-prone communities in rural and urban Ghana.

I am delighted you offered to participate in this interview and want to assure you of my absolute commitment to secure your privacy and confidentiality in as far as your responses or information you provided are concerned. The information collected will be for academic purpose only and your name will not be mentioned.

If you have any issues or concerns regarding this survey, do not hesitate to contact me at +233244580883. You may also contact my Advisers, Professor Dr. Dr. Daniel Bour and Dr. Dacosta Aboagye, Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology, Kumasi.

Thank you,

Abass Kabila
Department of Geography and Rural Development, KNUST.
Phone: **0244580883**

1. **NATURE AND FREQUENCY OF FLOODS**
   - What is the nature of floods?
   - What is the frequency of floods?
   - How often does flood occur?
   - When did the last major flood occur?
   - How widespread? What is the spatial extent?

2. **CAUSES OF FLOODS**
   - What in your view is the main cause of floods in district/Metropolis?
   - Was it as a result of prolonged heavy rainfall?
   - Was it as a result of human factors?
   - What specific human factors intensify flooding in the district?
   - Probe for the following (building in waterways, proximity to drains etc.)

3. **FLOOD DAMAGE/EFFECTS/VULNERABILITY**
   - Would you say that floods have generally been catastrophic?
   - Who are the main victims of floods?
   - Which category of people are the most affected?
   - What kind of losses are normally reported?

- What are the main complaints usually reported by victims?
- Can the human vulnerability to floods be stopped/ reduced in the District/Metropolis?
- In what specific ways can flooding be curbed/reduced?

4. **FLOOD VICTIMS SUPPORT and MITIGATION**
   - What kind of support does your outfit offer to flood victims/communities?
   - Where do you concentrate your efforts? Provision of relief items/risk mitigation through public education etc.
   - Mode of flood risks communication to communities? Probe for the following (Early warning efforts etc.)
   - Do you collaborate with other agencies in mitigation efforts *i.e.* (with NADMO, Assembly, GMET, MOFA, Fire service etc.)

5. **SUCCESS STORY/SIGNIFICANT RESULTS**
   - Would you say that your outfit has made significant success in terms of your mandate? Probe
   - If yes, probe for specific areas (*demolition, building storm drains, provision of relief items, shelter, rescue operations* etc.)

6. **CHALLENGES/PROBLEMS**
   - Do you have challenges that militate against your **efforts** (i.e. *demolition, building storm drains, provision of relief items, shelter, rescue operations* etc.) at carrying out your mandate to flood disaster victims?
   - What specific challenges do you face? Logistical, financial, uncooperative community attitude etc.? Explain
   - Link challenges with specific efforts

APPENDIX 4

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI
FACULTY OF SOCIAL SCIENCES
DEPARTMENT OF GEOGRAPHY AND RURAL DEVELOPMENT

Informed consent form for household heads in Kumasi Metropolis and Central Gonja who are being invited to participate in research titled " Household Vulnerability and Adaptation to Floods: Comparative Studies of Rural and Urban Ghana".

Principal investigator: Kabila Abass

Institution: Department of Geography and Rural Development, KNUST

Introduction

I am Abass Kabila, a PhD candidate, Department of Geography and Rural Development, KNUST. I am carrying out research on household vulnerability and adaptation to floods in rural and urban Ghana. The success of this survey depends largely on your voluntary participation. You are not under compulsion to take decision to be part of the research now. Before you take decision, you are at liberty to talk to anyone you feel comfortable with about the research. Should you find any word in this consent form that you do not understand, do not hesitate to ask me for clarification. If you have questions later, feel free to contact me or any other researcher of your choice.

Subject Information

Flooding has become a perennial issue, wreaking havoc to both life and property. We want to assess the factors that account for households' increasing vulnerability to floods and how they adapt to the effects of floods. We want to know how people cope with and adapt to floods. We want people to know the circumstances that expose them to flood risks and how these risks can be reduced or managed.

In this household survey, household heads are the target groups. As a household head, we have firm belief that you can provide the research team with the requisite information that will make the research successful.

We are asking you to help us learn more about your flood experience in the community. We are inviting you to take part in this research project. If you accept, you will be asked to participate in an interview with the research team. You will share with the research team the household flood experiences, coping and adaptation mechanisms.

Your participation in this research is entirely voluntary. The choice to participate or not rests entirely with you. You have absolutely nothing to lose if you choose not to participate. You may change your mind later and stop participating even if you agreed earlier. If you do not wish to answer any of the questions during the interview, you may say so and the interviewer will move on to the next question. No one else but the interviewer will be present unless you would like someone else to be there. The information recorded will be treated with utmost confidentiality. Any information such as your name that will identify you in person will not be needed. The information provided will be deleted after it has been used.

There will be no direct benefit to you, but your participation is likely to help us find out more about how to reduce household vulnerability to floods. The knowledge that we get from this research will be shared with you and your community before it is made widely available to the public.

Statement of Consent

I have been invited to take part in research about household vulnerability and adaptation to floods. The preceding information has been read to me. I was given the opportunity to ask questions and I have had satisfactory answers to all questions that I asked. I consent voluntarily to be a participant in this study

Name of Participant ……………………………………….
Signature of Participant …………………………………..
Date ………………………………………………………..
Day/month/year

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness_____________ Thumb print of participant
Signature of witness ______________
Date __________________________
Day/month/year

Researcher's statement

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands what the research expects or will demand from them.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced or forced into giving consent, and the consent has been given freely and voluntarily.

Name of Researcher ……………………………………………….

Signature of Researcher …………………………………………..
Date …………………………………………….
Day/month/year

APPENDIX 5

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI
FACULTY OF SOCIAL SCIENCES
DEPARTMENT OF GEOGRAPHY AND RURAL DEVELOPMENT

Informed consent form for key informants in Kumasi Metropolis and Central Gonja who are being invited for an in-depth interview on the research topic " Household Vulnerability and Adaptation to Floods: Comparative Studies of Rural and Urban Ghana".

Principal investigator: Kabila Abass

Institution: Department of Geography and Rural Development, KNUST

Introduction

I am Abass Kabila, a PhD candidate, Department of Geography and Rural Development, KNUST. I am carrying out research on household vulnerability and adaptation to floods in rural and urban Ghana. The success of this survey depends largely on your voluntary participation. You are not under compulsion to take decision to be part of the research now. Before you take decision, you are at liberty to talk to anyone you feel comfortable with about the research. Should you find any word in this consent form that you do not understand, do not hesitate to ask me for clarification. If you have questions later, feel free to contact me or any other researcher of your choice.

Subject Information

Flooding has become a perennial issue, wrecking havoc to both life and property. We want to assess the factors that account for households' increasing vulnerability to floods and how they adapt to the effects of floods. We want to know how people cope with and adapt to floods. We want people to know the circumstances that expose them to flood risks and how these risks can be reduced or managed.

In this household survey, household heads are the target groups. As a household head, we have firm belief that you can provide the research team with the requisite information that will make the research successful.

We are asking you to help us learn more about your flood experience in the community. We are inviting you to take part in this research project. If you accept, you will be asked to participate in an interview with the research team. You will share with the research team the household flood experiences, coping and adaptation mechanisms.

Your participation in this research is entirely voluntary. The choice to participate or not rests entirely with you. You have absolutely nothing to lose if you choose not to participate. You may change your mind later and stop participating even if you agreed earlier. If you do not wish to answer any of the questions during the interview, you may say so and the interviewer will move on to the next question. The entire interview will be tape-recorded, but no one will be identified by name on the tape. The information recorded is confidential, and no one else except the principal investigator will have access to the tapes. The information provided will be deleted after it has been used.

There will be no direct benefit to you, but your participation is likely to help us find out more about how to reduce household vulnerability to floods. The knowledge that we get from this research will be shared with you and your community before it is made widely available to the public.

Statement of Consent

I have been invited to take part in research about household vulnerability and adaptation to floods. The preceding information has been read to me. I was given the opportunity to ask questions and I have had satisfactory answers to all questions that I asked. I consent voluntarily to be a participant in this study

Name of Participant ……………………………………….
Signature of Participant …………………………………..
Date ………………………………………………………..
Day/month/year

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness____________ Thumb print of participant
Signature of witness _____________
Date _________________________

Researcher's statement

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands what the research expects or will demand from them.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced or forced into giving consent, and the consent has been given freely and voluntarily.

Name of Researcher ……………………………………………….

Signature of Researcher …………………………………………..
Date ……………………………………………
Day/month/year

APPENDIX 6

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI
FACULTY OF SOCIAL SCIENCES
DEPARTMENT OF GEOGRAPHY AND RURAL DEVELOPMENT

Informed consent form for Focus Group discussants in Kumasi Metropolis and Central Gonja who are being invited for an in-depth interview on the research topic " Household Vulnerability and Adaptation to Floods: Comparative Studies of Rural and Urban Ghana".

Principal investigator: Kabila Abass

Institution: Department of Geography and Rural Development, KNUST

Introduction

I am Abass Kabila, a PhD candidate, Department of Geography and Rural Development, KNUST. I am carrying out research on household vulnerability and adaptation to floods in rural and urban Ghana. The success of this research depends largely on your voluntary participation. You are not under compulsion to take decision to be part of the research now. Before you take decision, you are at liberty to talk to anyone you feel comfortable with about the research. Should you find any word in this consent form that you do not understand, do not hesitate to ask me for clarification. If you have questions later, feel free to contact me or any other researcher of your choice.

Subject Information

Flooding has become a perennial issue, wrecking havoc to both life and property. We want to assess the factors that account for households' increasing vulnerability to floods and how they adapt to the effects of floods. We want to know how people cope with and adapt to floods. We want people to know the circumstances that expose them to flood risks and how these risks can be reduced or managed.

In this household survey, household heads are the target groups. As a household head, we have firm belief that you can provide the research team with the requisite information that will make the research successful.

We are asking you to help us learn more about your flood experience in the community. We are inviting you to take part in this research project. If you accept, you will be asked take part in a discussion with 7 other persons with similar experiences. This discussion will be moderated by the principal investigator, Kabila Abass.

You will share with the research team the household flood experiences, coping and adaptation mechanisms. Then we will ask you questions about local or indigenous ways of predicting flood occurrence. We will also seek your views on the principal causes of floods as well as your flood risk perceptions. We can also answer questions about the research that you might have.

The discussion will take place in location convenient for the group and no one else but the participants and the research team will be present during this discussion. The entire discussion will be tape-recorded, but nobody will be identified by name on the tape. The information taped will be kept in strict confidentiality, and no one else except the principal investigator will have access to it. The information will be deleted after it has served its use.

Your participation in this research is entirely voluntary. The choice to participate or not rests entirely with you. You have absolutely nothing to lose if you choose not to participate. You may change your mind later and stop participating even if you agreed earlier. If you do not wish to answer any of the questions during the interview, you may say so and the interviewer will move on to the next question.

There will be no direct benefit to you, but your participation is likely to help us find out more about how to reduce household vulnerability to floods. The knowledge that we get from this research will be shared with you and your community before it is made widely available to the public.

Statement of Consent

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Name of Participant ……………………………………….
Signature of Participant …………………………………..
Date ………………………………………………………..
Day/month/year

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness____________ Thumb print of participant
Signature of witness _____________
Date _________________________
Day/month/year

Researcher's statement

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands what the research expects or will demand from them.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced or forced into giving consent, and the consent has been given freely and voluntarily.

Name of Researcher ……………………………………………….

Signature of Researcher …………………………………………..
Date ……………………………………………
Day/month/year

APPENDIX 7

Scoring key/scheme for indicators

Indicators	Points (Total=190 points)	
1. Building material	plastic sheets =10 -Wooden frame = 8 -Metallic sheet = 6	-Mud =3 -Bricks/cement blocks/stone = 1
2. Floor material	-Not cemented/bare ground/ clay = 10 -Not cemented but covered with plastic sheets/linoleum = 9	-Wooden tiles =5 -Tiled (non-wooden)/cemented = 1
3. Roof material	-Plastics sheets = 10 -Grass thatch = 9	-Bamboo/Sticks with mud =8 -Metallic sheets/roofing tiles = 0
4. Foundation exists	No= 10	Yes=0
5. Proximity to water body	No= 0	Yes=10
6. Wetland location	No= 0	Yes= 10
7. Site of dwelling	-In a valley = 10 -Plain = 5	Hill top = 0
8. Accessibility	Accessible = 0	Inaccessible = 10
9. Electricity supply	No= 10	Yes=0
10. Possession of telephone	No= 10	Yes=0
11. Possession of TV/radio/	No= 10	Yes=0
12. Level of education	-No formal education = 10 -Basic education = 8	Secondary/Technical/Vocational = 3 Tertiary education = 1
13. Employment status	unemployed = 10	Employed = 3
14. Income level	-Less than GH¢100 = 6 -GH¢100 -GH¢ 300 = 5 -GH¢301- GH¢500 = 4	-GH¢501- GH¢700 = 3 -GH¢701- GH¢900 =2 -Above GH¢900 =1
15. Access to credit facilities	No= 10	Yes= 0
16. Insurance coverage	No= 10	Yes= 0
17. Social capital	No= 10	Yes= 0
18. Possession of flood preparedness plan	No= 10	Yes= 0
19. Length of stay in community	< 5yrs = 8 5-10 yrs = 6 11-15yrs = 4	16-20yrs = 3 > 21yrs = 1