12-7-2018 10:00 AM

Examining Climate Change-Health Nexus in Ghana

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A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Geography

Abstract

Climate change is one of today's most pressing global issues with its physical, biological and social impacts widely recognized. One area of concern is its potential health consequences. The postulated health effects from climate change are far-reaching that climate change induced health risks are signaled as the most pressing problems to public health in the 21st century. Although developing countries such as Ghana had been suggested as a vulnerable hotspot for the health consequences of climate change, there is a paucity of empirical research on climate change and its health linkages in the country.

The purpose of this dissertation is to examine climate change-health nexus in terms of current knowledge on climate change and health among the general public and health practitioners, as well as health systems preparedness and capacity towards climate change-related health risks in two districts in Ghana. This research adopts a mixed-methods approach that combined quantitative and qualitative data (cross-sectional surveys and in-depth interviews, respectively) to better understand and account for the complexities of climate change perceptions, knowledge, and health systems preparedness and capacities in Ghana. Furthermore, multicriteria decision/evaluation analysis is used to prioritize and identify climate-sensitive human infectious disease of national import to public health under climate change inducement conditions. Methodologically, this research developed a multicriteria evaluation model for climate-sensitive infectious disease prioritization under changing climate.

The research reveals several important findings and suggests potential pointers to policy options. Foremost, it reveals that knowledge on climate change and its health linkages is low within the study contexts which underscores the need for increased education, enlightenment programs on climate change and its associated health problems for the public and health officials. Additionally, it was found that there is a need for efforts to strengthen human and institutional capacity and adaptation within the health systems in order to build health institutions and service providers' resilience towards climate-related health risks. This effort is very critical as research findings revealed challenges related to incomplete knowledge, inadequate staffing, logistics and infrastructure, and insufficient training on climate change and health. The results of this research also call for improvements in current disease surveillance, forecasting and monitoring systems for climate-sensitive diseases in Ghana. In particular, epidemic prone and food and water related diseases, as they were identified to be of significance to public health under climate change conditions based on the disease prioritization procedure carried out.

Keywords:

Climate change; climate-impact; climate and health; health professionals/practitioners; health risk perception; public health; multicriteria evaluation/decision analysis; health resilience, preparedness and capacity; Analytic Hierarchy Process; group decision making; infectious disease prioritization; Ghana

Co-Authorship Statement

This dissertation follows the integrated article format and is made up of a collection of manuscripts, that are at various stages in the publication cycle. The manuscripts are as follows:

Chapter Four: Hussey, K. L., & Arku, G. (Revised resubmitted). Conceptualizations of Climate-Related Health Risks Among Health Experts and The Public in Ghana. *Social Science & Medicine.*

Chapter Five: Hussey, K. L., & Arku, G. (under review). Are We Ready for It? Health Systems Preparedness and Capacity Towards Climate Change-Induced Health Risks: Perspectives of Health Professionals in Ghana. *Climate and Development.*

Chapter Six: Hussey, K. L., & Arku, G. (under review). Prioritizing Climate-Sensitive Infectious Diseases Under A Changing Climate: A Multicriteria Evaluation Analysis Approach. *Global Environmental Change.*

While each manuscript has been co-authored with my supervisor, I hereby certify that the research process has been my full responsibility with constant guidance from Dr. Godwin Arku. The interpretation of the results and content of all the manuscripts are my own original contributions with constructive feedback from Dr. Godwin Arku.

The bibliographies of the individual chapters are consistent with The University of Western Ontario Graduate and Postdoctoral Thesis requirements.

Dedication

In memory of Mr. Ambrose Kwasi Hussey and Madam Christine Abla Kwawu.

Thank you for the gift of education.

Acknowledgments

Several organizations and individuals have contributed immensely, in diverse ways, towards completion of this PhD dissertation. Foremost, I would like to extend my profound gratitude to my supervisor, Dr Godwin Arku for his endless and tireless support and guidance. I cannot thank you enough for the intellectual, professional, and financial support in connection with this dissertation and throughout my graduate program. I also wish to express my sincere appreciation to Dr Isaac Luginaah and Dr Jacek Malczewski for the various assistance over the course of my doctorate such as serving on my graduate committee.

I would like to specially thank the Queen Elizabeth II Diamond Jubilee Scholarship (Collaborative Research and Training), the Faculty of Social Science Graduate Research Awards Funds, the Africa Institute Graduate Student Research Fund: Western University; and the 2016 Association of American Geographers Dissertation Research Grant for generously funding this study, particularly, the field research in Ghana. Likewise, Western University for offering me graduate research scholarship to pursue my PhD studies.

Also, I wish to express my gratitude to the health practitioners who participated at a short notice, even when they were time constrained; the in-charge of the health institutions who warmly welcomed me into their facilities and the individuals within these institutions who provided support with the data collection. In addition, the community members who trusted me and willingly participated, and to the individuals who partook in my experts survey; thank you for welcoming me and sharing your expertise despite your busy schedules. To all the research participants, I am particularly grateful for your time, experiences, perceptions and knowledge shared; you made this study possible. Dr Alex Owusu-Barimah, I appreciate all the assistance during my field research. And to my field research assistants, thank you for your dedication and hard work.

I would also like to thank the following for constructive comments on chapters of the dissertation, or for goodwill, advice, and encouragement throughout my program: Drs. Frederick Ato Armah, Hanson Nyantakyi-Frimpong, and Vincent Z. Kuuire. Cheers to my graduate friends and colleagues: Dr. Lydia Osei, Dr. Yvonne Asare-Bediako, Dr. Emmanuel Songsore, Dr. Jonathan Amoyaw, Gloria Kumordji, Arnold Paintsil, Emmanuel Kyeremeh, Emmanuel-Andrew

Tepari and everyone else for the help, moral support and memories. To the girls: Massah, Chloé, Adwoa and Ellen, thanks for your support and prayers; you are the best! To Lori Johnson, Angelica Lucaci, Joe Smrekar and all the staff in the Department of Geography, thank you for the administrative and technical support. Karen Vankerkoerle, thank you for expertly assisting me to develop my study area maps. I am also grateful to the Church of Pentecost, London Assembly, Canada for your persistent prayers and support.

At the end of it all, my family members have been my strongest backbone. Mum and Dad, without your sacrifices and support, I would not be where I am today, I owe my future success to you, even though you are not here to see the fruits of your labor. Mum, you have been my greatest support, your prayers and well wishes has borne its fruits. My endless gratitude goes to my siblings: Benedicta, Berlinda, Celestine and Richard for your never-ending love. I am also thankful to Mr. Pawson Kuadzi for all the diverse support.

Finally, to God be the Glory! Great things He has done. Without the unfailing Grace of God, all this would not have been possible. You never gave a promise that the journey would be easy, your grace and mercy has brought me thus far!

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List of Abbreviations

CCRPM	Climate Change Risk Perception Model
CHPs	Community-Based Health Planning and Service
CHS	Community Health Services
CSIDs	Climate Sensitive Infectious Diseases
EPA	Environmental Protection Agency
GHS	Ghana Health Service
GMA	Ghana Meteorological Agency
GSS	Ghana Statistical Service
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Conversion Zone
MCDA	Multicriteria Decision Analysis
MCE	Multicriteria Evaluation Analysis
MESTI	Ministry of Environment, Science, Technology and Innovation
MMDAs	Metropolitan, Municipal and District Assemblies
MoH	Ministry of Health
NCCP	National Climate Change Policy
PPMED	Policy, Planning, Monitoring and Evaluation Division
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION: CLIMATE CHANGE AND THE NEED TO IMPROVE KNOWLEDGE

> "Given the potential of climate change to reverse the health gains from economic development, and the health co-benefits that accrue from actions for a sustainable economy, tackling climate change could be the greatest global health opportunity of this century" (Watts et al., 2015: 1861).

> "risk communication will be most successful and efficient when it is directed toward correcting those knowledge gaps and misconceptions that are most critical to the decisions people face" (Read et al. 1994: 971).

1.1 Defining and Contextualising Climate Change

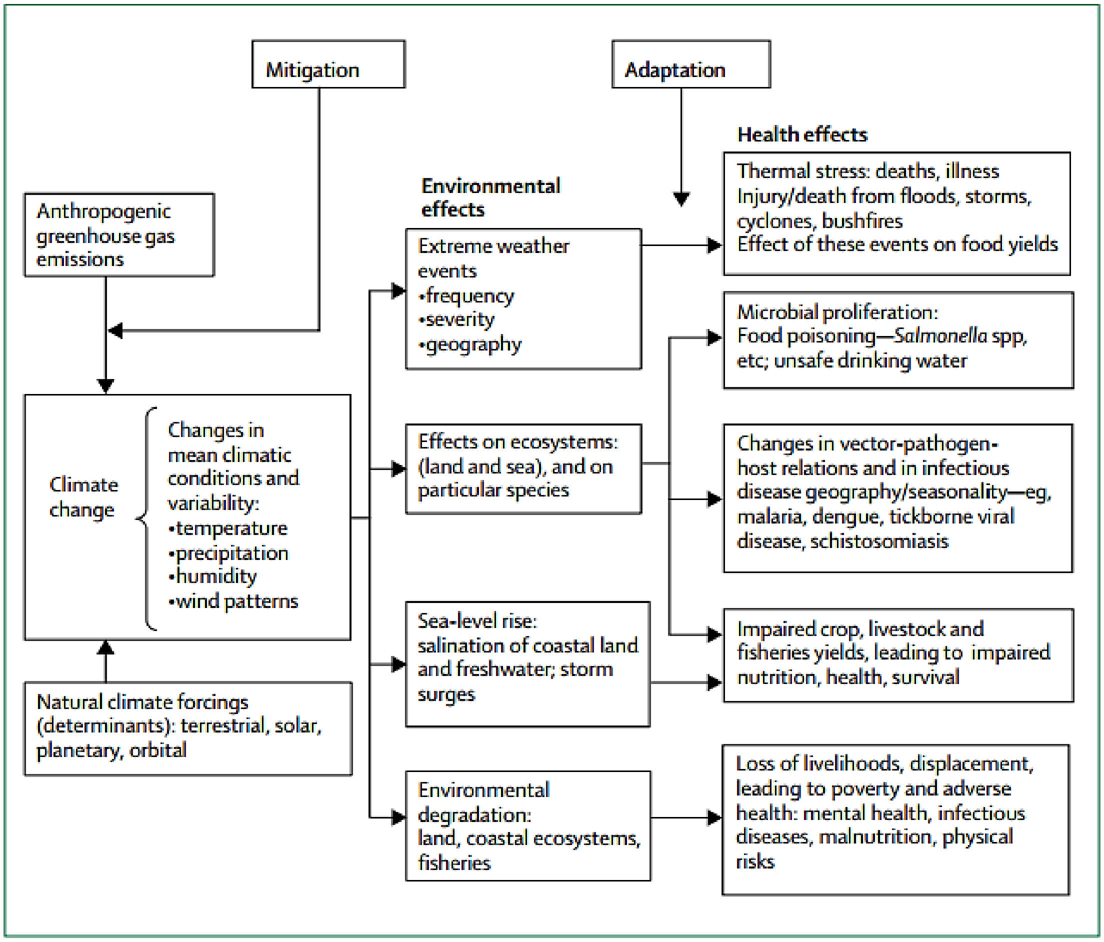
Climate change generally refers to the processes and outcomes of long-term and persistent altering of climatic conditions, often identified as a statistically significant variation in either the mean and/or the variability of its properties. Factors driving climatic change can be both natural and anthropogenic (IPCC, 2014a). In providing an understanding of the processes and trends in climate change, the Intergovernmental Panel on Climate Change (IPCC) draws on global warming research from several scientists. Evidenced in these studies include increasing greenhouse gas accumulations, warming ocean temperatures, decreasing snow cover and glaciers, intensified drought, heat and storm activities, as well as sea level rise in the past century. These findings have led the IPCC to conclude that the "warming of the climate system is unequivocal, and … many of the observed changes are unprecedented over decades to millennia …" (IPCC, 2013: 4).

Globally, land and ocean surface temperature has risen between 0.65°C and 1.06°C, which represents an average rise of 0.85°C over the period 1880 to 2012. Global surface temperature change at the end of the 21st century is projected to exceed 1850 to 1900 levels by 1.5°C, and the global mean surface temperature change for the period 2016–2035 relative to 1986–2005 is estimated to be in the range of 0.3°C to 0.7°C. In addition, extreme precipitation events over most of the mid-latitude landmasses and over wet tropical regions will likely become more intense and more frequent by the end of the 21st century, as global mean surface temperature increases (IPCC, 2013). Thus, climate change poses differentiated consequences for the world, whereby low-income countries with weak adaptation mechanisms and systems become more vulnerable to its adverse impacts (IPCC, 2013).

1.2 Contextualizing the Research Problem

In the last two decades, climate change has featured prominently on the global agenda. As noted in Section 1.1, there is widespread scientific consensus that the world's climate is changing, with mounting evidence suggesting dire current and future effects on human health. It has been argued that many human health conditions are tied either directly or indirectly to global climate change (Costello et al., 2009; McMichael, Woodruff & Hale, 2006). For instance, McMichael et al. (2006) suggested that environmental consequences of climate change, both observed and projected, such as sea-level rise, changes in precipitation resulting in flooding and drought, changes in temperature, heat waves, and degraded air quality, would affect livelihoods, worsen deprivation and poverty and increase thermal stress and microbial proliferation, which would ultimately affect human health both directly and indirectly (Figure 1.1). Figure 1.1 provides the principal pathways linking climate change with health of populations. The central section shows the main climatic-environmental manifestations of climate change, with the right-hand boxes entailing its potential or subsequent health effects.

Figure 1.1: Schematic Summary of Main Pathways by Which Climate Change Affects Human Health



Source: McMichael et al. (2006: 860)

The IPCC has projected increases of vector-borne and diarrhoeal diseases in the coming decades, and speculated on the nature, magnitude, frequency, distribution and extent of possible changes in human health risk (IPCC, 2007; 2014b). For example, various IPCC reports have projected that global climate change would trigger the spread of infectious diseases into new regions and increase the intensity of diseases in already endemic regions such as sub-Saharan Africa (SSA) and other low-income regions.

Nonetheless, the fifth assessment report of the IPCC (2014b) suggests that, impacts and health risks of climate change can be reduced and managed through adaptation measures. As earlier argued by Khasnis & Nettleman (2005) and the World Health Organization (WHO) (2009), the worry over climate change lies in our inability to adequately adapt and respond to its related livelihood and health burdens. One of the critical components of adaptation is knowledge of the climate change problem itself. How individuals understand and perceive climate change greatly shape their responses, including their support for policies that focus on addressing climate change problems, and adherence to climate related behaviour change initiatives (Lorenzoni & Pidgeon, 2006; Milfont, 2012; Shi, Visschers & Siegrist, 2015; Vignola, Klinsky, Tam & McDaniels, 2013). In explaining how knowledge of climate change relates to adaptation mechanisms, Lorenzoni and Pidgeon (2006) suggest that individual's perception of climate change risks tends to influence their decisions on how to mitigate and adapt to current risks, while averting future perceived threat. According to them, public risk perceptions have strongly influenced how people respond to hazards. In addition, Tschakert and Sagoe (2009: 154) have argued that, "if one doesn't understand what to adapt to, choosing the most appropriate and timely proactive strategies and trade-offs becomes problematic, if not impossible." As a result, public knowledge on climate change (i.e. perceived risk, processes and pathways of occurrence, and how to respond to climate induced hazard) is a vital consideration for policy makers.

The IPCC (2014b) and WHO (2009) further stipulate that infectious diseases could become more prominent if public-health systems unravel under climate change. According to the WHO (2009), countries need to assess their health vulnerabilities to climate change and prioritize on most relevant adaptive actions. In reducing adverse impacts of climate change induced infectious diseases and further lessening disaster risks, policy-makers need to identify climate sensitive infectious diseases prevalent in their context and focus on preventing and controlling them. Effective infectious disease control and prevention measures entail prioritization of potential disease risks to public health in order to optimize the use of scarce resources in research, surveillance and other activities (Krause, 2008; Ng & Sargeant, 2013). Prioritization would further ensure that both adaptation planning and resource allocation against diseases that pose a greater risk are effectively carried out. In addition, local level prioritization of climate change disease impact can tailor cross-scalar capacities to context-sensitive and specific interventions for optimal impact. Therefore, the efficiency of climate change related health interventions and policies largely depend on knowledge and understanding of the risk levels of climate sensitive infectious diseases.

Developing countries, such as Ghana, are the most vulnerable to climate change and are projected to disproportionately carry the greatest health burden that comes with it (IPCC, 2014b; WHO, 2009). For many decades, failed attempts at tackling infectious diseases have led to endemic levels, and with increasing impact of climate change, Ghana and other developing countries risk being over-burdened with multiple health problems. As recorded in recent years, Ghana has been exposed to periodic pandemics and major epidemics, including cholera, meningitis, yellow fever and viral haemorrhagic fevers (Ghana Health Service, and Ministry of Health [GHS/MoH], 2016). Besides, there are signs that the country is encountering growing incidence of climate-related natural disasters. Currently, the main cause of disasters includes pest and insect infestations, disease epidemics, fire outbreaks, floods and ethnic conflicts (GHS/MoH, 2016). With these persistent health problems, emergence of climate related health risks can exacerbate current rates of disease incidence and prevalence, and therefore pose serious risks to public health, and the health delivery in the country.

Unfortunately, knowledge and perceptions of climate change associated health risks, their latent health burdens, and current prevalence have been less explored in Ghana (Codjoe & Nabie, 2014; Codjoe & Larbi, 2016; Adu-Prah & Tetteh, 2014). Most significant is our limited understanding of health professionals' perceptions and knowledge regarding climate change-health linkages although such knowledge would help strengthen the technical capacities of the health systems to manage climate change–health risks and in communicating the related potential health concerns. An informed and well-prepared health sector would be able to plan and respond to potential climate-related infectious diseases. The devastating nature of the recent Ebola outbreak between 2014 and 2016 (although not climate related) for example, is partly blamed on weak and poor preparedness of a critical public health care system, whereby potential spread of the disease was not controlled, and important medicines and logistics were slow at reaching the field (Luginaah et al., 2016). For this reason, it is imperative that the capabilities and readiness of health institutions to handle potential health risks related to climate change be examined.

This dissertation explored these issues to better understand climate change-health nexus within the Ghanaian context. Although, the literature on climate change-health nexus is growing steadily, few studies in Ghana have examined the role of climate change on the incidence of infectious diseases and public perception on the issue (Codjoe & Nabie, 2014; Codjoe & Larbi, 2016; Adu-Prah & Tetteh, 2014). Investigation of these issues within the Ghanaian context is important given the significance of health-related climate change impacts, coupled with Ghana's vulnerability to climate change and existing disease burdens. Knowledge of these issues can help improve both human and health system resilience to climate change health threats as policy-makers could use the information to formulate and implement important environmental, and climate change-health policies and programmes. Ghana's ability to achieve its Sustainable Development Goals (SDGs) hinges partly on addressing climate change-human health effects.

1.3 Research Question and Research Objectives

This dissertation seeks to investigate current knowledge on climate change and its health risks, the ability of health systems to respond effectively to probable climate-related adverse health outcomes and identify priority climate sensitive infectious diseases to public health under climate change conditions.

Broadly, this dissertation is guided by the overarching research question: What is the current knowledge on and capacity towards addressing climate change health risks in Ghana? To answer this question, three distinct but interrelated research objectives were formulated to guide this thesis:

1. To examine climate change-health knowledge among the public and health experts in Ghana;

2. Assess the preparedness and institutional capabilities of health systems and professionals towards climate change health risks; and

3. Prioritize climate sensitive infectious diseases for policy attention in Ghana under climate change inducements based on their cumulative threat and burdens to human populations and health systems.

By investigating level of knowledge among the public and health experts, as well as the health system preparedness and capacities, and prioritizing infectious diseases, the current research hope to contribute to academic discussions about climate change, as well as to help inform policy planning processes to be responsive towards climate change health risks and outcomes in Ghana.

1.4 Organization of the Dissertation

This dissertation consists of seven chapters, including this introductory chapter. Chapter Two provides a contextualization of climate change-health linkages as well as the theoretical frameworks guiding the dissertation. The chapter also situates this dissertation within the current climate change and health literature. Chapter three presents the study methodology as well as its geographical setting. The next three chapters consist of three manuscripts, each addressing one of the three study objectives. Chapter Four (manuscript one) investigates knowledge levels and perceptions and or awareness of climate change and its health risks among the public and health experts in Ghana. Chapter Five (manuscript two) assessed how prepared health institutions and health professionals in Ghana are towards potential climate induced health risks. In Chapter Six (manuscript three), a multicriteria evaluation framework is used to evaluate and prioritize climate sensitive infectious diseases for policy attention under climate change inducements. Although each manuscript can be read on its own as a discrete piece, collectively they provide a comprehensive account of the empirical aspect of the study. Therefore, they address the overall motivation of the study, which is to understand the current knowledge on and capacity towards addressing climate change health risks in Ghana. Chapter Seven concludes this study and provides over-arching findings of this research. The chapter also highlights the contributions of the study to the field of climate change and health, policy recommendations and opportunities for future research are identified.

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CHAPTER TWO

CLIMATE CHANGE-HEALTH NEXUS AND THEORETICAL UNDERPINNINGS

2.1 Introduction

This chapter provides a synthesis of key concepts and issues in the broader climate change and health literature, as each of the stand-alone Chapters (Chapters four to six) has their own literature review. In doing this, first, a contextualization of climate change-health outcomes is provided. The chapter then proceeds to situate this dissertation within current climate change and health literature. Afterwards, the broad theoretical and conceptual frameworks employed to examine climate change-health nexus in Ghana is outlined.

2.2 Climate Change and Health Nexus

As noted in Chapter 1, climate change is projected to have adverse impacts on public health in many ways (see McMichael et al., 2006; McMichael et al., 2003; Watts et al., 2015; Watts et al., 2018). Up to the mid-21st century, it is projected that, climate change will impact human health mainly by exacerbating existing health problems. However, throughout the 21st century, climate change is anticipated to lead to increases in ill-health in many regions and especially in low income developing countries (IPCC, 2014).

Many direct and indirect ways that climate change will affect health have been suggested (Costello et al., 2009; Watts et al., 2018). Directly, regional weather changes in temperature, sea level, precipitation, and extreme weather events will cause downstream effects on the environment that will lead to adverse health effects (Costello et al., 2009). According to Costello et al. (2009) climate endangers health through these key ways: changing patterns of disease and mortality, food insecurity, water scarcity, extreme weather events, population and migration, and threats to shelter and human settlements, including built structures. Costello and colleagues projected that, rising temperatures due to climate change will affect the spread and transmission rates of vector-borne and rodent-borne diseases. They also projected climate change to threaten human health by compounding existing food insecurity leading to under nutrition. Due to changes in rainfall over the next decades, it is anticipated that climate change would cause health challenges either through drought or increased rainfall and further make provision of clean water even more complicated than it is now. The connection between population growth and migration, and climate change is complex. Population growth and migration are anticipated to interface with climate change in ways that intensify several other mechanisms, specially shelter, food, and water scarcity (Watts et al., 2015).

Other scholars such as Ebi (2008) have outlined three broad categories of direct health impacts associated with climatic conditions: direct climate variability impacts (e.g. heat waves, floods, droughts, and windstorms); environmental changes due to climate variability and change (e.g. changes in the geographic range and incidence of water, food and vector borne diseases, and fluctuations in the concentrations of certain air pollutants and aeroallergens); and climate-induced impacts on economic dislocation and environmental decline (e.g. under-nutrition due to prolonged drought).

Studies by international development agencies and non-governmental organizations have also identified various consequences of climate change. For instance, the World Health Organization (WHO) (2008a) identified five major health consequences of climate change. The first aspect relates to the agricultural sector which is extremely sensitive to climate variability. According to WHO (2008a, b), rising temperatures and more frequent droughts and floods can compromise food security which can result in increased malnutrition, especially within countries where large populations depend on rain-fed subsistence farming. The second involves frequent extreme weather events which are expected to lead to more potential deaths and injuries caused by storms and floods. Flooding can then be followed by outbreaks of diseases such as cholera. The third health effect relates to water issues. Both scarcities of water, which is vital for hygiene, and excess water due to more frequent and torrential rainfall are anticipated to increase the burden of diarrhoeal disease, which is spread through contaminated food and water. The fourth involves heat waves especially in urban 'heat islands', and is predicted to directly increase morbidity and mortality, mainly in elderly people with cardiovascular or respiratory disease. Aside heat waves, higher temperatures are also projected to increase ground-level ozone and hasten the onset of the pollen season, leading to asthma attacks. Finally, changing temperatures and patterns of rainfall are expected to alter the geographical distribution of insect vectors that spread infectious diseases.

The fourth assessment report of the IPCC (2007:16) summarized the key health impacts from climate change as follows: (1) increased burden from malnutrition, diarrhoeal, cardio-respiratory, and infectious diseases; (2) increased morbidity and mortality from heat waves, floods and droughts; (3) changed distributions of some disease vectors; and (4) substantial burden on health services.

Smith et al. (2014) in their contribution to the fifth IPCC assessment report indicated three basic pathways through which climate change affects health. These are: (1) direct impacts, which relate primarily to changes in the frequency of extreme weather including heat, drought, and heavy rain leading to mortality and morbidity, (2) effects mediated through natural systems: that is, indirect impacts from environmental and ecosystem changes, such as shifts in patterns of disease carrying vectors, or increases in waterborne diseases due to warmer conditions, air pollution, increased precipitation and runoff, and (3) effects heavily mediated by human systems. Among the indirect impacts that may be mediated through societal systems are undernutrition and mental illness from altered agricultural production and food insecurity, stress, and violent conflict caused by population displacement. Others relate to economic losses due to widespread ‘heat exhaustion’ impacts on the workforce; or other environmental stressors, and damage to health care systems by extreme weather events.

From the above, climate change puts at risk the basic determinants of health. In summary, the changing climate will affect the basic requirements for maintaining health namely, clean air and water, sufficient food and adequate shelter. Climate change will affect health through a complex set of interdependent interactions. It is projected to amplify existing climate-related risks and create new risks for natural and human systems.

Although the projected health risks are of concern to public health, they are of differing values to countries and continents. The African continent has been projected as one of the most vulnerable to climate change, due to its high exposure and low adaptive capacity (Niang et al., 2014). Niang et al. (2014) in their contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) outlined many key climate health risks for the African continent. Climate change and climate variability is projected to potentially exacerbate or multiply existing threats to human security including food, and health. Climate change is anticipated to particularly increase the burden of a range of climate-relevant health outcomes. Variations in the incidence and geographic range of vector- and water-borne diseases due to changes in the mean and variability of temperature and precipitation, mainly along the edges of their distribution is a major key risk that has been identified for the continent.

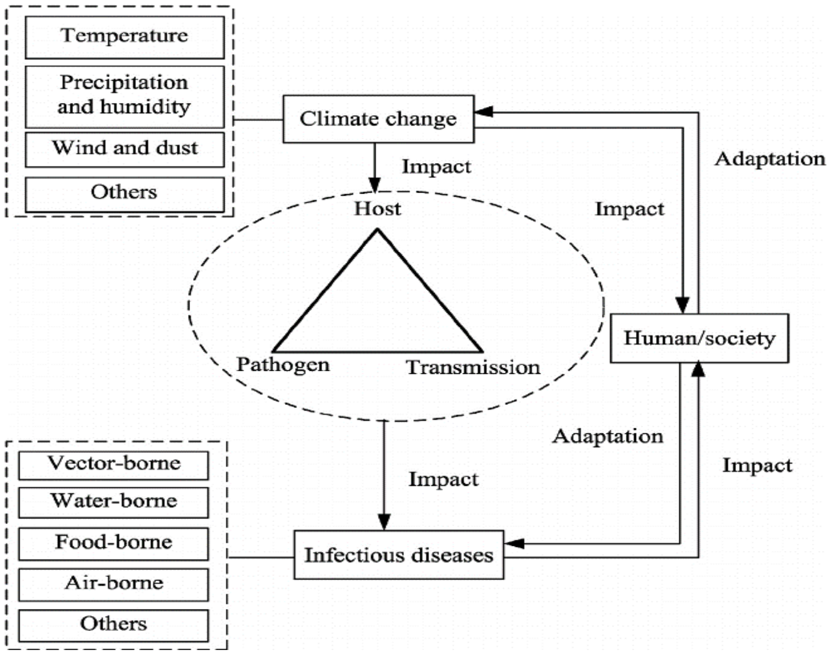
For food- and water-borne diseases, it is estimated that the projected increases in precipitation in certain areas in the continent will lead to more frequent cholera outbreaks in the affected sub-regions; for instance, West Africa where cholera is already endemic. A wide range of vector-borne diseases are also expected to be impacted by climate change within the region such as malaria, leishmaniasis, schistosomiasis, meningococcal meningitis and human and animal trypanosomiasis. Other health issues have also been identified to be impacted by climate change within the African region. Climate change is projected to increase the burden of malnutrition, with the highest toll expected in children. It is also noted that, any increase in food insecurity due to climate change would likely compromise the poor nutrition of people living with HIV/AIDS within the continent.

Currently, climate change impacts relating to infectious diseases is one of the most pressing issue of concern to global public health and particularly the African continent (WHO, 2014). The African region currently experiences high burdens of health outcomes whose incidence and geographic range is to be impacted by changing temperature and precipitation patterns, including diarrheal diseases, malaria and other vector-borne diseases (WHO, 2018). As noted in Chapter 1, prevalence and endemicity of infectious diseases are of public health significance in Ghana, hence, any climate-related impacts are of concern. Based on the pressing nature of climate-related infectious disease risks, the high vulnerability of the African continent, coupled with current infectious diseases trends in Ghana, climate change risks to infectious diseases is of interest to this study.

2.2.1 Climate Change/ Variability and Infectious Disease Linkages

Climate change impacts on infectious diseases is one of the major postulated health effects that have gathered attention (see WHO, 2014). This climate change-human infectious disease relationship is illustrated by Wu et al. (2016) (Figure 2.1).

Figure 2.1: Climate Change, Human Infectious Diseases, and Human Society



Source: Wu et al. (2016: 16)

Human infections are complexly linked to the global environment and by altering this environment, climate change has a significant potential to intensify some infectious diseases (Khasnis & Nettleman, 2005). Several infectious agents, vector organisms, non-human reservoir species, and rate of pathogen replication are sensitive to climatic conditions (Pascual & Dobson, 2005). Through temperature, rainfall, and humidity, climate limit the spatial and temporal variations of infectious diseases. It does through its consequent physical and ecological characteristics of the environment that sets limits on the occurrence of a particular infectious disease (Swaminathan, Viennet, McMichael, & Harley, 2017). As a result, there are many varied mechanisms whereby climate change can influence the occurrence of infectious diseases.

Climate influences the biology of pathogens, hosts, and vectors of infectious diseases and hence their incidence (Cox, 2011). According to Swaminathan et al. (2017) pathogens in terms of viruses and bacteria reproduce and survive only under certain conditions with each species having limits in terms of temperature which affects reproduction and transmission rates. Nonhuman hosts of human infectious diseases are also affected by climatic conditions due to their sensitivity, whiles vectors are affected by environmental factors like temperature. The anticipated temporal and spatial changes in temperature, precipitation and humidity to occur under different climate change scenarios will affect the biology and ecology of vectors and intermediate hosts and consequently, the risk of disease transmission (Githeko, Lindsay, Confalonieri, & Patz, 2000). Climate change is expected to affect the abundance and distribution of disease vectors and cause changes in the epidemiology of infectious diseases (Khasnis & Nettleman, 2005).

Although changes in climate have been postulated to impact infectious diseases, the existing predictions have identified vector and water borne diseases as those that climate change would have the worse implications on. Climate change will impact infectious diseases through the process of transmitting vector and waterborne diseases (Wu et al., 2016). Climate change is also likely to have various effects on health through distribution, seasonal transmission and changes in the geographic range of vector-borne diseases (McMichael et al., 2006). These diseases would include malaria, dengue fever, and yellow fever (all mosquito-borne), various types of viral encephalitis, schistosomiasis (water-snails), Lyme disease (ticks), and onchocerciasis (West African river blindness, spread by black flies) (McMichael, 2003). Temperature, precipitation, humidity, and other climatic factors have been recognized to affect the reproduction, development, behavior, and population dynamics of the arthropod vectors of vector borne diseases and their capability to transmit disease agents. Climate also affects the development of pathogens in vectors (external incubation period), as well as the population dynamics and ranges of the nonhuman vertebrate reservoirs of many vector-borne diseases (Gage, Burkot, Eisen, & Hayes, 2008; Zhang, Bi, & Hiller, 2008).

Gubler et al. (2001) listed a range of possible mechanisms whereby changes in temperature and precipitation will impact on the risk of transmission of vector borne disease. Changes in temperature are expected to cause an increase or decrease in survival of vectors, variations in rate of vector population growth as well as feeding behaviour, susceptibility of vectors to pathogens, changes in the incubation period of pathogen among others. Changes in precipitation will impact risk of vector-borne disease transmission through increased surface water which can provide breeding sites for vectors or low rainfall which can also increase breeding sites by slowing river flow. Also, increased rain can lead to growth in vegetation and allow expansion in population of vertebrate host. Flooding due to increased precipitation may eliminate habitat for both vectors and vertebrate hosts or may force vertebrate hosts into closer contact with humans. Climate conditions thus affect the transmission of vector-borne diseases in three ways: (1) altering the distribution of vector species and their reproductive cycles; (2) influencing the reproduction of the pathogens within the vector organism, known as the external incubation period (EIP); and (3) affecting human behaviors and activity (Zhang et al., 2008).

Concerning waterborne diseases, the current evidence of the impact of climate on the epidemiology of waterborne disease is considered under three headings; the impact of heavy rainfall events, the impact of flooding, and the impact of increased temperature (Hunter, 2003). All these factors are determined by changes in climatic conditions and seasonality. Outbreaks related to water borne diseases can occur after heavy rainfall. For surface water sources, heavy rainfall can lead to overflow of storm drains that may be combined with the sewage system. This can then allow substantial amounts of faecal polluted water into rivers. Some bacteria and pathogens (e.g. *Giardia* or *Cryptosporidium oocysts* in river water) are found in rivers and surface waters after heavy rains, thus, bathing or swimming in the waters can lead to risk of infection (Hunter, 2003). Increased temperatures, on the other hand, relates to the blooms of various planktonic species that are directly or indirectly hazardous to human health. The most evidence of the effect of temperature on waterborne diseases is in relation to cholera (see Lipp, Huq, & Colwell, 1996).

2.3 Overview of Current Research: Climate Change Knowledge and Health Risk Perceptions, and Assessment of Health Systems Preparedness and Capacity

Given the range of the health implications of climate change demonstrated by scholars, there have been calls for increased understanding of the public's views and perceptions on climate change and its associated human health risks. This knowledge and understanding of human health risks related to climate change is important for adaptation actions such as behaviour change (Akerlof et al., 2010). In responding to this call, studies have begun to assess public perceptions on climate change and its health linkages (e.g., Cardwell & Elliott, 2013; Dana, Roy, & Haque, 2015; DeBono, Vincenti, & Calleja, 2010; Haque, Yamamoto, Malik, & Sauerborn, 2012; Mishra, et al., 2015; Nesha, Rahman, Hasan, & Ahmed, 2014; Asekun-Olarinmoye et al., 2014). Overall, these studies have assessed awareness, knowledge and perceptions about climate change and its health impacts or associated risks. For instance, Haque et al. (2012) explored households' perceptions of climate change (changes to heat, cold and rainfall) and their knowledge of the effects of climate change on diseases and other health problems in Vietnam. Mishra et al. (2015) also explored community perceptions of climate variability and human health risks in Nepal, particularly amongst the most at-risk communities. Adolescents' perception of environmental change and health risk was also assessed in two divisions of Bangladesh by Dana et al. (2015). Asekun-Olarinmoye et al. (2014) accounted for public perceptions of climate change and its impact on health and the environment in rural southwestern Nigeria. Cardwell and Elliott (2013) study focused on facilitators and barriers to behaviour change.

Given the seriousness of the health threat of climate change, there have been calls to frame climate change as a public health issue rather than an environmental one (Maibach, Nisbet, Baldwin, Akerlof, & Diao, 2010). In line with that, studies have advocated for the voice of health professionals to be heard in driving forward progress on climate change and realising the health benefits of this response. Further, health professionals are asked to support actions directed at reducing the effect of climate change on health (Maibach, et al., 2010; Watts et al., 2018). Consequently, health professionals must be aware of the health implications of climate change and possess the skills necessary to address potential health risks. Based on these, studies have sought to determine the knowledge and attitudes of health professionals regarding climate change, health effects of climate change, and their ability to address climate change health impacts (e.g., AnAaker, Nilsson, Holmner, & Elf, 2015; Nigatu, Asamoah, & Kloos, 2014; Polivka, Chaudry, & Mac Crawford, 2012; Xiao, et al., 2016). Polivka et al. (2012) determined the knowledge and attitudes of public health nurses concerning climate change and the role of public health nursing in divisions of health departments in addressing health related impacts of climate change in the U.S. AnAaker et al. (2015) explored nurses' perceptions of climate and environmental issues and examined how nurses perceive their role in contributing to the process of sustainable development. Nigatu et al. (2014) advanced these studies by examining the knowledge and perception of health sciences students on climate change related health impacts in Ethiopia.

Despite emerging research on the assessment of knowledge and perception of climate change and health impacts among both the public and health professionals, none of these previous studies have contrasted the views of these two groups. As argued by Hathaway and Maibach (2018) the extent to which the general public and practicing health professionals are aware of the health relevance of climate change around the world is unclear. This dissertation contributes to this missing link by assessing health professionals and the general public's perceptions on climate change health linkages in Ghana.

Managing the health risks of climate change involves adaptation, which is a means to build resilience and adjust to climate change impacts. Adaptation is the process of adjustment to actual or expected climate and its effects in order to either lessen or avoid harm or exploit beneficial opportunities (IPCC, 2014). With respect to health, adaptation comprises efforts to reduce injury, illness, disability, and suffering from climate-related causes. The ability to adapt to climate change and specifically, the impacts on health will be contingent on many factors, including, existing infrastructure, resources, technology, information and the level of equity in different countries and regions. Capacity building is also an essential step for adaptation and include education, training and awareness raising (Kovats et al., 2000).

In line with the above, attention within the climate change health literature has shifted towards assessment of health systems and professionals' capacity to address climate change health risks (e.g., Bedsworth, 2009; Dasgupta, Ebi, & Sachdeva, 2016; Maibach et al., 2008; Olaris, 2008; Purcell & McGirr, 2014; Roser-Renouf, Maibach, & Li, 2016). In their study in the U.S. Maibach et al. (2008) sought to understand how directors of local public health departments viewed and were responding to climate change as a public health issue. Bedsworth (2009) study also examined how local health agencies in California are prepared to deal with a changing climate. Roser-Renouf, Maibach and Li (2016) also carried out a study in the U.S. to assess the city and county health department's readiness to address local climate change health impacts. As well, Olaris (2008) carried out a study in Victoria (Australia) to determine the capacity of the metropolitan Community Health Services (CHSs) to respond to climate change.

Currently, there has been relatively little empirical research on health systems and professionals in developing world's context capacity and preparedness to address the extra disease burden anticipated from climate change, considering their vulnerabilities to these risks. This dissertation through its focus on assessing health systems and professionals' capacity to address climate change induced health risks and emergencies in Ghana, seeks to account for perspectives from a developing world to contribute to the emerging scholarly work from developing countries.

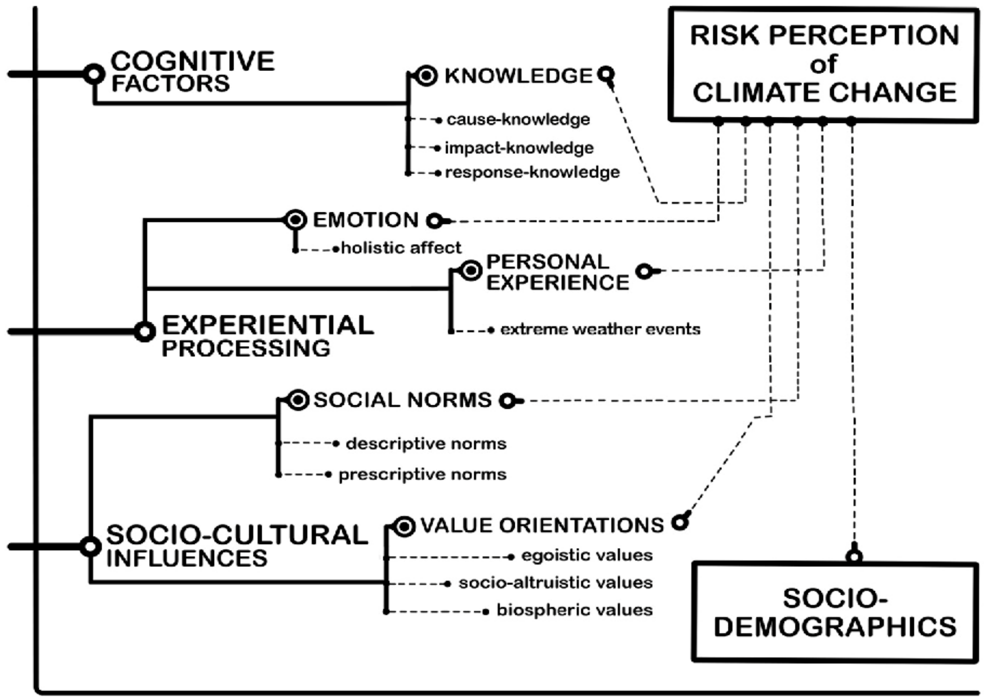
2.4 Theoretical Underpinnings

This dissertation engages relevant theoretical frameworks to make its substantive arguments and assessments for each of its research objectives. Insights are drawn from the Climate Change Risk Perception Model (CCRPM) and the World Health Organization's Operational Framework for Building Climate Resilient Health Systems. These frameworks supplement each other and act as the foundation for achieving the broad aim of this dissertation, as each is unable to do this on its own.

2.4.1 Climate Change Risk Perception Model (CCRPM)

Risk perception is a multidimensional construct and therefore, a wide range of different items has been used to tap into and measure how the public perceives the risk of climate change. The Climate Change Risk Perception Model (CCRPM) was advanced by van der Linden (2015) as an integrated theory of risk perception that combines four key theoretical dimensions to maximize explanatory power; 'cognitive,' 'experiential,' 'socio-cultural' and 'sociodemographic' factors (Figure 2.2). These dimensions are not necessarily assumed to be independent but can often be expected to interact in complex ways. This CCRM model advanced by van der Linden provides a more systematic and theoretically integrated overview of the main social-psychological determinants of climate change risk perceptions. According to van der Linden (2015:117) "risk perceptions of climate change can be described as a function of cognitive factors (i.e., knowledge about climate change), experiential processing (i.e., affective evaluations and personal experience) and socio-cultural influences (including social norms and broad value orientations) - controlling for key socio-demographic characteristics." As argued by van der Linden, while these dimensions are particularly critical in explaining public risk perceptions of climate change, the framework proposed is not meant to provide an ultimate explanation nor is the list of included predictors meant to be exhaustive.

Figure 2.2: The Climate Change Risk Perception Model (CCRPM)



Source: van der Linden (2015:117)

Cognitive Dimensions of Risk

The cognitive dimension of risk considers climate change knowledge. To estimate both the probability with which climate change is expected to occur and the severity of linked ramifications, some ‘knowledge’ on these factors need to be acquired first (van der Linden, 2015). Consequently, knowledge about climate change is largely viewed as a cognitive aspect of risk judgments (Sundblad et al., 2007). This knowledge is of different forms and consist of either an individual's ‘subjective’ knowledge (i.e., what people think is true) and the actual ‘evidence’. In line with this, climate change knowledge is assessed either subjectively (self-reported knowledge) or objectively (‘accurate’ knowledge people hold about climate change). van der Linden (2015) provided a more reliable assessment of knowledge under the cognitive dimension by measuring three interrelated and converging subject areas: public knowledge about the causes, impacts and responses to climate change.

Experiential Processes

In addition to holding cognitive knowledge about a risk, people frequently experience risks in affective and emotional terms as well. As argued by van der Linden, it is now widely recognized that human information processing is guided by emotion and affect and consequently, both the *'risk-as-feelings'* hypothesis and the *'affect-heuristic'* have turn out to be influential in describing and understanding public risk perceptions. The experiential dimension of risk perception takes into consideration *affect*. The term *'affect'* as used under the experiential dimension indicates a subtler form of emotion, defined as a positive (like) or negative (dislike) evaluative feeling towards an external stimuli (Slovic et al., 2007). Thus, an *'affective response'* under this dimension is described as a first, associative and automatic reaction that guides information processing and judgment (Zajonc, 1980).

The second component under experiential processes is that of personal experience. It is argued that more direct path to establishing visceral concern depend on personal experience with a threat or hazard. Direct experiences are argued to be able to provoke strong emotions, making them more memorable and dominant in processing. Furthermore, people's emotional reactions to risks often hinge on the vividness with which negative consequences can be imagined or experienced (Weber, 2006). Evidence from studies suggests that personal experience with extreme weather events influence risk perceptions of climate change although some exceptions exist. van der Linden (2015) adopted a wider approach to personal experience by measuring a respondent's experience with both flooding as well as other types of extreme weather events (e.g., heat waves, freak/snow storms, droughts etc.) compared to the focus on flooding that has been adopted.

Socio-cultural Influences

This dimension considers culture, values and worldviews and the social construction of risk that affects risk perceptions. Existing theories of risk perception, both cognitive and affective theories, have been criticized by early sociological research as lacking consideration of social influence processes (competing social and cultural structures that shape individual risk perception). The arguments revolve around the notion that culture gives rise to socially constructed systems of beliefs, or ‘worldviews’. Out of this critic, ‘the cultural theory of risk’ (Douglas & Wildavsky, 1983) emerged to account for cultural differences in risk perception. Operationalized empirically, studies have found a significant relationship between ‘cultural worldviews’ and risk perceptions of climate change (e.g., Akerlof et al., 2013; Leiserowitz, 2006).

Relating to the social construction of risk, it is argued that the way in which people approach and evaluate risks is influenced by other people. In response, two sociological approaches were developed: Social Representations Theory (Moscovici, 1984) and the Social Amplification of Risk Framework (Pidgeon, Kasperson, & Slovic, 2003). Both approaches account for how interpersonal interactions, societal norms, and the mass media shape and circulate social representations of a given risk in society. These theories take into consideration the process of how risk signals are received, interpreted, and diffused which they argue is pertinent in understanding how the communication of climate risks is impacted and moderated by social processes. van der Linden (2015) added to this literature by examining the role of social factors in driving (individual) risk perceptions of climate change through measuring the normative influence of important social referents directly using a social norms approach. Social norms were defined as “expectations of how people are supposed to act, think or feel in specific situations” (Popenoe, 1983:598; cited in van der Linden, 2015:116). In accordance with the ‘focus theory of normative conduct’, van der Linden measured both ‘descriptive social norms’ (i.e., the extent to which referent others are acting to help reduce the risk of climate change) as well as ‘prescriptive social norms’ (i.e., the extent to which an individual feel socially pressured to view climate change as a risk that requires action).

Socio-Demographic Characteristics

Also, it has been documented by climate change risk perceptions studies (e.g., Akerlof et al., 2013; Leiserowitz, 2006) that various sociodemographic and social-structural factors influence climate change risk perception, even though results tend to vary from sample to sample and from study to study. These socio-demographic characteristics include age, gender, education, income, religion, among others.

Using elements from the cognitive and the socio-demographic dimensions, this study evaluated the extent to which cognitive and socio-demographic aspects predict perceptions of climate change as a health risk in two districts in Ghana.

2.4.2 Operational Framework for Building Climate Resilient Health Systems

Considering the increasing evidence of climate change and its connected health risks and the need to build health resilience and protect population health, the World Health Organization (WHO) introduced the Operational Framework for Building Climate Resilient Health Systems. This framework responds to the call from Member States and partners for guidance on how the health sector and its operational basis in health systems can systematically and effectively deal with the challenges presented by climate variability and change (WHO, 2015). This operational framework is particularly oriented towards health systems in low- and middle-income countries, which currently face difficulties in effectively preparing for health emergencies and controlling disease burdens, provide coverage of basic healthcare and public health services, manage inequity, and use resources in a cost-effective way. Specifically, the framework's objectives are threefold:

1. Guide professionals working in health systems, and in health determining sectors (e.g. water and sanitation, food and agriculture, energy, urban planning) to understand and effectively prepare for the additional health risks posed by climate variability and change, through a resilience approach;

2. Identify the main health functions that need to be strengthened to build up climate resilience, and use these as the basis for developing a comprehensive and practical plan;

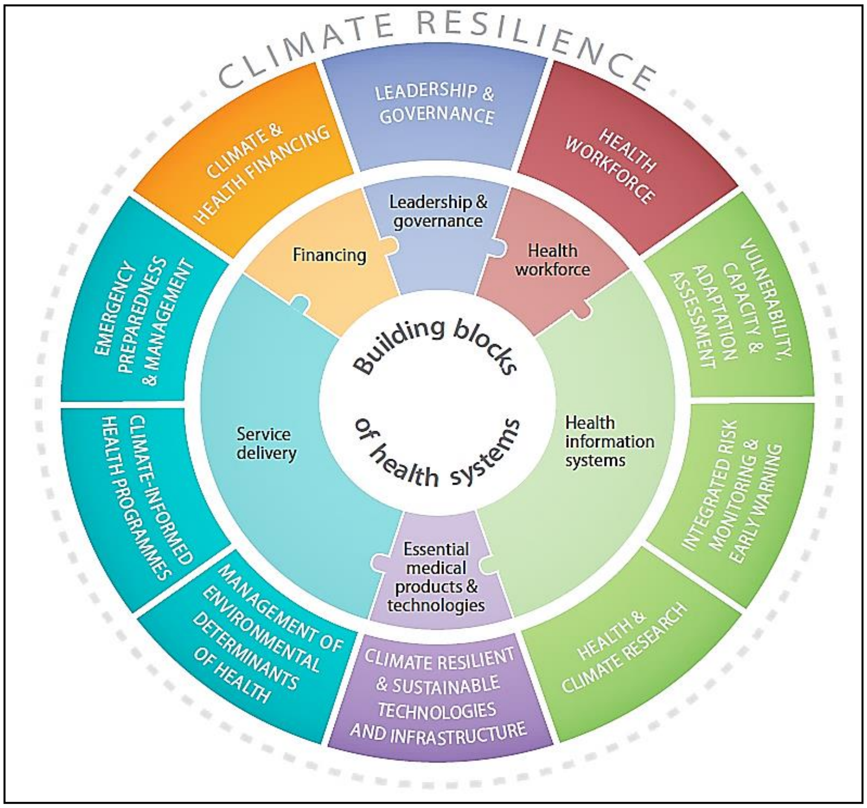
3. Support health decision-makers to identify roles and responsibilities to implement this plan, for actors both within and outside the formal health sector.

Overall, the operational framework aims to realise its goal through activities that build capacity to effectively monitor, anticipate, manage and adapt to the health risks related with climate variability and change.

Using the WHO six common heath sector building blocks as a starting point, the operational framework elaborates on 10 components that provide a comprehensive approach to integrating climate resilience into existing health systems. The building blocks: leadership and governance, health workforce, health information systems, essential medical products and technologies, service delivery and financing are used as a starting point for the expansion of the 10 primary components that specifically enhance climate resilience. These components provide the structure for a health adaptation plan, entailing the allocation of roles and responsibilities, as well as human and financial resources (WHO, 2015). Each component plays an important role in strengthening system capacity to address climate change and provide proposed objectives and examples of measurable outputs to enhance health systems climate resilience. Figure 2.3 shows the ten components comprising the WHO Operational Framework for Building Climate Resilient Health Systems, and the main connections to the building blocks of health systems.

The objective of this dissertation is to evaluate health systems capacity to address climate change-health risks in Ghana; as such, the study is situated within this broader framework. Elements from two components of the framework (health workforce and emergency preparedness and management) are used to investigate health institutions and professionals' capacity and preparedness to respond to climate change and human health risks in the context of Ghana.

Figure 2.3: The ten components comprising the WHO Operational Framework for Building Climate Resilient Health Systems, and the main connections to the building blocks of health systems



Source: WHO (2015: 12)

2.5 Summary

This Chapter provided the broad context of climate change and health within which the dissertation is positioned. First, the Chapter explored how climate change is linked with health, and some of the projected health implications of climatic changes globally and relating to the African context presented. This is followed by an overview of current scholarly works on climate change and health (i.e., climate change knowledge and health risk perceptions, and health systems preparedness and capability assessment), with the contribution of this dissertation research to these current works outlined. In concluding the Chapter, the theoretical frameworks: Climate Change Risk Perception Model and the WHO Operational Framework for Building Climate Resilient Health Systems within which the objectives of the thesis are situated in investigating climate change-health nexus in Ghana are introduced.

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CHAPTER THREE

RESEARCH CONTEXT AND STUDY DESIGN

3.1 Introduction

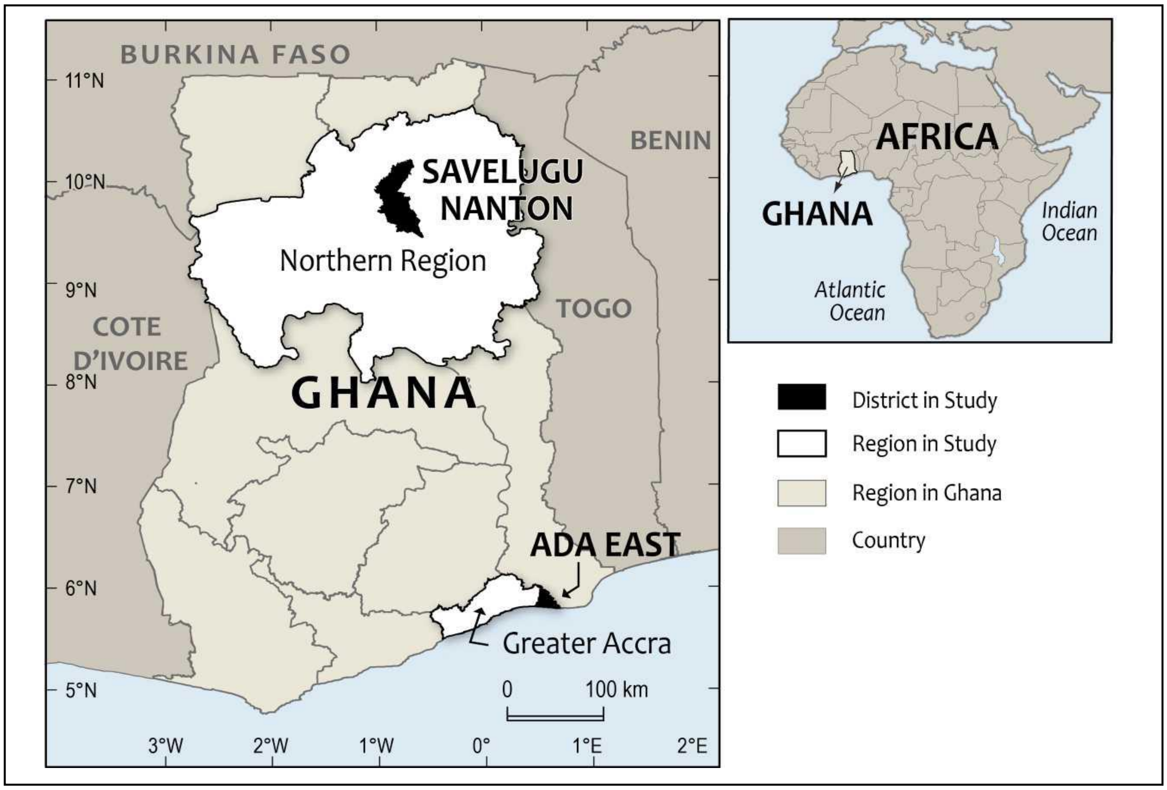
This chapter provides a detailed background of the context within which the research for this dissertation is situated and provides information on the data used in addressing the study objectives outlined in Chapter 1. First, the chapter provides an overview of Ghana, the country where the study took place, and then narrows in on Ada East District and Savelugu-Nanton Municipality: the two study areas where the field work was conducted. Further, a contextualization of climate change-health links and climate change policy in Ghana is presented. Second, it outlines the methodological approach/study design and briefly describes the data sources utilised in addressing the research objectives of the dissertation.

3.2 Study Context- Geographic Profile of Ghana

Ghana is a country with varied geographical and climatic features. It is situated in West Africa between Togo on the east, Burkina Faso on the north and northwest, Côte d'Ivoire on the west, with the Gulf of Guinea to the south (Figure 3.1). Ghana has an estimated land area of 238,537 km^2 and lies between latitude 4° and 12° north of the equator. It also lies astride longitude 0° and 10 minutes east. The country's population was projected to be 28,308,301 in 2016 based on the 2010 Population and Housing Census (Ghana Statistical Service [GSS], 2016). Ghana is constituted of ten administrative regions, which are subdivided into 254 districts consisting of six metropolitan, 102 municipalities, and 146 district assemblies (Ghana Districts, 2018). The districts are the third-level administrative subdivision of the decentralized administrative system of Ghana. The three-tier system in use is the national, the regional and the district.

Ghana has a tropical climate with temperatures generally high throughout the country. The mean annual temperature is usually above 24^0C, with average figures ranging between 24^0C and 30^0C for the southern parts, with 18^0C to 40^0C or more common in the northern parts. Rainfall generally in Ghana decreases from the south to north. The rainfall seasons in Ghana are controlled by the movement of the Inter-Tropical Conversion Zone (ITCZ) which oscillates between the northern and southern tropics over the course of a year. Two main rainfall regimes are identified for the southern sector with two maximum periods between April to July and from September to November (a shorter wet season), and a single rainy season from May to October in the northern sector which is followed by a long dry season occurring from November to May (EPA Ghana, 2011).

Figure 3.1: Map of Ghana



Source: Geography Department, Western University. Cartographer: Karen Vankerkoerle

3.2.1 Climate Change Profile of Ghana

According to Ghana's second national communication to the United Nations Framework Convention on Climate Change (UNFCCC) which the country is a signatory to, there are signs of climate change in the country and alludes to its vulnerability. Climate models and projections for Ghana predict that the country would continue to get warmer. The climate models indicate signs of warming with an increase of 1°C observed over the past 30 years (EPA Ghana, 2011). Mean annual temperature has increased by 1.0°C since 1960, an average rate of 0.21°C per decade with the rate of increase generally been more rapid in the northern regions of the country than in the south (McSweeney et al., 2012). According to McSweeney et al. (2012) daily temperature data for Ghana also indicate that, the frequency of 'hot 'days has increased significantly in all seasons except December, January, and February, and the frequency of 'hot nights has also increased significantly in all seasons. It is estimated that, the average number of 'hot' days per year in Ghana has increased by 48 (an additional 13.2% of days) between 1960 and 2003. The average number of 'hot' nights per year is estimated to have increased by 73 (an additional 20% of nights) between 1960 and 2003. The average number of 'cold' days per year is also shown to have decreased by 12 (3.3% of days) between 1960 and 2003 with the average number of 'cold' nights per year decreasing by 18.5 (5.1% of days). Rainfall over Ghana which was particularly high in the 1960s is shown to have decreased to particularly low levels in the late 1970s and early 1980s, causing an overall decreasing trend in the period 1960 to 2006 by an average of 2.3mm per month per decade. Rainfall levels in Ghana generally have reduced with the patterns becoming increasingly erratic in all ecological zones in Ghana (Ministry of Environment, Science, Technology and Innovation [MESTI], 2013). Overall, analysis of national historical data shows a progressive rise in temperature and decrease in mean annual rainfall in all agro-ecological zones in Ghana.

In terms of future climate projections, mean annual temperatures in Ghana are anticipated to increase by 1.0° to 3.0°C by the 2060s, and 1.5° to 5.2°C by the 2090s (McSweeney et al., 2012). The mean annual temperature is projected to rise by about 4.8°C on average from 1990 to 2100 (WHO, 2016). The probable rate of warming is more rapid in the northern inland regions of the country than the coastal regions. The projections indicate an extensive increase in the frequency of days and nights that are currently considered 'hot'. Annually, the projections indicate that 'hot' days will happen on 18-59% of days by the 2060s, and 25-90% of days by the 2090s. 'Hot' nights are projected to occur on 28-79% of nights by the 2060s and 39-90% of nights by the 2090s. It is estimated that, there would be decreases in the frequency of days and nights that are considered 'cold' in current climate. 'Cold' days and nights are projected to occur on less than 3% of days by the 2090s. While the projected mean annual temperature is anticipated to increase most rapidly in the northern parts, the projected changes in the daily temperature extremes ('hot' and 'cold' days and nights) are predicted to be larger in the coastal areas (McSweeney et al., 2012).

For rainfall, projections of mean annual rainfall average over the country indicate a wide range of changes in precipitation for Ghana. However, the projections seasonally tend towards decreases in January, February, March and April, May, June rainfall and increases in July, August, September and October, November, December rainfall (McSweeney et al., 2012).

3.2.2 Existing Policies and Strategies Related to Climate Change in Ghana

Ghana faces significant challenges due to the negative impacts of climate change which directly or indirectly affect ecology, economy and society. There are clear signs of the direct climate change impacts in the country including increased temperatures, rainfall variability, unpredictable extreme events, and sea-level rise (MESTI, 2013). Due to Ghana's high reliance on sectors that are particularly sensitive to climate change (e.g. agriculture, forestry and energy production), climate change manifestations would affect various facets of the country's socio-economic structure. Ghana is highly vulnerable to climate change due to its impact on key sectors such as health, energy, agriculture, infrastructure, water resources, land, fisheries and forestry.

One of the vulnerable sectors of concern to Ghana is that of health. It is projected that, more than half of the diseases in Ghana have a direct link to climate variability and exposure and climate change may result in higher infection rates for diseases such as malaria and meningitis (USAID, 2012). Climate variability affects health throughout the country and climate change is likely to impose new stresses, resulting in several direct and indirect impacts which are summarized in Table 3.1.

Table 3.1: Potential Impacts of Climate Change on Health in Ghana

Impact mode	Impacts	Consequences
Direct	• Exposure to thermal extremes, especially heat waves. • Altered frequency and/or intensity of other extreme weather conditions (droughts, floods, storms, etc.).	• Altered rates of heat- and cold-related illness, especially cardiovascular and respiratory diseases. • Deaths, injuries, and damage to public health infrastructure.
Indirect (due to disturbances of ecological systems)	• Impacts on range and activity of mosquitoes and parasites. • Altered local ecology of water- and food-borne infective agents. • Altered food (especially crop) productivity due to changes in climate, weather, and associated pests and diseases. • Shifts in the quantity, quality, and distribution of fresh water. • Sea level rise with population displacement and damage to infrastructure. • Extreme events such as floods and droughts, with population displacement and damage to infrastructure. • Increased levels and biological impacts of air pollution, including pollens and spores.	• Change in the transmission zones of mosquito-borne diseases and the numbers of people affected. • Changed incidences of diarrhoea and infectious diseases. • Regional malnutrition and hunger with consequent impairment of child growth and development especially in vulnerable communities. • Injuries, increased risk of various infectious diseases (due to migration, overcrowding, contamination of drinking water). • Asthma and allergic disorders, other acute and chronic respiratory disorders, and deaths. • Wide range of consequences affecting public health (e.g. mental health, nutritional impairment, infectious diseases, civil strife

Source: USAID (2012)

Acknowledging the increasing climate-related challenges, the Government of Ghana have begun to determine vulnerability and adaptation priorities, and to integrate this knowledge into development and sectoral planning. Based on its national circumstances, Ghana has put forward mitigation and adaptation actions towards climate change. The Government launched a National Climate Change Policy (NCCP) document for the country in July 2014 which seeks to ensure a coherent and pragmatic approach in dealing with the impact of climate change on the socio-economic development agenda of the economy. It aims to ensure a climate-resilient and climate-compatible economy, which addresses a low-carbon growth path for Ghana while achieving sustainable development. The NCCP is Ghana's integrated response to climate change within its socio-economic context and provides a strategic direction and coordinate issues of climate change in Ghana. The NCCP prioritized five main Policy Areas: (i) agriculture and food security, (ii) disaster preparedness and response, (iii) natural resource management, (iv) equitable social development, and (v) energy, industrial and infrastructural development (MESTI, 2013). These five Policy Areas have been subdivided into a total of ten programme areas that address the fundamental critical issues of climate change in Ghana, as listed below:

(1) Develop climate-resilient agriculture and food security systems,
(2) Build climate-resilient infrastructure,
(3) Increase resilience of vulnerable communities to climate-related risks,
(4) Increase carbon sinks,
(5) Improve management and resilience of terrestrial, aquatic and marine ecosystems,
(6) Address impacts of climate change on human health,
(7) Minimize impacts of climate change on access to water and sanitation,
(8) Address gender issues in climate change,
(9) Address climate change and migration, and
(10) Minimize greenhouse gas emissions

3.2.2.1 Climate Change and Health Policy Context in Ghana

Ghana has dedicated itself to pursue coordinated domestic policy actions to secure the health of its populations and to ensure that gains made in public health are secured under climate change. Within the NCCP prioritized five main Policy Areas, climate change and its health impacts were incorporated under Equitable Social Development. Relating to the ten specific programme areas of action, addressing climate change and its impact on human health is outlined under Focus Area six.

Under Focus Area six which seeks to address impacts of climate change on human health, it is acknowledged that climate change will have direct and indirect impacts on human health in the country. Direct impacts are observed for vector-borne and water-related diseases such as malaria and guinea-worm, which are anticipated to exhibit changes in distribution and or incidence based on changing temperature and humidity; these are expected to make conditions favourable for the proliferation of their vectors. Airborne diseases like cerebrospinal meningitis which are affected by changes in weather/climatic variables are also likely to be affected by climate change. In addition, diarrhoeal diseases such as cholera are predicted to be exacerbated by climate variability and long-term climate change. The indirect impacts on health include potential increases in injuries, hunger and malnutrition because of droughts and other extreme weather events (MESTI, 2013).

The NCCP's identified ten Policy Focus Areas for addressing Ghana's climate change challenges and opportunities, and each has specific programmes for dealing with the critical policy actions necessary to achieve the desired objectives. Three key policy objectives are outlined for Focus Area six: addressing impacts of climate change on human health, with some key interventions for achieving the objectives indicated under policy actions. The NCCP further identified six programme areas for Focus Area six. Table 3.2 presents a summary of these policy objectives, actions and programme areas.

Table 3.2: Policy Objectives, Actions and Programme Areas for Addressing Impacts of Climate Change on Human Health in Ghana

Policy Objective	Policy Actions	Programme Areas
1. Identify and improve data recording, reporting, analysis and storage of climate-sensitive diseases at all levels of service delivery 2. Enhance knowledge and sensitize the health sector on the impacts of climate change including issues for vulnerable groups such as the aged, women and children 3. Minimize the impacts of climate change on health in communities whilst strengthening public health care delivery and preventive care	1. Establish community health groups and development of capacity to identify health risks and facilitate access to services and decision makers 2. Strengthen technical capacity to manage climate-change-related health risks 3. Strengthen disease surveillance systems through early warning 4. Improve data sharing and develop health information management systems for diseases including climate-sensitive diseases at all levels of the health delivery system 5. Improve partnerships between relevant ministries and other stakeholders to improve access to potable water, instead of direct dependence on natural water bodies, and environmental sanitation 6. Map disease incidence and identification of vulnerable groups for climate-sensitive diseases 7. Strengthen existing units within the health delivery system to manage climate-related epidemics 8. Collaborate with relevant stakeholders to improve nutrition through increased food processing capacity, food banks, nutrition education, and food storage and quality control 9. Improve surveillance systems for existing and new disease risks and ensure health care systems are geared up to meet future demands 10. Mainstream climate change health risks into decision-making at local and national health policy levels 11. Identify, document and incorporate climate-relevant traditional knowledge into health delivery systems and practices 12. Develop structures to effectively manage and disseminate information on climate change health risks.	P1. Capacity-building of health care providers and groups P2. Research and improved data management and storage P3. Strengthened disease surveillance and response systems P3. Improved public health measures (immunization, improved drainage, sanitation and hygiene) especially in vulnerable communities P4. Emergency health preparedness, e.g., provision of ambulances in vulnerable areas P5. Collaboration and partnerships for improved nutrition, water and sanitation P6. Social protection and improved access to health care

Source: MESTI (2013)

In 2015, Ghana National Climate Change Master Plan Action Programmes for Implementation: 2015–2020 was developed (MESTI, 2015). This document is the second phase of Ghana's policy response to climate change. The National Climate Change Policy (NCCP), which provides a clearly defined pathway for dealing with the challenges of climate change consisted of Phase 1: NCCP presents the policy, analyses the current situation and states the broad policy vision and objectives. Ghana National Climate Change Master Plan Action Programmes for Implementation: 2015–2020, the Phase 2 is set out by sector and presents the initiatives and programmes identified in the NCCP in the form of Action Programmes for implementation. The NCCP Action Programme for Implementation includes the details of initiatives and programmes to achieve the objectives of each Policy Focus Area identified in Phase 1.

Climate change and its health implications are addressed under Focus Area six in the Action Programme for Implementation, as it builds from the NCCP. It acknowledges that climate change and variability can have a major effect on the health of human populations. As a result, there is the need to improve the capacity-building of health care providers and groups which would include strengthening disease surveillance and response systems. The NCCP Action Programme for Implementation gives a detail account of the programme areas outlined in the main NCCP document and includes the objective of each of the outlined programme areas, actions to achieve them, the purpose of such actions, and the anticipated outputs from them. Table 3.3 presents these accounts for Focus Area six: addressing impacts of climate change on human health, the focus of this dissertation.

Within this study, one of the programme areas of interest under Focus Area six is 6.1: capacity-building of health providers and groups associated with climate change. One of the actions to be achieved under this programme is effort to develop and strengthen individual, institutional and systemic capacity in climate change-related health issues across the health sector. And the purpose of this action plan is to improve the knowledge of health professionals on climate change and health issues across the country. It is anticipated that this action would result in health professionals who are trained in climate change and health issues, with individual and institutional capacity in climate change and health issues strengthened. The timeframe for implementation of these actions is from 2015 – 2020, indicating these actions should have been initiated at the time of this research. A review of the policy documents shows that, attempts to address the health impacts of climate change which also entails improving knowledge base is largely tailored towards the health systems and personnel with little attention being paid to the public. Public education and awareness on climate change and its health links is not explicitly stipulated. However, some of the objectively verifiable indicators that the policy proposes under the objective of developing and strengthening individual, institutional and systemic capacity in climate-change-related health issues across the health sector are: structured periodic awareness campaigns in place, and number of key messages on climate change and health delivered through the media. Hence, it is assumed that education and awareness programmes are to be carried out to sensitize the public on climate change and its health impacts. This is the policy context in which this study seeks to elucidate climate change health knowledge among health professionals and the community in our study districts in Ghana. Furthermore, the study examines health systems capacity and preparedness to address climate emergencies related to health (infectious diseases).

Table 3.3: NCCP Action Programme for Implementation-Focus Area 6: Address Impacts of Climate Change on Human Health

Programme	Objectives	Action	Timeline	Purpose of Action	Output
Programme 6.1: Capacity-building of Health Providers and Groups associated with Climate Change	In the health sector, to improve individual, institutional and systemic capacity to deal with climate change and health. To improve data management, storage and links in the health sector.	Develop and strengthen individual, institutional and systemic capacity in climate-change-related health issues across the health sector.	2015–2020	To improve the knowledge of health professionals of climate change and health issues across the country.	Health professionals trained in climate change and health issues. Individual and institutional capacity in climate change and health issues strengthened Availability of relevant data on climate change and health to inform policy.
		Enhance technical capacity in data collection, management, reporting and storage.		To improve data management and storage in the health sector so as to build reliable databases from which to conduct research.	
Programme 6.2: Climate-related Health Research	To conduct well-coordinated scientific research on the impacts on health of climate change	Development of research programmes to address gaps in health and climate change issues.	2015–2020	To provide a source of information for the management and monitoring of the impacts on health of climate change.	Establishment of a centre on climate change and health. Climate change and health research integrated into key action plans of the Ministry of Health, Ghana Health Service and other relevant institutions and civil society organizations.

6.3: Strengthen Climate-sensitive Disease Surveillance and Response Systems	To improve disease surveillance and response systems for the prevention and control of priority climate-sensitive diseases at all levels of national health systems	Integrate environment and health surveillance systems	2015–2020	To track environmental changes resulting from climate change and their associated effects on public health.	Standardized tools and protocols developed and validated. Capacity of relevant national institutions strengthened. Early warning system for management of environmental climate-sensitive risk factors established.
Programme 6.4: Improve Public Health Measures (immunization, drainage, sanitation and hygiene), especially in climate-vulnerable communities	To improve drainage, sanitation and hygiene services. To increase immunization coverage especially in vulnerable communities.	Establish collaboration and partnerships for improved drainage, sanitation and hygiene services.	2015–2020	To improve drainage, sanitation and hygiene services, so as to reduce the risk of associated diseases.	Drainage, sanitation and hygiene services improved Effective and sustainable waste management system established Integrated vector management
		Establish collaboration and partnerships for improved public healthcare delivery and immunization coverage.		Improve access to and coverage of healthcare services.	Improved immunization coverage. Improved access to health care services.
Programme 6.5: Emergency Health Preparedness and Climate-proof Health Infrastructure	To strengthen and operationalize the health-related components of disaster risk reduction plans.	Put mechanisms in place to reduce the number of casualties resulting from the health consequences of extreme weather events and to strengthen curative interventions to manage the acute health impacts of climate change.	2015–2020	Expected casualties resulting from the health consequences of extreme weather events are minimized or prevented.	Mechanisms established to coordinate emergency responses to climate change impacts on health. Guidance, tools and technical assistance available to mitigate identified impacts on public health associated with climate change. Health legislation developed for climate change and emergency preparedness.

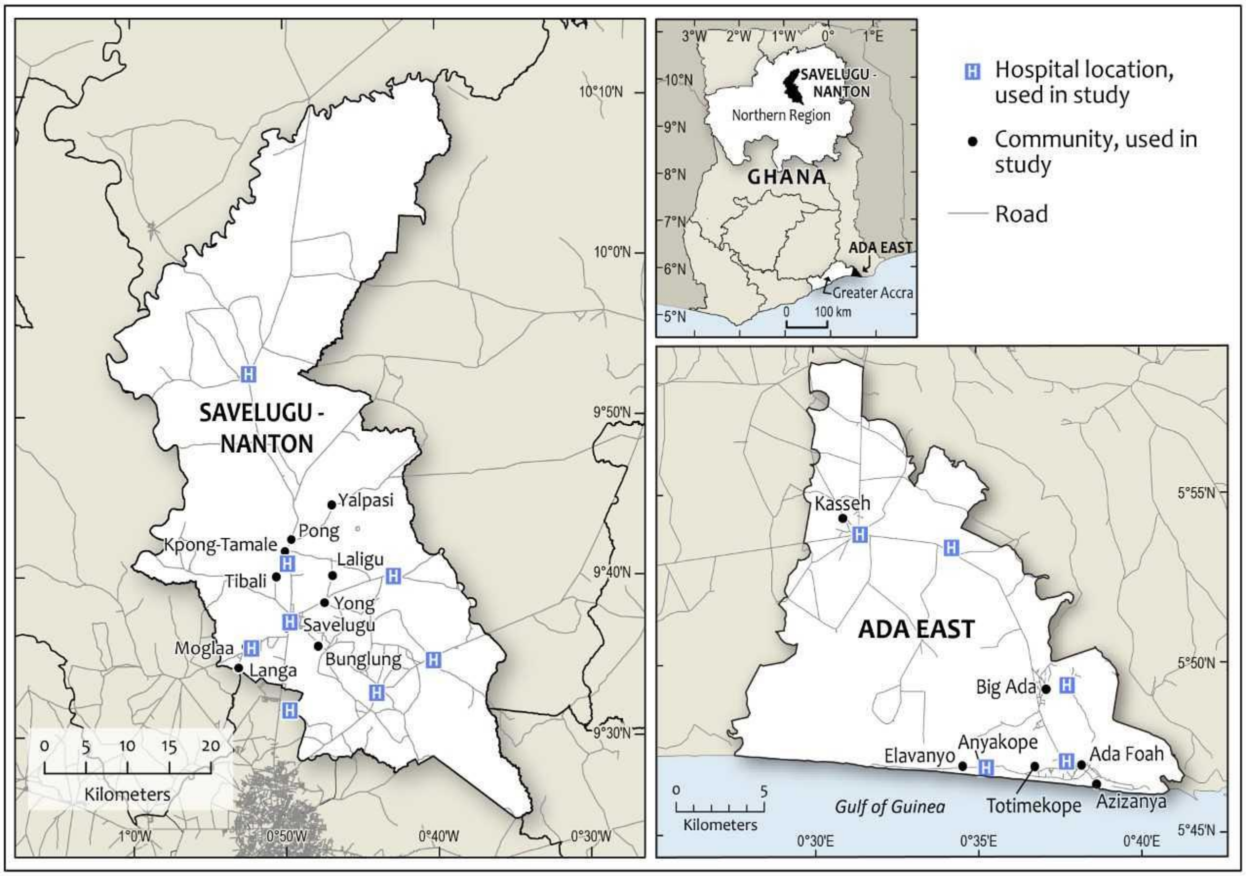
Programme 6.6: Collaboration and Partnership for Improved Nutrition, Water and Sanitation	To establish and strengthen multisectoral, intersectoral and multi-stakeholder processes for policy dialogue, coordination, planning and accountability To jointly implement public health adaptation interventions by the Ministry of Health and the Ministry of Environment, Science, Technology and Innovation, engaging other relevant sectors and stakeholders in accordance with the Libreville Declaration on Health and Environment in Africa. To establish mechanisms for collaboration, partnership and coordination with international bodies working on climate change adaptation and mitigation measures relevant to the health sector	Develop or strengthen platforms for intersectoral collaboration and policy dialogue with relevant ministries and institutions working on the availability of food and the management of water and sanitation.	2015–2020	To establish mechanisms to ensure that the health sector can interact at the policy level with other sectors to ensure appropriate implementation of appropriate adaptation measures.	Functional mechanisms in place for intersectoral collaboration and policy dialogue. Country task teams set up for the implementation of the Libreville Declaration, and other sectors strengthened to incorporate climate change and health risks and appropriate adaptation measures into action plans.
		Develop or strengthen platforms for collaboration and coordination with other countries and with international bodies.		To improve north-south and south-south collaboration, implement international frameworks, and mobilize funds and other resources to improve adaptation to risks and impacts posed by climate change on health.	Strengthened collaboration and partnerships with countries in the sub-region and beyond.
Programme 6.7: Social Protection and Improved Access to Health Care	To improve access to social protection programmes and improve the quality of health care.	Establish and strengthen universal, comprehensive social protection policies and strategies.	2015–2020	To develop a climate-resilient social environment that addresses inequities and inequalities in health issues	Universal, comprehensive social protection policies and strategies strengthened
Programme 6.8: Indigenous traditional knowledge and practices in health	Integrate indigenous traditional knowledge into formal health mitigation and adaptation strategies.	Adopt and integrate indigenous knowledge and practices concerning human health into national health care policies and strategies.	2015–2020	To create baseline data on indigenous knowledge and practices to inform health adaptation policies and strategies	Catalogue of indigenous traditional health practices and practitioners developed. Indigenous knowledge and practices adopted and integrate into health policies and strategies.

Source: MESTI (2015)

3.3 Overview of Study Areas

The study was carried out in two districts in Ghana: Savelugu-Nanton and Ada East located in the northern and southern parts of Ghana respectively (see Figure 3.2).

Figure 3.2: Map of Study Districts



Source: Data for study locations provided by Author.
Cartographer: Karen Vankerkoerle, Geography Department, Western University.

3.3.1 Savelugu-Nanton Municipality

The Municipality is one of the 28 administrative Metropolitan, Municipal and District Assemblies (MMDAs) of the Northern Region. The Savelugu-Nanton District was carved out of the Western Dagomba District Council, which comprised Tamale, Tolon and Savelugu in 1988 under the Local Government Act 462, 1993 by Legislative Instrument (LI) 1450. The District in March 2012 was upgraded to a municipal status and has its administrative capital at Savelugu (Savelugu-Nanton Municipal Assembly, 2018).

3.3.1.1 Location, Size and Population Characteristics

Located in the northern part of Ghana's Northern Region, the Savelugu-Nanton Municipality shares boundaries with West Mamprusi to the north, Karaga to the east, Kumbungu to the west and Tamale Metropolitan Assembly to the south. The Municipality has a total land area of about 2,022.6 km^2, and a population density estimated at 68.9 persons per sq. km. The total population of the district according to the 2010 Population and Housing Census of Ghana stands at 139, 283. The Municipality is predominantly rural with six out of every 10 residents located in rural areas (60.3%). The Municipality is composed of mainly Dagombas (88.4%) and Frafra (nearly one percent). The other ethnic groups are Mampurises, Ewes and Gonjas. Islam is the dominant religion, representing (95.4%) beside Christianity and other religions (GSS, 2014a).

3.3.1.2 Climate

The Municipality experiences a unimodal rainfall regime annually, mostly from late April–mid October. The Municipality receives an annual rainfall averaging 600mm, considered enough for a single farming season. The rainfall pattern is described as erratic at the beginning but sometimes intensifies as the season advances to raise the average from 600mm to 1000mm. Temperatures for the Municipality are usually high, averaging 34^{o}C, with the maximum as high as 42^{o}C and the minimum around 16^{o}C. The low temperatures are usually experienced during the dry season (known locally as Harmattan) from December to late February, during which the North-East Trade winds (Harmattan) greatly influence the Municipality (GSS, 2014a).

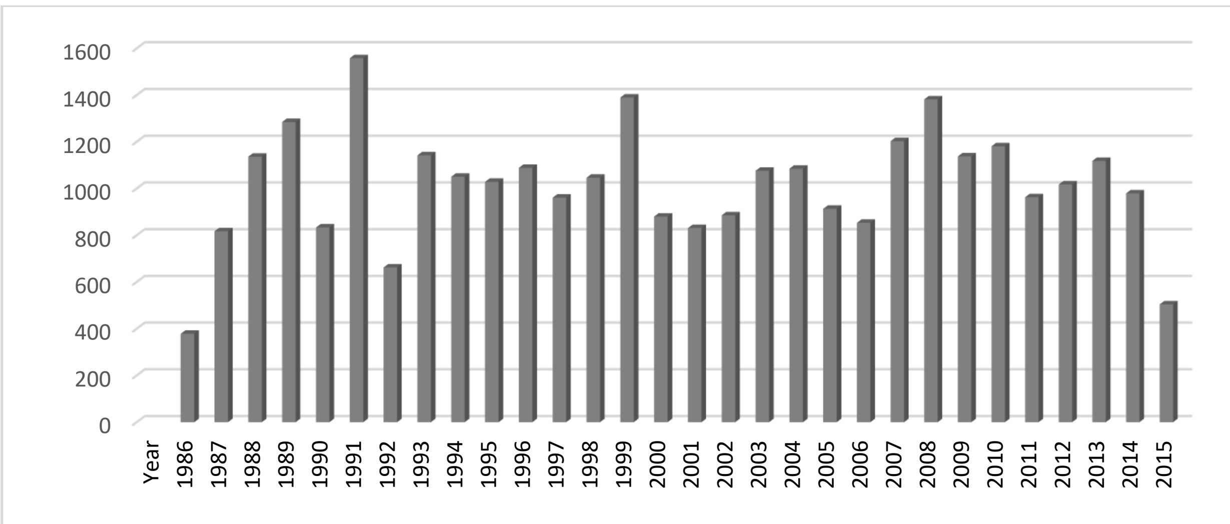
Current climate records indicate some variation for the Municipality (see Figures 3.3 and 3.4). The data consisted of monthly rainfall totals and mean minimum temperatures for the period 1986- 2015 and mean monthly maximum for 1986-2013[1]. Analysis of the data indicates temporal variability in climate data for the Municipality. Annual rainfall for the period 1986-2015 shows temporal surges and halts (Figure 3.3). The long-term (1986 to 2015) mean annual rainfall is (1,012mm), with the highest rainfall (1,557 mm) recorded in 1991. The years 1989, 1991, 1999,

[1] There were no rainfall data for January to June 1986, March 1992, November 1996, February 2011, and May and August 2015. Maximum mean monthly temperature was also missing for January 1986, March, May, June and August 1996, November 2004, September to December 2011, August to December 2012 and October to December 2013.

For minimum mean monthly temperature, data for January 1986, March 1992, November 1996, February 2011 and May and August 2015 were missing.

and 2008 recorded rainfall totals over 1,200mm, which was significantly above the normal annual average of about 1000mm when the rainfall season intensifies. Further analysis of the rainfall data indicates that the mean yearly amount of rainfall during the rainy season months (April to October) increased from 937mm during the decadal range of 1986-1995 to 977mm between 1996-2005. But a mean decrease of 7mm was observed for the decadal range 2006-2015 (970mm).

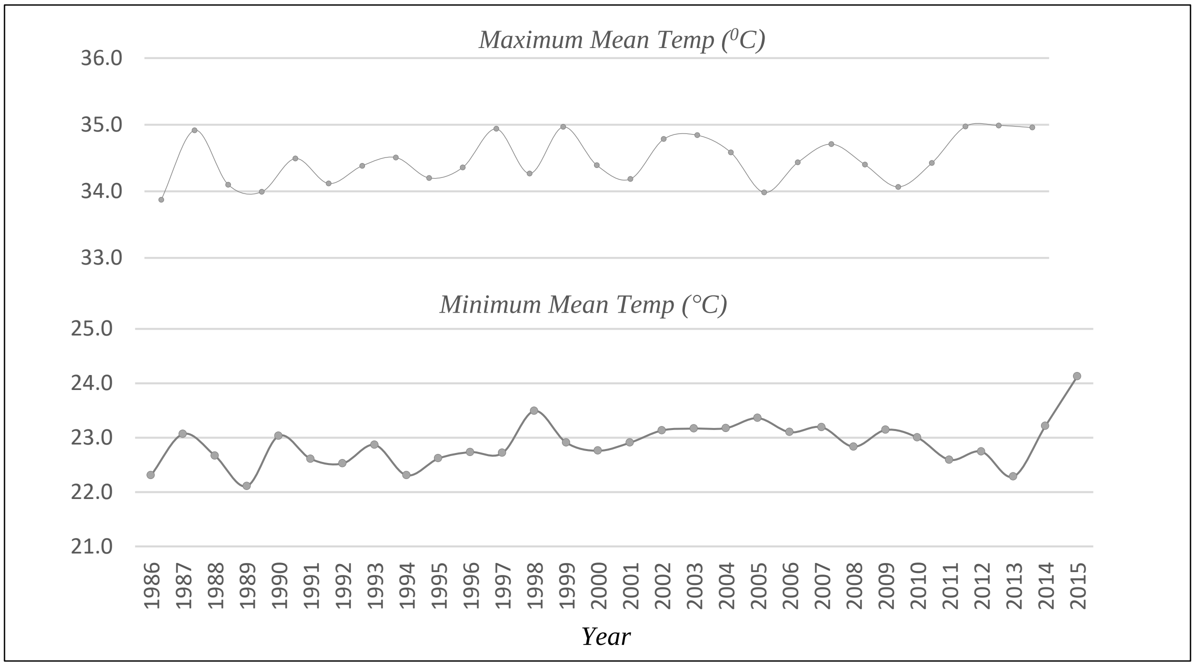
Figure 3.3: Total Annual Rainfall (mm) for Savelugu-Nanton Municipal Assembly (1986-2015)



Source: Author's analysis of data provided by Ghana Meteorological Agency (GMA) from Pong Tamale Station

The mean annual maximum temperature for the period 1986-2013 varies between 34^0C in 1989 to 35^0C in 1998, 2010, 2011 and 2012 (Figure 3.4). The mean maximum temperature shows a stable trend with figures ranging around 34^0C until 2009 when it started to rise. The mean annual minimum temperature for the period 1986-2015 varies between 22.1^0C in 1989, and 24.1^0C in 2015.

Figure 3.4: Maximum and Minimum Mean Temperature (°C) for Savelugu-Nanton Municipal Assembly



Source: Author's analysis of data provided by GMA from Tamale Station

3.3.1.3 Health

The Municipality is zoned into five sub-districts for health administrative purposes namely Diare sub-district, Nanton sub-district, Pong Tamale sub-district, Savelugu sub-district and Tampion sub-district. The major health facility in the Municipality is the Savelugu District Hospital which serves as a referral centre. Other health facilities in the Municipality include three health centres at Nanton, Diare, Pong-Tamale and five clinics at Janjori-Kukuo, Zoggu, Moglaa, Pigu, and Tampion. There are twelve Community-Based Health Planning and Service (CHPS) compounds at Nambagla, Dopali, Pigu, Kuldanaali, Nyolugu, Nanton Kurugu, Fazihini, Sandu, Gungtingli Bunglung, Nagdigu and Kukuobilla. There are fourteen operational CHPS zones at Dipali, Guntingli and Kuldalnaali, all under the auspices of the District Health Directorate (Savelugu-Nanton Municipal Assembly, 2018). Country profile mapping of neglected tropical diseases in Ghana shows that the Savelugu-Nanton Municipal has schistosomiasis, onchocerciasis, lymphatic filariasis and trachoma being co-endemic (GHS, 2016). Analysis of morbidity data for the period 2008 to 2015 on selected infectious diseases indicate that malaria has the highest disease burden in the Municipality followed by diarrhoeal diseases and typhoid fever (Table 3.4). As the top three infectious diseases are climate sensitive, any exacerbation of cases because of climatic changes would be a cause of concern to the health systems and human populations in the district.

Table 3.4: Morbidity Data for Prevalent Infectious Diseases in Ghana for Savelugu-Nanton Municipal

INFECTIOUS CASES	YEAR							
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Trypanosomiasis cases	0	0	0	0	0	0	0	0
Total OPD cases (Malaria)	50,241	75,518	77,087	72,537	93,798	95,622	91,835	87,555
Tuberculosis	3	1	2	4	30	18	0	12
Schistosomiasis (Bilharzia)	4	0	0	2	2	2	0	0
Onchocerciasis	0	0	0	0	3	0	0	0
Meningitis	2	3	3	0	0	0	0	0
Suspected Cholera	0	0	3	0	0	0	0	0
Measles	3	0	2	1	1	5	1	1
Trachoma	0	0	0	0	5	11	0	0
Suspected Guinea Worm	3	1	0	0	0	0	0	0
Yellow Fever (YF)	0	0	0	0	0	0	0	0
Diarrhoeal Diseases	4,069	6,950	7,438	5,209	7,561	7,410	9,305	8,969
Typhoid Fever	121	25	7	94	1,155	1,058	2,100	2,495

Source: Monitoring and Evaluation Department-Policy, Planning, Monitoring and Evaluation Division (PPMED), Ghana Health Service (Field work, 2016)

3.3.2 Ada East District

The Ada East District forms part of the twenty-six (26) MMDAs in the Greater Accra Region. The Ada East District formerly Dangme East District was created in 1989. Ada West (a new district) was carved out of Dangme East in June 2012, and a new district was established and known as Ada East with Ada Foah as the district capital. Other major settlements in the District include Big Ada and Kasseh.

3.3.2.1 Location, Size and Population Characteristics

Ada East District is situated in the eastern part of the Greater Accra Region. It is located between latitudes 5°45'S and 6°00'N and longitude 0°20'W and 0°35'E. Ada East shares boundaries with Central Tongu District to the north, South Tongu District and Ada West to the east and west respectively, with the south bounded by the Gulf of Guinea which stretches over 18km from Kewunor to Totope. The District is also bounded by the Volta River south–eastwards extending to the Gulf of Guinea southwards; forming an Estuary about 2 kilometers away from the District capital Ada-Foah. Ada East District has a total land area of about 289.78 square km. The 2010 Population and Housing Census put the population of the District at 71,671. About 70 percent (68.3%) of the population is in the rural areas while 31.7 percent resides in urban localities (Ada East District Assembly, 2018; GSS, 2014b).

3.3.2.2 Climate

Temperatures are high throughout the year and ranges between 23°C and 28°C, with a maximum temperature of 33°C typically attained during the very hot seasons. Rainfall is mostly heavy during the major seasons between March and September with an average of about 750 millimetres annually. The area is however very dry throughout the Harmattan season when there is no rainfall at all. Due to the proximity of water bodies (e.g., the Sea and the Volta River), humidity is about 60% high.

Existing climate records show temporal variability for the District (see Figures 3.5 and 3.6). The data consisted of monthly rainfall totals and mean minimum temperatures for the period 1986- 2015 and mean monthly maximum for 1986-2012 [2].

Analysis of the data revealed that in the Ada East District, total annual rainfall is characterized by tremendous temporal variability, with sporadic surges, and halts (Figure 3.5). The least amount of rainfall for the period 1986-2015 was recorded for 1992 (352mm), with the year 1991 recording the highest (1,289mm). Observed patterns indicate that the mean yearly

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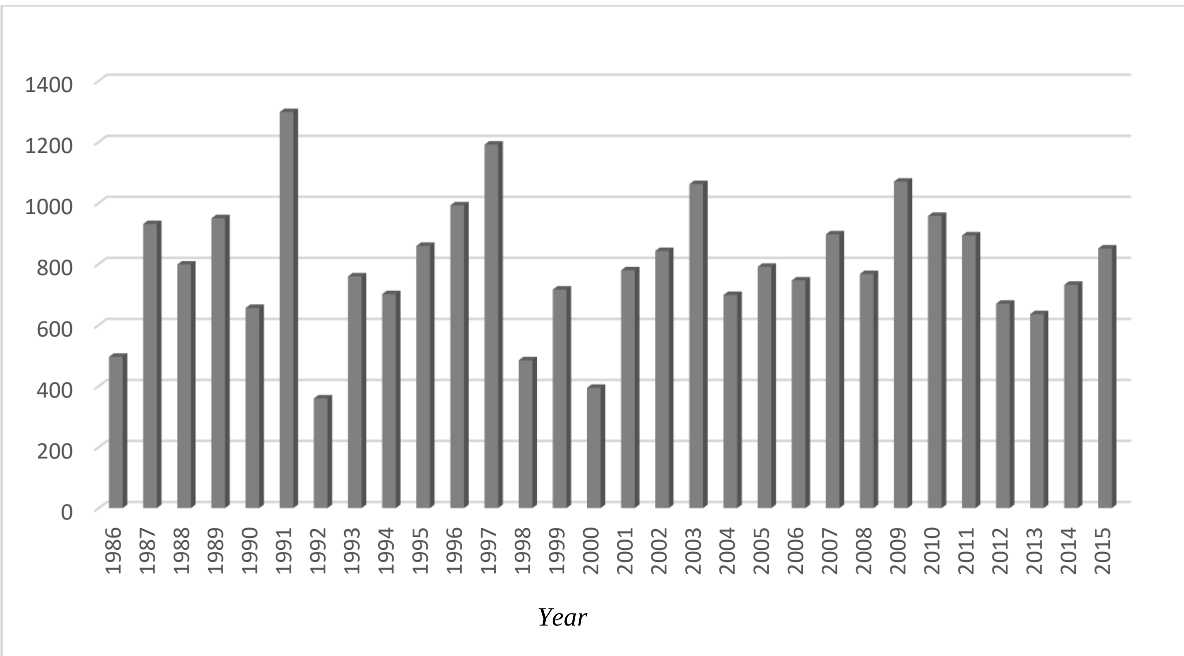
[2] Rainfall data for October 2014 and February 2015 were missing. For the monthly mean maximum temperature, data were missing for June 1986, September 1988, October 2011, January, February and October 2014 and February, April and September to December 2015. Data for September 1988, October 2011, and August to December 2012 were missing for the mean monthly maximum temperature.

amount of rainfall during the major rainy season months (between March to September) increased from 657mm during the decadal range of 1986-1995 to 676mm between 1996-2005, and 710mm through 2006-2015. This suggests the major rainy season may have become wetter, which can have implication for the survival of climate sensitive disease vectors such as mosquito by providing a breeding ground.

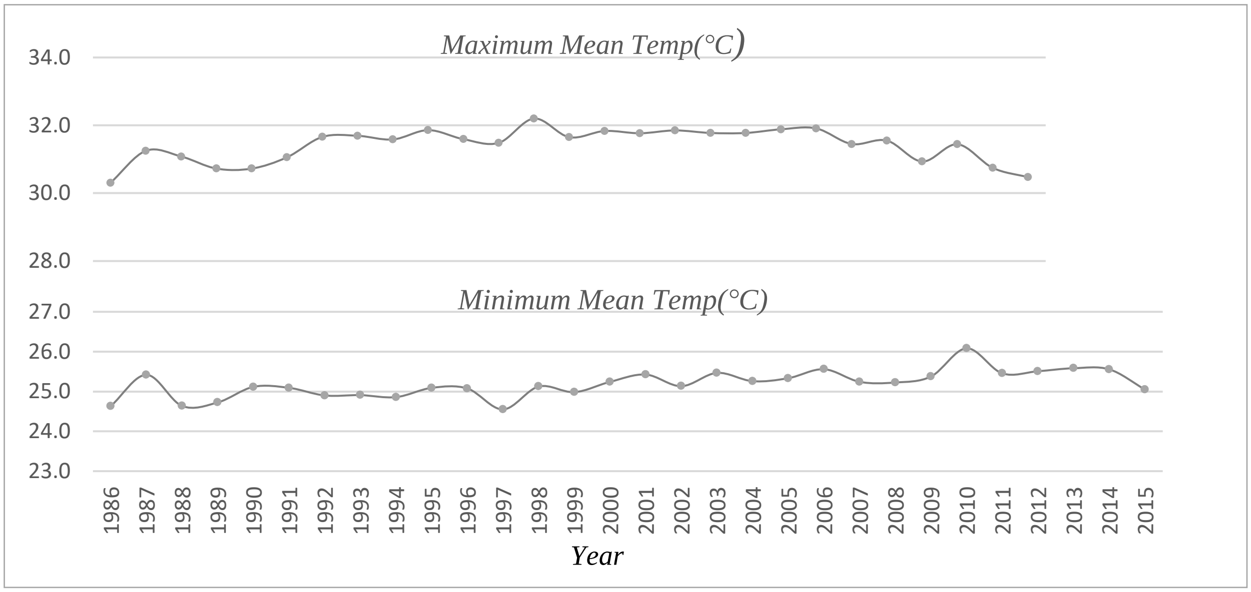
Figure 3.5: Total Annual Rainfall (mm) for Ada East District (1986-2015)



Source: Author's analysis of data provided by GMA from Ada East Station

The mean annual maximum temperature for the period 1986-2012 varies between 30.3^{0}C in 1986 and 32.2^{0}C in 1998 (Figure 3.6). The mean maximum temperature shows a stable trend with figures ranging around 31^{0}C. The mean annual minimum temperature for the period 1986-2015 on the other hand varies between 24.6^{0}C in 1986, 1988 and 1997, and 26.1^{0}C in 2010.

Figure 3.6: Yearly Maximum and Minimum Mean Temperature (°C) for Ada East District



Source: Author's analysis of data provided by GMA from Ada East Station

3.3.2.3 Health

The Ada East District Health Directorate which oversees the health issues in the Ada East District has thirteen health facilities under its jurisdiction comprising of 12 government facilities and a private facility. The District is divided into three administrative sub-districts as follows: Ada-Foah sub-district, Kasseh sub-district and Pediatorkope sub-district. There are currently two Health Centres in Kasseh and Ada-Foah, one Clinic at Pediatorkope, a District Hospital in Faithkope, and eight CHPS facilities at Anyakpor/Adedetsekope, Asigbekope, Pute, Azizanya, Agorkpo, Tei-Kpitikope, Dogo and Tamatoku (Ada East District Assembly, 2018). In addition to malaria which is of national scale, the District has neglected tropical diseases such as schistosomiasis also being endemic (GHS, 2016). Analysis of morbidity data for the period 2008 to 2015 on selected prevalent infectious diseases in Ghana indicate that malaria has the highest disease burden in the District, followed by diarrhoeal diseases and typhoid fever. Tuberculosis and schistosomiasis have also recorded some high numbers over the period (Table 3.5). From the morbidity data, the infectious diseases that are currently presenting the highest burdens are climate sensitive in nature. Hence, climatic changes may have repercussion on these prevalent climate-related diseases and they might pose further challenges to health systems and populations in the district.

Table 3.5: Morbidity data for Prevalent Infectious Diseases in Ghana for Ada East District

INFECTIOUS CASES/	**YEAR**							
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Trypanosomiasis cases	0	0	0	0	0	0	0	0
Total OPD cases (Malaria)	36,662	41,307	42,636	52,501	43,522	49,372	56,530	66,813
Tuberculosis	16	6	5	9	106	122	192	75
Schistosomiasis (Bilharzia)	51	193	20	34	18	9	22	27
Onchocerciasis	0	0	0	0	0	0	0	0
Meningitis	0	0	0	0	0	0	0	0
Suspected Cholera	0	0	0	0	0	0	3	0
Measles	0	3	0	0	0	0	0	0
Trachoma	0	0	0	1	5	4	0	0
Suspected Guinea Worm	0	0	0	0	0	0	0	0
Yellow Fever (YF)	0	0	0	0	0	0	0	0
Diarrhoeal Diseases	2,220	2,508	2,998	3,678	4,449	4,130	4,814	5,500
Typhoid Fever	339	496	452	301	368	228	30	295

Source: Monitoring and Evaluation Department-Policy, Planning, Monitoring and Evaluation Division (PPMED), Ghana Health Service (Field work, 2016).

3.4 Methodological Approach/Study Design

3.4.1 Mixed Methods Design

This dissertation employed a mixed-method design (combined qualitative and quantitative methods) and Multicriteria Evaluation Analysis (MCE) to achieve the objectives of this research. Specifically, quantitative data (surveys) and qualitative data (in-depth interviews) from primary sources were used in addressing the objectives one: To examine climate change-health knowledge among the public and health experts in Ghana; and two: Assess the preparedness and institutional capabilities of health systems and professionals towards climate change health risks in this dissertation, whilst quantitative data from both secondary and primary sources were used to address objective three (prioritizing climate sensitive infectious diseases for policy attention) of the research. This approach of using different methods to address the same research problem has been termed methodological triangulation (Morse, 1991). When a single research method is inadequate, methodological triangulation is adopted to ensure that the most comprehensive approach is adopted to address the research problem. Methodological triangulation enables obtaining complementary findings that strengthen research results and contribute to theory and knowledge development (Morse, 1991).

A mixed methods design is generally adopted when a researcher aims to reach solutions to research questions for which knowledge from both quantitative and qualitative methods are valuable, and either the quantitative or qualitative approach by itself is inadequate to best understand the research problem (Creswell, 2014). Due to its problem-solving ability, Johnson and Onwuegbuzie (2004) suggest that the primary philosophy of mixed methods research is pragmatism, with its logic of inquiry including “the use of induction (or discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one’s results)” (p. 17).

Johnson and Onwuegbuzie (2004: 17) define mixed methods research as “the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study.” Schensul, Schensul, and LeCompte (2013:155) also define mixed methods as the “serial or joint use of qualitative, quantitative survey, and quantified qualitative data collection methods to achieve a systematic understanding of both the magnitude and frequency of the phenomena (quantitative) under study and the context, meaning and motivation of those phenomena (qualitative)”. The adoption of mixed methods for examining climate change-health linkages in Ghana in this dissertation is informed by the advantages associated with the approach.

First, given the inherent complexity of the phenomenon of climate change-health nexus, usage of only one research method would not permit a deep understanding of the issues investigated in this dissertation. Mixed method is an expansive and creative form of research (Johnson & Onwuegbuzie, 2004). It enables answering of a broader and more complete range of research questions because the researcher is not confined to a single method or approach. The mixed method approach adopted in this dissertation provides the ability to expand the breadth and range of inquiry by using different methods for different inquiry components of the research

(Bryman, 2006). Quantitative methods provide data on magnitude and allows for quantitative predictions, whiles qualitative methods help in unearthing the complexities in the issues under study as it enables generation of rich, detailed, valid process data embedded in local contexts. Thus, using a mixed method approach in this dissertation offers me very rich and varied research data to help pry open multi-layered explanations and provide a comprehensive analysis of the research problem which might be missed when only a single method is used. Further, mixed methods also improve the reliability of research findings through complementarity (Greene, 2006; Bryman, 2006). That is, it enables elaboration, enhancement, illustration, and clarification of the results from one method with the results from another (Bryman, 2006).

Another advantage which mixed methods approach offer relates to providing stronger evidence for a conclusion through convergence and corroboration of findings (Bryman, 2006; Greene, 2006). Mixed method approach inherently has triangulation built into it due to the use of more than one method in investigating phenomena. This enables a researcher to seek convergence and corroboration of results from different methods and designs studying the same phenomenon. The overall purpose of employing a mixed method strategy in this study was to develop a better understanding of the linkages between climate change and health.

3.4.2 Multicriteria Decision/ Evaluation Analysis (MCDA)

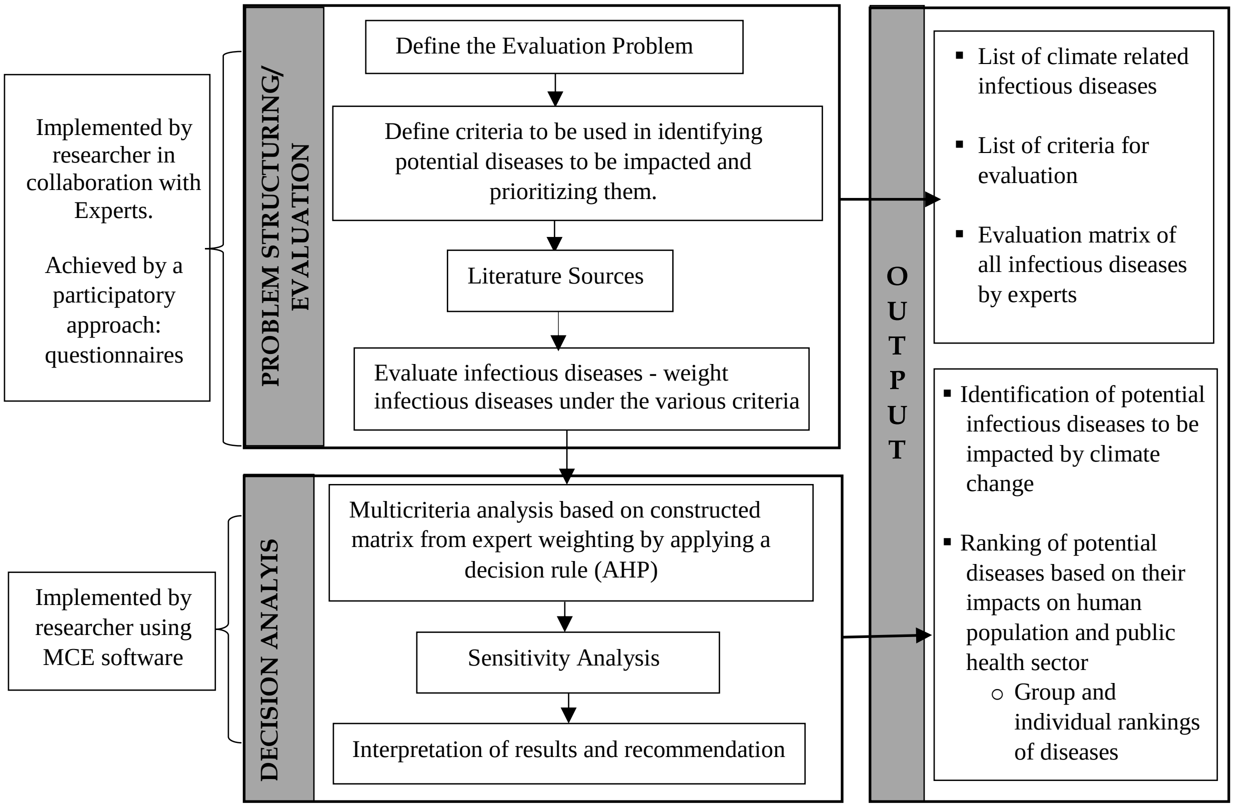
MCDA was used to address the third objective of this study. Multicriteria evaluation analysis (MCE) is used to evaluate climate sensitive infectious diseases based on multiple criteria and rank them in the presence of diverse criterion priorities. MCDA is an "umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter" (Belton & Stewart, 2002:2). MCDA is a family of techniques that aid decision makers in formally structuring multi-faceted evaluation/decisions problems (e.g. climate change impacts on infectious diseases) and evaluating decision alternatives on the basis of multiple, conflicting and incommensurate criteria, using decision rules to aggregate those criteria to rate or rank the alternatives and selecting the best alternative(s) in the presence of diverse criterion priorities according to the decision maker's preferences (Bah & Tsiko, 2011; Greene, Devillers, Luther, & Eddy, 2011; Malczewski & Rinner, 2015). MCDA aids people in making complex decisions and has evolved as a response to the observed inability of people to efficiently analyse multiple streams of diverse information (Baltussen & Niessen, 2006). MCDA as an aid to decision making or an evaluation procedure is a process which seeks to incorporate objective measurement with value judgement and also make explicit and manage subjectivity (Belton & Stewart, 2002).

The nature of multiple criteria problems comprises information of a complex and conflicting nature, normally reflecting differing viewpoints or options. One of the principal objectives of multicriteria evaluation and decision analysis methods is to help decision makers organise and synthesize such complex and conflicting problem information and further helping to minimize the potential for post-decision regret by being satisfied that all criteria or factors have properly been considered (Belton & Stewart, 2002). As a result, the fundamental principle of multicriteria decision making is that decisions should be made by use of multiple criteria (Cheng, Li, & Yu, 2005).

A vital strength of multicriteria evaluation /decision analysis is the ability to incorporate multiple stakeholder and experts' perspectives as well as uncertain, subjective and qualitative information into an explicit and transparent decision-making process (Hongoh et al., 2011). In the absence of quantitative data for a criterion in an explicit context to allow data-driven evaluation, multicriteria evaluation/ decision analysis methods allow for the integration of qualitative evaluations, for example based on expert opinion in the field under assessment.

MCE models were developed to assess various climate related infectious diseases in Ghana such as malaria, cholera, and schistosomiasis, and facilitate identification of those most likely to be a threat to public health in the country under climate change through expert assessment and judgement that would inform regulators and guide policy decision making process. MCE approach was used to prioritize climate sensitive infectious diseases through expert assessment based on their cumulative threat and burdens to populations and health systems using multiple criteria (e.g. disease burden, and ability of health sector to control diseases). Chapter 6 presents a detail account of the disease prioritization procedure; however, Figure 3.7 provides the general steps of the MCE procedure that guided this research.

Figure 3.7: General Steps of Multicriteria Evaluation Procedure and Outcomes



Source: Author

The Analytic Hierarchy Process (AHP) is applied as a decision rule in the prioritization process. AHP is a multicriteria method for decision-making in complex settings, and it aims at supporting decision-making processes in individual and group contexts by aiding decision makers in structuring their priorities. The major feature of AHP is that it makes explicit a variety of tangible and intangible goals, attributes and other decision elements (Malczewski, 1999). In addition, it reduces complex decisions to a series of pairwise comparisons and implements a structured, repeatable and justifiable decision-making approach (Saaty, 2005). More specifically, in AHP, the evaluation of the alternatives against the criteria considers both subjective and objective information in order to determine the preferred option among the alternatives.

The choice of AHP over other MCDA methods is underpinned by its simplicity, versatility, transparency and its ability to account for the objective and subjective aspects considered by the decision maker. A significant advantage that AHP has relative to other methods is its practicability to consider decision processes adequate to reality; that is, with multiple actors (Ossadnik, Schinke, & Kaspa, 2016). The AHP method also compares and evaluates both the criteria and the alternatives. It is a very simple and intuitive method in which one evaluation only is required of the decision-maker at a time to express the level of preference between two options of criteria using a scale (Saaty, 2005). However, there are usually many pairwise comparisons required during the evaluation, which must be completed by the decision maker. Another strength of AHP method is that, it checks the consistency of the responses of the decision maker through a consistency index. Essentially, AHP is an empirical process more concerned with using information from a decision maker in its simplest and most natural form (Saaty 2005) and as such, easily usable.

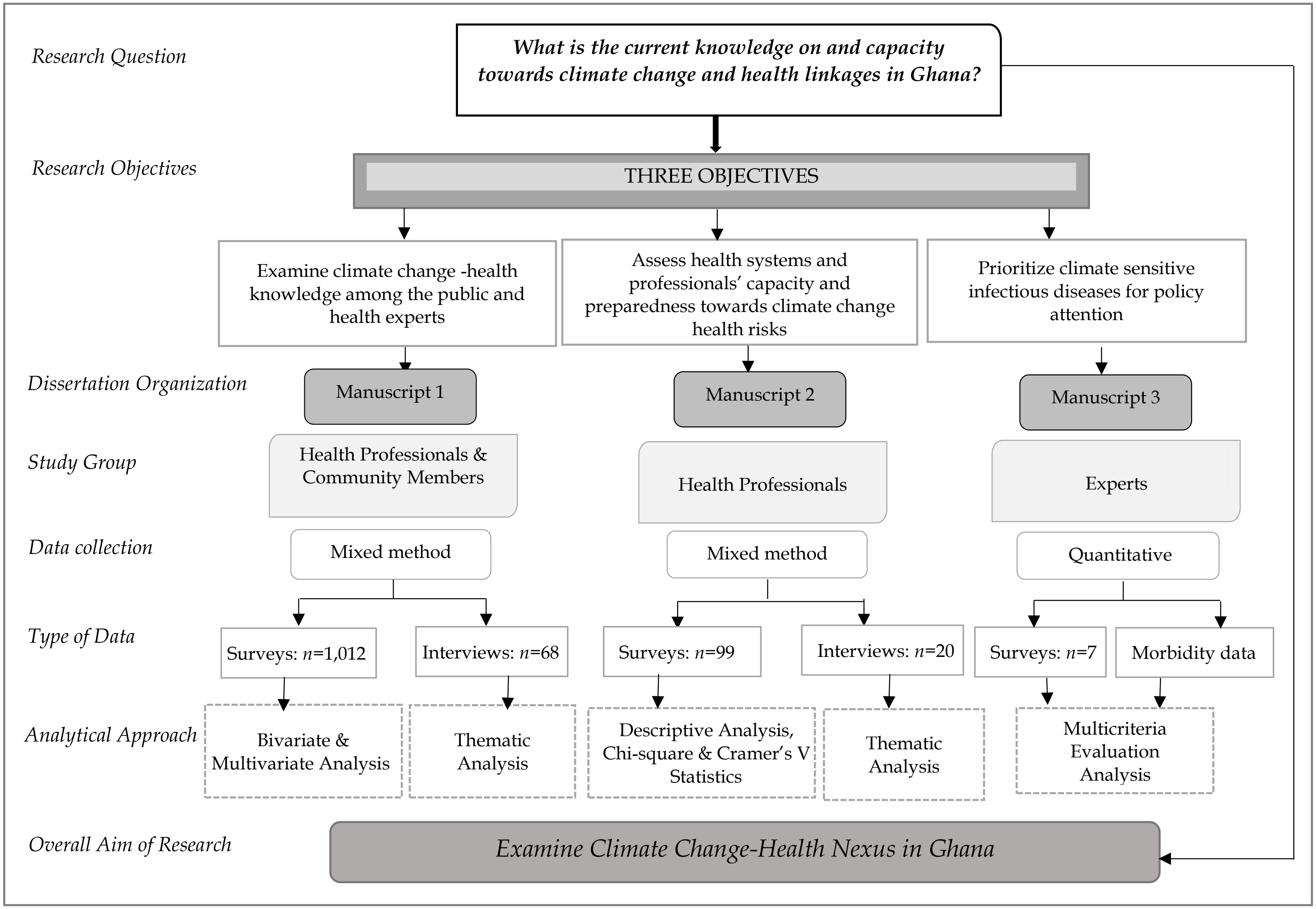
3.4.3 Data Collection and Method

Prior to recruitment and data collection, the research procedures received ethical approval from the Non-medical Research Ethics Board of Western University and by the Ghana Health Service Ethical Review Committee (see Appendices A & B). Data collection took place between May and October 2016.

A concurrent mixed-method design of gathering data using both quantitative and qualitative techniques was employed. Both secondary and primary data were collected and used in answering the objectives of this study. Secondary data consisting of morbidity data for climate sensitive infectious diseases in Ghana was obtained from the Monitoring and Evaluation Department-Policy, Planning, Monitoring and Evaluation Division (PPMED) unit of the Ghana Health Service.

Data collection for this study was done in collaboration with a team of six Research Assistants (RA) split into three each for both study areas. RAs were recruited with the help of a Senior Lecturer at the Department of Geography and Resource Development, University of Ghana. All RAs had tertiary education and were either natives of the study region or residents within the study areas. These criteria were adopted to enable RAs to provide intimate knowledge of the study districts. RA’s in each study district were trained on interviewing skills regarding culturally and ethically appropriate ways to ask the research questions and familiarized with the survey questionnaire and the research objectives. During the training sessions, the survey questions were thoroughly discussed, and process of translating the questions into the local dialects (ensuring quality and consistency in translation) was also carried out. RAs were given time to play-act the interview process, learning how to build rapport with participants, and become fluid in their questioning. Survey questionnaires were then pretested among ten community members each in the two study areas for clarity (feedbacks on question structure) and context (how to make it culturally appropriate) with edits made where applicable. Of the six RAs, one was selected from each study area to help with the qualitative aspect of the study based on ability to fluently translate the local language for the area to English and vice versa. This skill was needed because the RAs needed to understand the researcher's intentions with every question so that translation could be done accurately. RAs all signed confidentiality agreements that adhere to Western University's research ethics guidelines. All research participants provided either oral or written consent. Figure 3.8 provides a research overview for this dissertation.

Figure 3.8 Research Overview



3.4.3.1 Quantitative Data Collection

Primary quantitative data was collected through a survey instrument (questionnaire). Questionnaires are an effective technique for collecting standardized data categories to answer a set of predetermined questions (Bird, 2009). Questionnaires were administered to community members (*n*=927), health professionals (*n*=99) and among experts involved in the MCE process (*n*=7). Different surveys were designed for each category of respondents but with overlapping aspects on climate change and health issues for the community members and the health professionals. The survey collected information on various demographic and socioeconomic aspects of individuals and households.

Community surveys were administered to residents in the two study districts (*n*= 426 for Ada East; *n*=501 for Savelugu-Nanton). The survey was designed to collect information on perceived knowledge on climate change and health linkages, adaptation measures, individual adaptive capacities and demographic characteristics.

A total of 99 health professional's questionnaire were administered (Ada East *n*=52; Savelugu-Nanton; *n*=47). Heath professionals' survey was designed to elicit information on climate change health links, perceived knowledge towards potential health impacts of climate change in the context of infectious diseases, adaptation measures in place to deal with any climate change impacts, their adaptive capacities and barriers and constraints to their adaptation measures.

The experts' questionnaire collected information for evaluating the potential impacts of climate change on infectious diseases in Ghana as well as prioritizing the diseases based on various criteria. The survey instrument also included questions about planning, preparedness, and surveillance. The experts comprised individuals with a background and speciality in public health as well as climate change issues. The sampling approach used in recruiting respondents for the quantitative studies is explained in more detail in Chapters 4, 5 and 6.

3.4.3.2 Qualitative Data Collection

The qualitative data collection phase of this research employed in-depth interviews. In-depth interview is a conversational research technique which involves conducting intensive individual interviews with respondents to explore their perspectives on a particular issue, program, or situation in order to achieve a holistic understanding of the interviewee's point of view (Boyce & Neale, 2006).

In-depth interviews were utilized in this research to gain a deeper insight into the participants understanding of the capabilities and readiness of the health systems and practitioners to address extra health burdens from climate change. It was also meant to ascertain their perceptions and knowledge on climate change-health linkages in Ghana. A purposive sampling technique was used to recruit interview participants. Interviews continued until the point of saturation (Baxter & Eyles, 1997). A total of 20 interviews were conducted with health practitioners: 12 in Savelugu Nanton-Municipal and eight in Ada East District. Additionally, 48 interviews were done with community members: 28 in Savelugu Nanton-Municipal and 20 in Ada East District. All interviews were audio recorded with respondent consent for transcription and analysis. The interviews were carried out in various locations that were convenient for the participants, including homes, and hospitals. On average each interview took about 40 minutes.

3.4.4 Data Analysis

Data analysis was carried out separately for the quantitative and qualitative data, with the findings integrated at the discussion section of each study manuscript. Quantitative data involving surveys (questionnaire) was analysed at three different but related levels using *STATA 14 SE* data analysis and statistical software. Descriptive, bivariate and multivariate analysis was done on study variables. The detailed statistical description and analysis is provided in Chapters 4 and 5.

Qualitative data was analysed to provide context (i.e. to provide contextual understanding of findings uncovered through the quantitative analysis), complement the quantitative findings, as well as unearthing details not captured by the quantitative data. Interview transcripts were manually coded and summarized using key themes that emerged.

Data analysis for the MCE aspect of this study was done using the multicriteria evaluation software *SuperDecisions* (Creative Decisions Foundation, 2018). The analysis focused on prioritizing climate sensitive infectious diseases under climate change by identifying those with the greatest disease risks and threats to human population and health systems to enable planning preventive and control measures. In addition, identifying set of criteria that are important for consideration in prioritizing climate sensitive infectious diseases under climate change in Ghana based on experts' assessment.

3.5 Summary

This chapter provided the broader study context within which the dissertation is situated. The chapter described the geographic location and climatic conditions for Ghana and the study districts, and climate change and health policy context for the country. This is followed by a discussion of the methodological approach guiding the investigation of climate change health nexus in Ghana and the data sources on which this dissertation relies. Justification for employing a mixed methods approach is provided.

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CHAPTER FOUR

CONCEPTUALIZATIONS OF CLIMATE-RELATED HEALTH RISKS AMONG HEALTH EXPERTS AND THE PUBLIC IN GHANA

Abstract

One major area that has gathered public attention in relation to climate change is health risks. Studies into risk perceptions have acknowledged differences between public and expert knowledge. What is less known is how perceptions of climate change related health risk varies between the public and health experts and how these differentiated perceptions are shaped and modified by everyday complex climate change narratives from multiple actors, and contextual ecologies of social and physical spaces. A concurrent mixed-methods approach was used to elucidate climate change knowledge and awareness of climate-related health risks among health experts and the public. Qualitative and quantitative data were collected on community members (n=927) and health experts (n=99) in Savelugu-Nanton and Ada East Districts in Ghana. The results showed that both groups were likely to report climate change-related health concerns, top among which was diseases. However, differences exist in public and experts' perceptions of climate change health linkage. Community members were less likely to link climate change to health risks compared with health experts ($OR=0.02$, $p \leq 0.000$). The contrasting climate change health risk perceptions between health experts and the public adds to the literature on the health dimensions of global environmental change. The findings from this study highlight limited knowledge about climate change health related risks among the public. Hence, in building sustainable communities in light of persistent climate change impacts, it is crucial to improve climate change adaptation by implementing climate change sensitization programs. In addition, health infrastructure, decision-making and management should be strengthened for effective response to emerging climate-health risks in Ghana and similar contexts.

4.1 Introduction

Climate change is arguably one of the most pressing environmental challenges in recent history. Currently, the impact of climate change on human health has garnered public and policy attention. The health effects of climate change comprise changes in the prevalence and spread of infectious diseases, geographic expansion and range shifts in disease distributions, projected increases of vector-borne and diarrhoeal diseases, emergence of new infectious diseases and re-emergence of old ones (Costello et al., 2009; IPCC, 2014; WHO, 2008). The World Health Organization (WHO) has suggested that between 2030 and 2050, climate change impact is expected to cause approximately 250,000 deaths per year, largely from malnutrition, malaria, diarrhoea, dengue, coastal flooding and heat stress (WHO, 2014). Furthermore, the increased climatic changes being experienced is contributing to the emergence of infections carried out by mosquitoes such as Zika and Chikungunya (Asad & Carpenter, 2018). A 2018 Lancet report has also highlighted that, altered climatic conditions are contributing to growing vectorial capacity for the transmission of dengue fever by *Aedes aegypti*, of 3.0% compared with 1990 levels, and 9.4% compared with 1950 levels (Watts et al., 2018). Watts et al. (2018) further report about an increasing exposure to frequent and more intense heat waves; it is estimated that between 2000 and 2016, the number of vulnerable people exposed to heat wave events increased by about 125 million, with a recorded 175 million more people exposed to heatwaves in 2015. With these projected and current risks, climate change has been emphasized as a significant threat to public health and likely, the most pressing problem of the 21st century (WHO, 2009; Costello et al., 2009; Watts et al., 2018). The projected impacts of climate change on health will not only burden human populations, but also health systems.

Climate change adaptation has emerged as a key strategy, often employed to cope with anticipated climate change risks (IPCC, 2014). However, there are questions about the extent to which local populations understand climate change information provided by multiple stakeholders, and their capacity to utilize such information in developing sustainable climate change adaptation mechanisms within their socio-cultural spaces. As suggested by Capstick et al. (2015) and Shi et al. (2016), knowledge and awareness of climate change and its consequences are important in developing adaptation strategies against its potential risks. Yet, understanding climate change information and translating it into actionable mechanisms has been a major challenge. Yu et al. (2013) acknowledge this challenge as a major barrier to the development of climate change knowledge and adaptation among local populations in China. In furtherance of this, other studies have explained peoples' adaptive behaviour as a reflection of their knowledge, perception, and attitude towards climate change risks (Baptise, 2017; Rudiak-Gould, 2012). Thus, knowledge and awareness of climate-related health effects is crucial in building adaptation against health risks.

In recent years, some researchers have assessed public perceptions of climate-related health risks (e.g., Cardwell & Elliot, 2013; Dana et al., 2015; Kabir et al., 2016; Maibach et al., 2015), while others have extended the analysis to compare lay persons and experts' perceptions of the causes of climate change and risk assessment. For instance, Weber and Stern in their 2011 study in the United States found disparities in climate change knowledge between lay persons and experts. They assert that lay people's mental models of climate change and its causes often diverge from those of experts (Weber & Stern, 2011). Studies into risk perceptions have also acknowledged differences between public risk assessment compared to those of professionals, scientists and experts (Hansen et al., 2003; Kellstedt et al., 2008). Although studies on climate change risk perception is prevalent in the literature, few have contrasted the views of health practitioners and the general public (Hathaway & Maibach, 2018).

Thus, the main purpose of this study is to examine knowledge and awareness of climate-related health risks in Ghana, comparing the views of health experts and the general public. For developing countries like Ghana, climate change-health risks are of concern. Currently, they are projected to carry a greater burden and risk being overwhelmed with multiple health issues (Costello et al., 2009). Despite Ghana's vulnerability to climate-related health risks, studies that have assessed public knowledge and perceptions of climate change-health linkages are limited (Codjoe & Nabie, 2014; Codjoe & Larbi, 2016). The goal of this study is to provide a nuanced understanding of perceptions of climate change-health linkages between health experts and the public in Ghana. In our investigation, we aim to answer the following research questions:

1. What are the perceptions on climate-related health risks in Ghana?
2. How do these perceptions differ between health experts and the general public?
3. What factors predict perceptions and knowledge of climate-related health risks in Ghana?

The research questions are examined by using both quantitative and qualitative data from investigation carried out in two different ecological zones in Ghana. The rest of the paper is organized as follows: In the next section, we briefly present an overview of the conceptual dimensions as it relates to climate change risk perception, the study area and methodology, followed by the study findings, discussion, and conclusion.

4.2 Theoretical framework: Predictors of Climate Change Risk Perceptions

Knowledge of climate-related health risks are important for health practice and climate change policy, such as designing effective climate change health risk communication strategies. According to Read et al. (1994: 971), “risk communication will be most successful and efficient when it is directed toward correcting those knowledge gaps and misconceptions that are most critical to the decisions people face.” Perceived risk has a prominent role in health behavior theories and interventions. Several theories have been proposed to explain why different individuals make dissimilar approximations of the danger of risks. Risk perceptions of climate change are complex and influenced by a multitude of cognitive, affective, social, cultural, and socio-demographic factors (Helgeson, van der Linden, & Chabay, 2012). In line with these conceptual dimensions, van der Linden (2015) advanced a detailed social-psychological model of climate change risk perception by combining and integrating them. The model termed Climate Change Risk Perception Model (CCRPM) integrates four conceptual dimensions in explaining and predicting holistic risk perceptions of climate change. These dimensions are cognitive, experiential, socio-cultural and socio-demographic factors. Drawing from the cognitive and the socio-demographic dimensions outlined to be critical in explaining public risk perceptions of climate change from the CCRPM, this study evaluates the extent to which these dimensions predict perceptions of climate change as a health risk in two districts in Ghana.

van der Linden (2015) suggests that, to estimate the probability with which climate change is likely to occur and the severity of accompanying consequences, some knowledge of these factors must be first acquired. The cognitive dimension of climate change risk perception considers the fact that if an individual has no awareness about the climate change problem, then they are unlikely to form a judgement about it (van der Linden, 2017). Thus, knowledge about climate change is regarded as a cognitive aspect of risk judgments (Sundblad et al., 2007). Lee et al. (2015) have reported that understanding climate change as human-caused was an important predictor of public risk perception worldwide. Shi et al. (2016) found that different forms of climate change knowledge were significant predictors of climate change risk perceptions across continents. Other studies (Kellstedt et al., 2008) have also provided counter arguments, suggesting knowledge to be negatively associated with risk perceptions of climate change. Knowledge under the cognitive dimension can be measured in different ways: public knowledge about the causes, impacts, and responses to climate change (van der Linden, 2015). Within this current study, knowledge about the causes of climate change is measured.

In the climate change risk perception literature, there has been a mixed evidence regarding the extent to which socio-demographic and social-structural factors account for climate change risk perception (van der Linden, 2017). For instance, even though some studies found that higher education predicts stronger risk perceptions of climate change (e.g., Lee et al., 2015; van der Linden, 2015), other studies reported no education-effect (Akerlof et al., 2013; Kellstedt et al., 2008; O'connor, Bard, & Fisher, 1999). Results also vary for age, with some studies revealing a negative correlation between age and climate change risk perception (Kellstedt et al., 2008; Milfont, 2012), while others find no significant relationship (O'Connor et al., 1999; Sundblad et al., 2007). It has also been documented that females tend to have higher risk perceptions than males regarding climate change (e.g., O'Connor et al., 1999; Sundblad et al., 2007). Despite these mixed evidence regarding socio-demographic and social-structural factors, gender, political ideology and race have been identified as stable predictors of risk perception. Drawing insights from these previous studies, some theoretically relevant socio-demographic factors are evaluated in this study to determine their influence on perceiving climate change as a health risk in Ghana.

4.3 Study Setting

The geographical focus of this study is the Savelugu-Nanton and Ada East Districts in Ghana that are located in different ecological zones, the northern and southern parts of Ghana and experience different climatic conditions. The Savelugu-Nanton Municipality is located in the northern part of Ghana's Northern Region. It shares boundaries with West Mamprusi to the North, Karaga to the East, Kumbungu to the West and Tamale Metropolitan Assembly to the South. The Municipality has a total land area of about 2,022.6 km^2 with a population density of 68.9 persons per km^2 (Ghana Statistical Service, 2014a). The Ada East District on the other hand, is situated within the eastern part of Ghana's Greater Accra Region, with a total land area of 289.783km^2.

The District shares boundaries with the Central Tongu District to the North, South Tongu District and Ada West to the East and West respectively. It is also bounded by the Volta River south–eastwards, extending to the Gulf of Guinea southwards (Ghana Statistical Service, 2014b). Key facts about each of our study districts are presented in Table 4.1.

Seasonal variations in temperature in Ghana are greatest in the northern part of the country, with highest temperatures in the hot, dry season (February to May) averaging 27-32^{0}C, while the lowest (25-27^{0}C) is recorded in July through September. However, in the southern part of the country, temperatures range between 22^{0}C to 28^{0}C (McSweeney et al., 2012; Stanturf, et al., 2011). Rainfall variability increases in the north, while rainfall amount decreases from the southern to the northern part of the country. The wettest zone is the southwest corner of the country, where annual rainfall reaches 2000mm. In contrast, the annual rainfall in the dry savannah zone in the northern part of the country is well below 1100mm (EPA Ghana, 2011). Recent projections of climate change impacts in Ghana vary between the southern and northern part of the country (McSweeney et al., 2012; Stanturf et al., 2011). National mean annual temperature is projected to increase by 1.0 to 3.0°C in the 2060's, and 1.5 to 5.2°C in the 2090's (McSweeney et al., 2012). The northern part of the country is expected to experience more dire impacts. For instance, the rate of warming is projected to rise more rapid in this zone than the coastal regions (McSweeney et al., 2012). These variations in climatic conditions and projections are likely to have different implications for health outcomes, thus influencing the choice of districts from both sectors of the country for this study. In addition, the selection of districts from different geographical zones in Ghana is to help account for any potential 'differentiated' perspectives on the links between climate change and health within the country. Curtis and Oven (2012) have advocated for such a perspective to help in capturing diverse factors that might induce health vulnerabilities and affect resilience towards climate change among individuals.

Table 4.1: Key Facts of Study Districts

	Savelugu-Nanton Municipal	**Ada East District**
Population	139,283	71,671
Total Land Area	2022.6 sq. km	289.783 sq. km
Rural Urban Status	60% rural	68.3% rural
Climate	- Average annual rainfall of 600mm. which sometimes rises to 1000mm. - High temperatures with average temperature of 34ºC, a maximum of 42ºC and a minimum as low as 16ºC (The low temperature is experienced during harmattan)	- Rainfall is normally heavy with average of about 750mm - Temperatures are high throughout the year. Ranges between 23°C and 28°C with a maximum temperature of 33°C (attainable during hot seasons). - Area very dry during the harmattan season when there is no rainfall. - Humidity is about 60 percent high due to water bodies around.
Vegetation	The municipal is in the Savanna woodland which could sustain large scale livestock farming, as well as the cultivation of food crops such as rice, groundnuts, yams, cassava, maize, cowpea and sorghum	The vegetation is basically the coastal savannah type, characterized by short savannah grasses and interspersed with shrubs and short trees. Along the coast, there are stretches of coconut trees and patches of coconut groves. A few strands of mangrove trees can be found along the tributaries of the Volta River where the soil is waterlogged and salty.
Top 10 Diseases 2015 *(listed in order of magnitude)*	Malaria, Upper Respiratory Tract Infection, Anaemia, Pneumonia, Urinary Tract Infection, Diarrhea, Hypertension, Joint pains, and skin diseases ****	Upper Respiratory Tract Infection, Malaria, Diarrhoea, Rheumatism & Joints Pain, Skin Diseases, Intestinal Worms, Acute Urinary Tract Infection, Anaemia, Acute Eye Infections, Septicaemia. ***
Health Facilities	14 Operational Community-Based Health Planning and Service (CHPS) zones, 12 CHPS compounds, 3 Health Centers, 5 Clinics, and a District Hospital **	8 CHPS facilities, 3 Health Centers, 1 Clinic, and a District Hospital***

Source of information:

** Savelugu-Nanton Municipal Assembly (2018)
***Data from the Ada East District Assembly (2017)
**** Data obtained from Savelugu-Nanton District Hospital (Fieldwork, 2016).
All others: Ghana Statistical Service 2014, (2010 Population and Housing Census District Analytical report for Ada East District and Savelugu-Nanton Municipal).

4.4 Methodology

This study uses data collected through a concurrent mixed-method research design (Bryman, 2006). Quantitative approach (surveys) and qualitative approach (face-to-face in-depth interviews) are used to address overlapping but also different facets of climate change and its health linkages, as well as enrich and deepen our understanding of the complexities of the linkages (Creswell, 2014). The study protocol was approved by the authors' institution and in Ghana by the Health Service Ethical Review Committee. All research participants provided either oral or written consent.

4.4.1 Data Collection

The sample was drawn from the adult population residents in both districts and comprised of individuals aged 18 years and above. Total respondents of the study consist of 1,026 individuals (i.e., n=99 health practitioners; n=927 community members). The overall sample consists of 526 males and 500 females, with age ranging 18-70 years. The study employed a two-staged stratified sampling framework (Onwuegbuzie & Collins, 2007) in recruiting community members. The population was grouped into two strata (urban and rural) based on Ghana Statistical Service's definition of rural areas (population less than 5,000) (Ghana Statistical Service, 2015). Simple random sampling was used to select study communities and households from them for interviews. For health practitioners, government health institutions within both study districts were identified, and public health practitioners were sampled from them and interviewed.

Qualitative interview respondents were purposively selected from the larger quantitative survey sample. Qualitative data were collected to a point of saturation, after which the themes already captured were being repeated in subsequent interviews (Cresswell, 2014). Interviews consisted of semi-structured questions that allowed exploration of new ideas in every new interview. Participants were asked to describe and reflect on climate change, impacts and links to health and any potential health implications they know. Participants in qualitative interviews consist of 68 individuals (health experts, n=20; community members, n=48). The overall sample consists of males (n=45) and females (n=23), with age ranging from 25 to 65 years.

4.4.2 Data Analysis

4.4.2.1 Quantitative Analysis

Climate change knowledge is of different forms and consist of either an individual's 'subjective' knowledge (i.e., what people think is true) and the actual 'evidence'. It is assessed either subjectively (self-reported knowledge) or objectively ('accurate' knowledge people hold about climate change). Climate change knowledge evaluated in the literature include public knowledge about the causes, impacts, and responses to climate change (van der Linden, 2015). In this study, objective knowledge about climate change was measured because it provides useful connections to policy on health-related risk of climate change (Kahlor & Rosenthal, 2009). Climate change knowledge is conceptualized as knowing the underlying cause of climate change. Lee et al. (2015) indicate that understanding the cause of climate change is the strongest predictor of climate change risk perceptions.

4.4.2.1.1 Dependent Variable

"Cause of climate change" and "health link" were the dependent variables used to evaluate the public and health experts' perceptions and knowledge on climate change and its health implications. Cause of climate change was derived from the question: what is the single most important cause of climate change? The response categories were deforestation, overpopulation (births and immigration), greenhouse gas emissions, resource extraction, God's will, violating/transgressing cultural values and norms, and don't know. Responses were categorized into two, with greenhouse gas emissions, resource extraction and deforestation coded as "1" (factual knowledge of causes of climate change) and the others combined and coded "0" (non-factual knowledge of causes of climate change) because they constitute incorrect beliefs about the cause of climate change. The response categories classified as factual knowledge have been shown to have scientific contributions to climate change. Greenhouse gases have been established in the literature as the major contributor to climate change (Read et al., 1994, IPCC, 2014). Deforestation and resource extraction also contribute in a modest way through emission of greenhouse gases, removal of carbon sinks, and changes in albedo which are changing the concentration of atmospheric constituents (Bord, O'Connor, & Fischer, 2000; Haines, 2012; IPCC, 2014; Read et al., 1994). With knowledge being a significant predictor of risk judgments, we hypothesize based on previous literature that, factual knowledge of the cause of climate change will strongly predict perceptions of climate change as a health threat.

The "Health link" variable, which looks at perception of climate change as a health threat was created from the question: "Do you think there is a link between climate change and health?"

Yes, was coded “1” (health link) and No coded “0” (no health link).

4.4.2.1.2 Independent Variable and Controls

The key independent variable was group (health expert vs. public). It is documented that climate change knowledge and risk perception varies with socio-demographic and social-structural factors. Wolf and Moser (2011) argued that positionality in society as indicated by gender, age, socioeconomic status, and other social variables play an important role in differentiated judgments of climate change by various groups. These socio-demographic and social-structural factors have been grouped into compositional (Hartter et al., 2012) and contextual factors (Lee et al., 2015). According to Pol and Thomas (2013), compositional factors are made up of: 1) biosocial characteristics that encompass biological and physical components including age, gender, ethnicity; and 2) sociocultural factors which reflect positions of individuals in the social structure and include factors such as marital status, education, occupation, and religion among others. Contextual variables refer to the broader social and physical opportunities in a region, such as availability of and access to services: broader place specific characteristics (Collins et al., 2017). These theoretically relevant determinants were included in the analysis to discover their predictive values on objective knowledge of climate change and climate change health risk perception.

4.4.2.1.3 Quantitative Data Analysis

Analytic sample was 1,012 individuals who answered all the climate change knowledge questions. STATA 14SE software was used in data analysis. The analysis presented in Table 4.2 shows Chi-square and Cramer’s V statistics for the relationship between the two dependent variables and independent variables. In addition, a multivariate logistic regression analysis was performed to estimate the relationship between the outcome variables (‘cause of climate change’ and ‘health link’) and key independent variable –Group-health expert vs. public. Logistic regression was employed for the statistical analysis due to the dichotomous nature of our dependent variables.

4.4.2.2 Qualitative Analysis

Recorded in-depth interviews were translated into English and transcribed verbatim for analysis. To allow continued immersion in the field data, the analysis was manually conducted using hand coding which involved reading and re-reading the transcripts and associated field notes, and coding important texts (Miles et al., 2014). Codes were developed and organized according to emergent themes.

4.5 Results

4.5.1 Quantitative Findings

4.5.1.1 Knowledge of Underlying Cause of Climate Change

The results from multivariate logistic regression models are presented in Table 4.3. The analysis showed that the public have a lower odds of reporting factual knowledge of the underlying cause of climate change compared to health experts in model 1 (OR=0.45, $p \leq 0.001$). However, when compositional and contextual factors (collective effect) are included, the statistically significant relationship disappears. Further analysis revealed both ethnicity and educational status completely moderated the relationship. For compositional factors, gender, age and educational status were found to predict factual knowledge of the underlying cause of climate change. Females were 30% less likely to have factual knowledge of the underlying cause of climate change compared to males. Compared to the age group 18-30, respondents aged 41-50 were found to be more likely (OR=2.10, $p \leq 0.004$), while respondents 61 years and older were less likely (OR=0.37, $p \leq 0.031$) to have such knowledge. For contextual variables, region of residence was a significant predictor of factual knowledge of the underlying cause of climate change. Residents in the Greater Accra Region have significantly higher odds of reporting factual knowledge of the underlying cause of climate change relative to their counterparts in northern Ghana (OR=3.31, $p \leq 0.008$).

4.5.1.2 Perception of Climate-Related Health Risks

In Table 4.3, results from three multivariate models explaining the relationship between climate change-health link and the independent variable are presented. Model 2 controls for knowledge of cause of climate change, model 3 considers compositional and contextual variables. Taking the collective effect of all our variables into account in Model 3, community members were

98% less likely to associate climate change with health compared to health experts. Having factual knowledge of the cause of climate change was also associated with higher odds of linking climate change to health ($OR=1.51$, $p \leq 0.006$). Compositional variables, gender, age, educational level and ethnicity were found to be statistically associated with linking climate change with health. Females were 50% less likely to associate climate change with health compared to males. Compared to age group 18-30, individuals who are 51-60 years had higher odds of associating climate change with health ($OR=2.42$, $p \leq 0.004$). Respondents who had primary education and tertiary education were 88% and 108% respectively more likely to connect climate change with health relative to those without any formal education.

Table 4.2: Distribution of Cause of Climate Change (Underlying Cause) and Linking Climate Change with Health by Compositional and Contextual Factors

	Cause			Health link		
	Factual Knowledge (%)	Non-Factual Knowledge (%)	Statistics X^2(df), Cramer's V	No link (%)	Link (%)	Statistics X^2(df), Cramer's V
Group			(1) = 11.4577	2 (2)	95 (98)	(1) = 95.4156
Health expert	25 (26)	72 (74)	Pr =0.001	498 (54)	419 (46)	Pr =0.001
Community member	399 (44)	516 (56)	Cramer's V=-0.1064			Cramer's V=-0.3071
Cause of climate change						(1) = 25.1498
Factual knowledge				248 (58)	176 (41)	Pr = 0.000
Non-Factual knowledge				250 (43)	338 (57)	Cramer's V=0.1576
Compositional Factors						
Gender			(1) = 19.4569	206 (40)	311 (60)	(1) = 37.0833
Male	182 (35)	335 (65)	Pr = 0.000	292 (59)	203 (40)	Pr = 0.000
Female	242 (49)	253 (51)	Cramer's V=-0.1387			Cramer's V=-0.1914
Age						
18-30	147 (36)	259 (64)	(4) = 27.4310	181 (45)	225 (55)	(4) = 10.6510
31-40	135 (46)	158 (54)	Pr = 0.000	150 (51)	143 (49)	Pr = 0.000
41-50	73 (37)	123(63)	Cramer's V=0.1646	111 (57)	85 (43)	Cramer's V= 0.1026
51-60	44 (53)	39 (47)		36 (43)	47 (57)	
61+	25 (74)	9 (26)		20 (59)	14 (41)	
Educational Status						
No Education	227 (52)	208 (48)	(3) = 43.4186	283 (65)	152 (35)	(3) = 110.6197
Primary	69 (44)	88 (56)	Pr = 0.000	70 (45)	87 (55)	Pr = 0.000
Secondary	74 (33)	147 (67)	Cramer's V=0.2071	104 (47)	117 (53)	Cramer's V=0.3306
Tertiary	54 (27)	145 (73)		41 (21)	158 (79)	
Religion						
Christian	177 (35)	331 (65)	(2) = 20.9644	199 (39)	309 (61)	(2) = 41.8782
Muslim	244 (49)	253 (51)	Pr = 0.000	296 (60)	201 (40)	Pr = 0.000
Traditional	3 (43)	4 (57)	Cramer's V=0.1439	3 (43)	4 (57)	Cramer's V= 0.2034
Ethnicity						
Dagbani	252 (50)	254 (50)	(4) = 29.6594	310 (61)	196 (39)	(4) = 69.2302
Dangbe	121 (37)	209 (63)	Pr = 0.000	137 (42)	193 (58)	Pr = 0.000
Ewe	22 (33)	45 (67)	Cramer's V=0.1712	18 (27)	49 (73)	Cramer's V= 0.2616
Akan	15 (25)	46 (75)		14 (23)	47 (77)	
Others	14 (29)	34 (71)		19 (40)	29 (60)	
Marital Status						
Never married	113 (31)	248 (69)	(2) = 26.2713	141 (39)	220 (61)	(2) = 23.4947
Currently married	292 (47)	323 (53)	Pr = 0.000	339 (55)	276 (45)	Pr = 0.000
Formerly married	19 (53)	17 (47)	Cramer's V =0.1611	18 (50)	18 (50)	Cramer's V=0.1524
Occupation						
Health Professional	25 (26)	72 (74)	(6) = 45.0161	2 (2)	95 (98)	(6) = 133.7186
Unemployed	38 (40)	58 (60)	Pr = 0.000	38 (40)	58 (60)	Pr = 0.000
Agricultural Activities	217 (50)	216 (50)	Cramer's V=0.2109	271(63)	162 (37)	Cramer's V=0.3635
Business (Trading)	69 (49)	73 (51)		82 (58)	60 (42)	
Services (Gov't & NGOs)	22 (24)	69 (76)		33 (36)	58 (64)	
Student	8 (20)	32 (80)		23 (57.5)	17 (42.5)	
Others	45 (40)	68 (60)		49 (43)	64 (57)	
Contextual Factors						
Residential Locality			(1) = 7.2591			(1) = 10.3962
Urban	142 (37)	246 (63)	Pr = 0.007	166 (43)	222 (57)	Pr = 0.001
Rural	282 (45)	342 (55)	Cramer's V=-0.0847	332 (53)	292 (47)	Cramer's V=0.1014
Region			(1) = 26.9216			(1) = 37.2476
Northern	271 (49)	279 (51)	Pr = 0.000	319 (58)	231 (42)	Pr = 0.000
Greater Accra	153 (33)	309 (67)	Cramer's V=0.1631	179 (39)	283 (61)	Cramer's V=0.1918

Table 4.3: Logistic Regression Models for Cause of Climate Change, Linking Climate Change With Heath and Compositional and Contextual Factors

	Perceived Cause of Climate Change						**Health Linkage**								
	Model 1			Model 2			Model 1			Model 2			Model 3		
	Cause of Climate Change			Compositional & Contextual Factors			Health link			Cause of Climate Change			Compositional & Contextual Factors		
	OR	P>z	[95% CI]	OR	P>z	[95% CI]	OR	P>z	[95% CI]	OR	P>z	[95% CI]	OR	P>z	[95% CI]
Group *(ref: Health Expert)*															
Community Member	0.45	**0.001**	0.280, 0.721	0.74	0.359	0.384, 1.414	0.02	**0.000**	0.004, 0.073	0.02	**0.000**	0.005, 0.077	0.02	**0.000**	0.005, 0.094
Cause of Climate Change *(ref. Non- factual knowledge)*															
Factual knowledge										1.75	**0.000**	1.342, 2.284	1.51	**0.006**	1.127, 2.012
Gender *(ref: Male)*															
Female				0.70	**0.011**	0.526, 0.919							0.50	**0.000**	0.375, 0.677
Age groups *(ref: 18-30 years)*															
31-40				1.18	0.442	0.770, 1.823							1.35	0.192	0.861, 2.103
41-50				2.10	**0.004**	1.265, 3.472							1.45	0.151	0.873, 2.415
51-60				1.01	0.967	0.554, 1.850							2.42	**0.004**	1.332, 4.412
61+				0.37	**0.031**	0.150, 0.914							1.39	0.394	0.651, 2.979
Religion *(ref: Christian)*															
Muslim				1.16	0.646	0.624, 2.138							1.62	0.178	0.803, 3.259
Traditional				1.15	0.891	0.165, 7.952							1.46	0.606	0.347, 6.133

Educational Status *(ref: No Education)*						
Primary	1.05	0.855	0.645, 1.695	1.88	**0.015**	1.130, 3.116
Secondary	1.46	0.131	0.894, 2.373	1.54	0.101	0.920, 2.567
Tertiary	1.90	**0.032**	1.058, 3.402	2.08	**0.014**	1.157, 3.736
Ethnicity *(ref: Dagbani)*						
Dangbe	0.45	0.112	0.170, 1.205	4.64	**0.018**	1.299, 16.555
Ewe	0.51	0.214	0.177, 1.475	7.72	**0.006**	1.823, 32.676
Akan	0.67	0.461	0.233, 1.935	2.73	0.171	0.649, 11.468
Others	1.14	0.747	0.524, 2.464	2.37	0.080	0.902, 6.255
Marital Status *(ref: Never Married)*						
Currently married	0.68	0.101	0.431, 1.078	0.99	0.973	0.622, 1.582
Formerly married	0.75	0.493	0.323, 1.726	1.27	0.589	0.536, 2.998
Urbanicity *(ref: Urban Residence)*						
Rural	0.95	0.750	0.702, 1.290	1.12	0.509	0.804, 1.553
Region *(ref: Northern Region)*						
Greater Accra	3.31	**0.008**	1.375, 7.976	0.56	0.364	0.164, 1.943
Total			= 1,012			= 1,012
Log Pseudo-likelihood		=	-588.16764		=	-588.16764

4.5.2 Qualitative Findings

4.5.2.1 Contextualizing Climate Change-Health Linkages

Multiple themes emerged regarding participants' understanding of climate change and health from analysis of the in-depth interviews. The results are organized first by a theme-count table (Table 4.4) and then exemplary quotations that serve as low-inference descriptors for the themes identified (Miles et al., 2014). The theme-count table shows the number of participants who mentioned a given theme. Three of the most prominent themes are presented. To protect confidentiality, quotations are labeled using pseudonyms.

Table 4.4: Prominent Themes from the In-Depth Interviews

Themes (Pathways for Climate Change-health link)	Theme frequencies [a]	Number of participants: Health experts (N=20)	Number of participants: Community members (N=48)
Climatic variability	50	14	40
Ozone depletion	5	5	
Food system changes	20	5	10
No link	5		5

[a] The number of times theme emerged in interviews.

Source: Derived from in-depth interviews following analytical steps outlined by Miles et al. 2014

4.5.2.1.1 Climate Change and Health Risk Linkage: An Individualized Experience

Climate change and health linkage being a personal experience was a prominent theme among both study groups. Attributing poor health to climate change was informed by individualized conceptualizations of climate variability. Responses revealed that day-to-day experiences with climate shape views about climate change and health, especially among the public:

> "Yes, with the unstable temperature, we get diseases like 'catarrh' (common cold), headache and sometimes malaria. Because, we hang our mosquito nets in our rooms and at times, the room warms up to an extent that we cannot sleep there, we go out to sleep in the open resulting in us being mostly bitten by mosquitoes, and we get sick" [Yakubu (resident) Savelugu-Nanton Municipal].

> "Of course, it [climate variability] does affect us, because normally all over here we are farmers. In the past, 35 years back, when we go to the farm, the weather is not that sunny so what happens is that you can be there for the whole day and farm. But this time around, when you are there especially from February to May, you will really feel the intensity of the heat. So, if you are farming, at least by 10am you must come back. But if you want to continue, maybe up to 11am or 12 o'clock, then you will be compelled to fall sick, these are problems the climate is giving us now" [Ocran (resident) Ada East District].

> "Yes, we get high blood pressure and heart problems because of over thinking. Changes in the rainfall pattern cause us to over think which causes stress also. Due to changes in climate, we do not get the rains when we are supposed to and when it does rain, there is a destruction of our fields" [Aisha (female resident) Savelugu-Nanton Municipal].

Other narratives connecting climate change to health were reported in the form of variability in the local food systems (supply) and its potential health risks. Low crop yield was attributable to rainfall variability and depletion of farmlands. Participants also explained how use of chemical fertilizer, which has always been presented as a solution to changing climatic conditions for farming was posing health challenges:

> "The farmers, due to lack of irrigation, they will be dependent on the rainfall and the little that they will grow, the floods too will come and destroy them. If it doesn't rain too, the crops will also die. So, you will have hunger, poverty, diseases, when there is no money to buy food you can't eat and therefore your immune system will break down and definitely, you are susceptible to all kinds of diseases" [Mawuli (resident)-Ada East Municipal].

> "…some time ago, farmers used not to apply fertilizer to their crops before they can get a good yield. But now if you cultivate any crop without applying fertilizer, then do not expect to make any harvest and applying the fertilizer does affect our health" [Ibrahim (resident) Savelugu-Nanton Municipal].

4.5.2.1.2 Climate Change and Health Risk Linkage: A Learned Perspective

The next prominent theme that emerged involved narratives connecting climate change to health underpinned by some level of scientific understandings. This theme, however, emerged more in the health experts' interviews, probably because they have a better understanding of the science behind climate change. They highlighted extreme radiations and release of some poisonous gases from the atmosphere which have health ramifications:

> "If I should say, maybe if the ozone layer is depleted, there is a direct contact of the sun rays to the skin and it exposes you to so many infections and then damages the layers of the skin" [Health expert (public health nurse)-Ada East District].

> "You know, like I know that there are some poisonous gases that are being produced in the atmosphere due to climate change, those ones too can affect the air we breathe in and with all this, it can affect our health" [Health expert-Savelugu-Nanton Municipal].

In addition, climate change and its health linkage based on climate variability was also highlighted among the health experts.

> "To me there is a risk, the management of malnutrition is a priority to me, so if there is climate change, and then we have less amount of rainfall, definitely agricultural production will be reduced. If there is not enough food in the system, certainly the people will not be able to get enough food to eat to build their nutritional status, so therefore, there will be a fall in nutritional status …" [Health expert (community health nurse)- Savelugu-Nanton Municipal].

> “Too much of everything is bad. For instance, when you have excessive rains that will cause flooding, it can destroy physical properties, diseases will spread, people will get infested.... On infectious diseases, malaria for instance, when you have excessive rains, mosquitoes breed a lot, so you will have a lot of malaria cases. If you have flooding, water-bodies may be contaminated with fecal matter and other things and people could have cholera. When we do not have enough rains and there is drought, people will drink from other sources of water that may not be good for their health. So, some of these waterborne diseases, the diarrhoea diseases, may not be cholera, you can have typhoid and any of the diarrhoea diseases that maybe because people did not have good water. Perhaps their water bodies are dried now, and they are drinking from other sources that normally they should not. So that is how I think” [Health expert-Ada East District].

Although both health experts and the public connect climate change to health-related risks, our analyses revealed important distinctive differences in perspectives and conceptualization of the linkage between the two groups. The study found that conceptualization of climate change-health related risks among health experts were largely underpinned by climate change scientific knowledge. Even though the health experts’ conceptualization is underpinned by scientific understandings, they also demonstrated little understandings of climate change science. Some health experts conceptualized the health risks from climate change to result from release of some poisonous gases due to ozone layer depletion, which they synonymously attributed to be climate change. These views suggest that, despite their potential access to ‘scientific knowledge’, they have false beliefs and misunderstandings about climate change and its subsequent links to health.

In contrast, the conceptualization of the health linkage among the public happened through processed and perspectives created from personal experiences of climatic conditions in their individual social and physical spaces. As climate change and health dynamics are complex, members of the general public without training on climate change and the health consequences it poses to communities tended to rely on their individualized experiences to conceptualize and frame perspectives on climate change-health linkage.

4.5.2.1.3 No Knowledge of Climate Change-Health Linkage

From the qualitative interviews, it also emerged that health experts were more likely to connect climate change to health than the public. This was evident from the community interviews, as some members of the general public were unable to draw a link between climate change and health:

> "No, it doesn't have any impact on our health. Some people say so? Well, for me, I am not experiencing it, and nobody complains to me" [Tetteh (resident) Ada East District].

> "I do not think so, but in raining season malaria is severe" [Adisa (resident) Savelugu-Nanton Municipal].

Some respondents also indicated they cannot say much regarding climate change and its health risks, signifying a degree of lack of knowledge on the subject:

> "Concerning our health, I cannot say anything much about it but during the farming season, I can say it affects us" [Ocansey (resident) Ada East District].

4.5.3 Climate Change Related Health Risks

Respondents perceived different health risks attributable to climate change. The prominent ones are presented in Table 4.5. In the interviews, participants repeatedly mentioned health concerns related to changes in vector ecology (35 mentions) with malaria mostly coming top. This could be due to the malaria parasites sensitivity to climate variability (Ermert et al., 2012) and its endemic nature in Ghana.

The second health concern that emerged related to food and water supply shortage. Participants in the interviews report declining crop yields and water shortage due to extreme variability in the rainfall pattern. Such variability triggers rising temperatures, droughts, and floods, with cyclically impacts on food production and water availability for household consumption. These climate induced conditions tended to compromise food security and safety leading to health-related issues. Health experts were more likely to name health concerns related to this theme compared to the public. Malnutrition due to shortage in food supply or food security, food and water borne diseases such as diarrhoeal, typhoid and cholera were mentioned.

Extreme heat related health concerns or illness such as skin diseases or heat related rashes were reported as one of the major climate change related health risk to local populations. Respondents identified temperature variability as the main climatic condition responsible for skin diseases. One health expert (public health nurse) expressed concern over this during an interview:

> "I remember somewhere last year, most people were complaining of itching, severe itching all over. After the person exposes themselves to the sun and gets indoors the itching starts. Immediately there was a change in weather, when the rainy season set in then it normalized. So, don't you think is the climate"? [Agnes (health expert) Ada East District].

Health concerns related to upper respiratory tract infections consisting of common cold were also reported. The public also mentioned headaches, which was mostly associated with variability in climate**.**

Table 4.5: Perceived Health Concerns Associated with Climate Change

Health Concern	**Number of Participants Mentioning**		
	Total	Health	Community
Changes in vector ecology	35		
Malaria		15	20
Water & food supply	17	12	5
Malnutrition		3	
Diarrhoeal disease		5	1
Cholera		3	4
Typhoid		1	
Extreme heat related illness	14	10	4
Meningitis		5	
Skin rashes (heat related)		5	4
Upper Respiratory Tract Infections	11		
Common cold		5	6
Headaches	12	1	11
Body pains	5		5

Source: In-depth interviews among health experts and the public

4.6 Discussion

In this study, we examined perceptions of climate-related health risks in Ghana and how these perceptions vary between health experts and the general public. The findings of the study are discussed in the following order: 1) perceptions and knowledge of climate change and related health risks; 2) climate change health-related concerns; and 3) interrogating climate change health discourses.

4.6.1 Perceptions and Knowledge of Climate Change and Related Health Risks

Emerging from this research is an indication of limited knowledge of climate change and its related health risks. The results indicate that 26% of health experts and 44% of the public lacked knowledge of the underlying cause of climate change. This finding is not surprising, as it appears that the greatest misconception in public opinion about the concept of climate change relates to its underlying cause (see Read et al., 1994; Vignola et al., 2013). While there was not much difference between our study groups regarding knowledge of the underlying cause of climate change, health experts were more likely to link health-related risks to climate change compared to the public: perceiving it as a health threat. Health experts linking climate change to health have been reported in other studies (e.g., Paterson et al., 2012; Xiao et al., 2016). In addition, our study finding of the public not reporting a connection between climate change and health or not perceiving it as a health risk is consistent with prior studies in the United States, Canada and Malta (Akerlof et al., 2010; Leiserowitz, 2005). One plausible explanation for health experts' increased awareness of climate-related risk is that experts have a deeper understanding of climate change dynamics as they have more access to tools and methods to allow them better to evaluate the risks associated with climate change (Sundblad et al., 2009). Hansen et al. (2003) argued that scientifically trained experts tend to perceive environmental and health associated risks differently from the way lay-people perceived them. One obstacle to climate change knowledge is connected to the opportunities for obtaining firsthand information about scientific knowledge (Sundblad et al., 2009). According to Sundbald et al. (2009), experts have direct access to information in their own discipline, whiles laypersons are more dependent on information from other sources such as the media, which have been reported to contain misconceptions (Wilson, 2000). Thus, health experts relating climate change with health than the public could be accounted for by these issues, as they have more access to climate change related information through their disciplines and trainings.

Our findings also indicated that the objective knowledge measured (factual knowledge about the cause of climate change) was positively related to perceiving climate change as a health risk. Socio-demographic factors (compositional and contextual) examined contributions were of varying degrees in terms of their association with climate change knowledge and perceiving climate-health risk among our study population. Compositional factors, gender, age and educational status were found to predict factual knowledge of the underlying cause of climate change. These factors have been reported in other studies as accounting for understandings and perceptions of climate change (e.g., Kahlor & Rosenthal, 2009; Lee et al., 2015; McCright, 2010). Whereas gender, age, educational attainment and ethnicity were found to predict climate change health risk perception among our study participants. From these findings, it emerged that whiles socio-demographic factors belonging to both the compositional and contextual dimension predicted climate change knowledge, the contextual factors examined were not associated with perceiving climate change as a health risk amongst our study population.

The findings show that factual climate change knowledge increased with higher educational attainment as it had a positive effect: respondents with a high level of education were more likely than their less educated counterparts to know the fundamental drivers of climate change. Educational attainment having a positive relationship on climate change knowledge has also been established in other studies (Kahlor & Rosenthal, 2009; Lee et al., 2015). Educational attainment seems to account for the gender differences seen in this study as well. Analysis revealed that males in our sample had higher levels of education compared to females especially for the community members. Whiles 34% of males had no formal education, the percentage for females was 61% with only 6.5% of females having a tertiary education compared to 17% for males. Males possessing higher knowledge of climate change than females have been reported in other studies (e.g., Salehi, Nejad, Mahmoudi, & Burkart, 2016).

Region of residence was found to have an association with factual knowledge about climate change. Individuals living within the Greater Accra region were found to have a higher chance of knowing the most important underlying cause of climate change. Within the Ghanaian context, there is a North-South dichotomy in relation to access to resources and development which has implications on other sectors. For example, whiles only 10 percent of the population in the Greater Accra region (southern sector) have never attended school, this figure was approximately 57 percent for the Northern region (northern sector). Furthermore, only 0.5 percent of the Northern Region population has a bachelor’s degree compared to a 4.5 percent of the population in Greater Accra region as at the last census of the country in 2010 (GSS, 2012). This trend was replicated in the study sample especially at the community level with about 80 percent of respondents from the Savelugu-Nanton Municipal (Northern region) not having formal education compared to 9 percent in the Ga East District (Greater Accra region). This dichotomy in educational attainment could be accounting for why the residents in the Greater Accra region have higher odds of knowing the fundamental cause of climate change. Education enhances ability to pick information from different sources and is reported to be positively related to systematic processing of information linked to scientific issues (Kahlor, Dunwoody, Griffin, & Neuwirth, 2006). Educational level functions as a socioeconomic divide and as such, enabling individuals with more education to have a greater capacity for integrating new information into pre-existing structures or for creating new knowledge structures as well as having the trained capacity to follow certain issues such as climate change (Kahlor & Rosenthal, 2009).

Although region of residence was a significant predictor of climate change knowledge, place of residence was not. This finding has also been reported in studies such as (Lee et al., 2015; Salehi, et al., 2016). Lee et al (2015) research across countries found rural/ urban status not to be a key predictor among all countries. Whiles rural/ urban status was one of the key predictors in China, it was not an important predictor in the context of the United States.

Effect of age was found to vary based on different age groups. Age was a significant predictor for individuals aged 41-50 years and 61years and above. Analysis revealed that individuals belonging to these age groups were predominantly engaged in agricultural activities. As farmers, most of them attributed the underlying driver of climate change to deforestation which is unsurprising, as deforestation plays a strong role in national climate change awareness programs in Ghana. As farmers, they are usually admonished on the need for afforestation as a mitigation measure. Thus, these groups having factual knowledge compared to the other age groups could be accounted for by this factor. A study in the Offinso municipality in Ghana reported that farmers perceived deforestation to be the cause of climate change and climate variability in their area (Odame, Akondoh, Tabiri, & Donkor, 2018).

4.6.2 Climate Change Related Health Risks

Climate change related health risks have been shown to be unique in different context, yet the diseases and health conditions attributed to climate change in our study are corroborated in previous studies (e.g. Akerlof et al., 2010; Olaris, 2008). For instance, Akerlof et al. (2010) in a qualitative study into perceptions of community members on health risk related to climate change reported that 22% of Canadians attributed respiratory diseases to climate change. In contextualizing strategies for managing the health risks of climate change, Costello et al. (2009) estimated a rise in prevalence of malaria and other infectious disease as floods and temperature rise become more rampant with increasing climate change effect. Despite being consistent with the literature, most of the health risks reported among the general public stemmed from personal experiences with extreme weather and climate events. Exactly as to how the effects would manifest or be triggered could not be explained by some respondents in our study, which suggests limited knowledge about the underwriting mechanisms linking climate variability to health risks in the Ghanaian context. As narratives on climate change-health risks are mostly based on exacerbated climatic trends and associated endemic diseases and health conditions (Costello at al., 2009), it is important to interpret findings from the public by counter-balancing with findings from health experts to provide deeper understating climate change induced disease profiles in Ghana.

In addition, climate change has been acknowledged to facilitate growth of vector borne diseases (Berrang-Ford et al., 2009; De Casas & Carcavallo, 1995). It may not be surprising that most of the health concerns reported in our study involved vector borne diseases, and other more common health issues such as malaria. It is important to note that other well documented health effects of climate change such as air pollution related and increasing allergens (e.g. respiratory allergies, asthma) and severe weather-related effects (injuries, fatalities, mental health impacts) were not reported in our study especially among the public. The probable explanation could be poor knowledge of the general public on climate change and its impact on populations found in our study. Nonetheless, health experts reported an increasing prevalence of air pollution and asthma, indicating disparities in knowledge of climate change related health effects between health experts and the public.

4.6.3 Interrogating Climate Change Health Discourses

Our findings indicate that although discourses on climate change-health links from health experts and the public converge on basic knowledge of climate change, they diverge on conceptualization of underpinning factors driving climate change. Some subthemes are advanced more within a group or found only among one. An example is the ozone depletion subtheme, which was only indicated by the health experts. One other area of commonality in narratives was reporting of climate variability and its subsequent relations to health risks.

The discourses however diverged in terms of the knowledge used in the conceptualizations. The narratives of the health experts were found to have some level of scientific underpinnings, which was missing among most of the public. It was revealed that the public narratives were influenced by local knowledge, which was grounded in embodied experiences (Jackson & Neely, 2015). During data collection, it was found that there was no official focal point for climate change and health in Ghana. The WHO report on climate and health country profile for Ghana acknowledged this issue (WHO, 2016). Under national policy response, the country profile recommended a national focal point for climate change in the Ministry of Health. This lack of focal point has its challenges as one of the individuals recognized unofficially as focal points expressed: health is not represented on the committees under climate change issues in Ghana. Due to this missing link at the national level, it has translated to affect the local. During interviews, most of the respondents indicated not receiving any education on climate change-health implications, even among some health experts. This could account for the pattern we saw in the quantitative analysis whereby 54% of the public did not perceive a link between climate change and health. This lack of focal point or unit to advance climate change and health issues is potentially contributing to low levels of knowledge on the subject at the local level. Against this backdrop, health practitioners and physicians are being called upon to use their well-developed avenues of communication to raise awareness about the health aspects of climate change. The WHO calls for health professionals to take a leadership role in climate action planning (WHO, 2009).

There are limitations to this study that must be considered. Self-reported survey data may be influenced by respondent recall bias (Roser-Renouf, Maibach, & Li, 2016). This study is restricted to two districts, and it is possible these reported knowledge and conceptualizations of climate change-health links might be different in other districts in Ghana. Nonetheless, the findings are generally consistent with the literature and provide significant bases for policies on climate change in Ghana. Based on knowledge about people's perception of climate change, its health risk component and the potential associated health risks, important inferences can be drawn which are useful both for the organization of communication and public awareness campaigns on these subjects and for the design and implementation of relevant policies.

4.7 Conclusion

The findings of this study provide important insights into the different conceptualization of climate change, its causes, and health impact. Though studies have assessed perspectives on the health effects of climate change, none of the extant studies have looked at differences in how health experts and lay individuals or public conceptualize climate change and its health linkages. Current studies have not explored the pathways by which the public and health experts' links climate change to health (e.g. Akerlof et al., 2010; Cardwell & Elliott, 2013). This study has therefore shed light on the different discourses of climate change-health links and how health practitioners understanding differs from that of the public. Thus, providing a better understanding about the mental models' respondents used in processing and linking climate change with health. By characterizing these pathways from different groups in different geographical settings, this study responds to the call by Curtis and Oven (2012) for a more 'differentiated' perspective on the links between climate change and health, which explains the need to capture the diverse factors inducing health vulnerabilities and resilience to climate change of individuals and groups in different societies and different geographical settings.

Based on the current relatively inadequate climate change knowledge of our study group, more education is needed on climate change and its health implication within the country as a whole for both the public and health experts, which can be carried out by the government and civil society organizations. In addition, we recommend the development of climate change policy to embrace national and community level climate change health risk concerns. Such a policy would serve as a framework for developing, implementing and evaluating adaptation preparedness of local populations and health service providers. Lastly, findings also highlight that how groups experience and perceive climate change and its attendant risks are different, thus necessitating a nuanced and differentiated approach to health care provision and health promotion/communication in Ghana, and indeed similar contexts in the developing world such as sub-Saharan Africa.

4.8 References

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CHAPTER FIVE

ARE WE READY FOR IT? HEALTH SYSTEMS PREPAREDNESS AND CAPACITY TOWARDS CLIMATE CHANGE-INDUCED HEALTH RISKS: PERSPECTIVES OF HEALTH PROFESSIONALS IN GHANA

Abstract

Climate change poses unprecedented challenges for human health, having been identified as the biggest 'global public health threat' of the 21^{st} century. It has been suggested that health systems and infrastructure will be overwhelmed by the large-scale public health risks from climate change. With weak health systems, the impact is estimated to be far greater in developing countries, which are already over-burdened with poor health outcomes. Thus, health system adaptation and building of resilience to manage the adverse health outcomes is crucial. Yet, there is limited knowledge about the preparedness and capacities of health institutions and professionals in developing countries to respond to climate change health risks. Drawing from World Health Organisation's framework on health system capacities, effective response and emergency preparedness, and using mixed methods research design, we examined capacities and preparedness of public health professionals in Ghana to manage climate change-health risks and emergencies. Qualitative interviews (*n*=20) and quantitative surveys (*n*=99) were conducted on health professionals in Savelugu-Nanton and Ada East Districts in Ghana. The study found that, although health professionals perceived climate change as a public health risk (>90%), their knowledge on the subject was relatively low as approximately two-thirds of surveyed health professionals indicated not having adequate information on climate change and health connections. We also found that, capacity and preparedness to respond to climate change related health emergencies were weak in the study districts. Based on our findings, we recommend the development and implementation of a comprehensive policy on climate change and health to build capacities of health institutions and professionals, improve climate change health research, and increase funding to climate change programs and activities in local communities.

5.1 Introduction

Climate change represents a significant and increasing threat to human population and remains one of the most pressing public health concerns in the 21st century (WHO, 2014). It affects human health both directly and indirectly (Costello et al., 2009). In part, extreme weather events such as extreme temperatures and precipitation variability, rising sea levels, increased incidence of allergens, and altered patterns and prevalence of infectious disease vectors directly impact human health (Costello et al., 2009; Watts et al., 2018). These direct climate change induced conditions also impact human health through less direct pathways such as climate-induced conflicts over limited and fragile natural resources, and population dislocation and forced migration from coastal communities to escape more frequent and severe weather events like flooding (McMichael, Friel, Nyong, & Corvalan, 2008; Reuveny, 2008). Indeed, the effect of climate change on human health is projected to exacerbate prevailing known public health hazards and stressors, as it alters their prevalence, range and seasonality. Thus, it has been long argued that climate change does not only directly impact human health but also amplifiers prevailing health risks (IPCC, 2014; McMichael at al., 2008).

The ramifications of the multi-dimensional and complex health burdens of climate change on health systems are enormous. As has been suggested, health systems and professionals will not only have to deal with worrying trends of direct climate change impact such as malnutrition following droughts, they also have to respond to crises being created from the emergence of new diseases and increasing prevalence of existence ones (WHO, 2014). The health effects of climate change are projected to become progressively severe in the coming decades and threaten the advances being made in public health and the healthcare sector globally (AnAaker, Nilsson, Holmner, & Elf, 2015; Watts et al., 2015; WHO, 2014). Despite being a global threat, the burden of climate change on health systems in developing countries is relatively higher due to existence of persistent poor health infrastructure and weak health systems, leading some organizations to describe the impact as a double burden (WHO, 2015).

The capacity of public health systems to cope with the gradual and sudden changes in climate-related diseases have been acknowledged to be an important factor in sustaining public health in the era of climate change (Ebi & Burton, 2008). In emphasising this position, the World Health Organisation (WHO) indicated that, one of the most important, cost-effective and urgently required response to climate change is rebuilding of public health capacity globally (WHO, 2014). The magnitude of predicted human health risks from adverse climate change effects could be reduced with resilient health systems (Hess, McDowell, & Luber, 2011; WHO, 2015). The challenge to the public health community now is to respond to and be prepared for climate-related health emergencies.

In line with building resilience, health systems preparedness and capacity in responding to the predicted health risks of climate change has come to the fore (see Adlong & Dietsch, 2015; Barna, Goodman, & Mortimer, 2012; Cook, 2018). Within this discourse, there is a renewed imperative for strengthening health institutions and health systems in low-income countries. In sub-Saharan Africa, where some of the worst effects of climate change are anticipated, governments and health policymakers are encouraged to increase investment in health systems, improve capacity of health professionals and develop locally applicable communication tools to increase awareness and preparedness of the general public towards climate change induce health risks (Kula, Haines, & Fryatt, 2013; Mayhew, Belle, & Hammer, 2014). Despite this call, literature on health systems and health professionals' preparedness towards climate-related health risks have largely been limited to developed countries (e.g., Maibach et al., 2008; Carr, Sheffield, & Kinney, 2012; Roser-Renouf, Maibach, & Li, 2016). In this regard, knowledge of preparedness of health systems in developing countries for climate change remains sparse. Currently, there is limited information about health professionals' readiness and capacity to respond to the projected health risks from climate change. In contributing to this area of the climate change literature and policy, our study examined perceived preparedness and institutional capabilities of public health professionals to respond and manage climate-related health risks in Ghana, with three interrelated research questions:

1. What are health professionals' perceptions of climate change as a public health risk?
2. How prepared are health service providers to respond to climate-related health emergencies?
3. What potential reforms or actions do health professionals perceive they need to equip them and the health sector to carry out their role as frontline respondents effectively?

Preparedness as used in this study entails activities and measures taken prior to the occurrence of climate change health effects in order to guarantee an effective response. It includes the development of knowledge and capacities to efficiently anticipate, respond to and recover from the impacts of likely, imminent or current disasters (UN, 2017). According to Ogden, Sockett, and Fleury (2011: 170) public health preparedness consist of "ability to assess immediate and evolving risk to communities and populations, and the ability to respond to emergency events". Ogden et al. (2011) argue that, risks comprises of changes anticipated to occur over decades as well as sudden disaster or near disasters. Additionally, capacity as used here is a combination of strengths, attributes and resources available to manage and reduce disaster risks and strengthen resilience. It may include knowledge about the event and skills to manage and reduce the impact of the event (UN, 2017). In the next section, we further discuss these concepts within the realm of health systems preparedness, and capacity towards climate change-health risks. We also discuss the theoretical and methodological underpinnings of the study to help situate the discussion of our findings within the literature.

5.2 Conceptualizing Health Systems and Service Providers' Preparedness and Capacity in Relation to Climate-Health Risks

Extant studies have employed varied concepts and frameworks to operationalize measurement of health systems and service providers' preparedness and capacity to address climate change-health risks. These range from perceptions and knowledge on climate change and its health risks, to evaluation of adaptation and mitigation programs in place within health facilities, and availability of expertise and specialised services to respond to health effects of climate change (see Carr et al., 2012; Maibach et al., 2008; Bedsworth, 2009; Roser-Renouf et al., 2016).

In analysing global health systems' readiness for climate change health effect, Maibach et al. (2008) evaluated the concept of preparedness along five main domains. The first domain comprises health professionals' perception of climate change knowledge among local population. Maibach et al. (2008), argues that development of strategies for effective response to climate change impact requires an understanding of the knowledge base of local population about climate change health risk. Their second domain appraised the perceptions of experts about the availability of plans and planning mechanisms in health departments for climate change mitigation and adaptation. The third domain examined the presence of programs to address specific threats to health, while the fourth assessed the extent to which climate health risk adaptation have been incorporated into existing health programs. The last domain appraised health institutions on how they were incorporating longitudinal climate change information into the planning and design of future health programs.

Despite the utility of Maibach et al. (2008)'s framework in evaluating the preparedness of health institutions towards climate change health risk, later work by Carr et al. (2012) have broadened the concept to embrace other dimensions. Unlike Maibach et al. (2008), Carr et al. (2012)'s study in the U.S. evaluated the perceptions of local health personnel about the health risk of climate change at the local level. Their study assessed preparedness in four major areas: 1) local health department officials' perceptions of climate change and its potential public health effects; 2) the preparation status of local health departments regarding health impacts of climate change; 3) existing or planned activities of local health departments that could help reduce the health impact of climate change; and 4) resources needed by local health departments to better address climate change-related health risks. Similarly, Bedsworth (2009) assessment of health personnel perceptions of climate change health risks included questions about programs implemented or being designed by health agencies to address climate change, actions undertaken, or tools employed to reduce the public health impacts of climate change, and the adequacy of public information on climate change, and resources for implementing climate change health risk agendas and program. In addition, Sarfaty, Mitchell, Bloodhart, and Maibach (2014)'s study amongst African American physicians evaluated the preparedness of primary hospitals providing in-patient services for persons impacted by climate change events including disasters, emergencies, extreme weather events, and increases in certain diseases. A similar study in India assessed health sector preparedness for adaptation planning by focussing on existing preparedness of the health systems in managing the consequences of extreme events (Dasgupta, Ebi, & Sachdeva, 2016). These various studies underscore both the necessity and complexity associated with capturing the extent of preparedness of health professionals and health systems to deal with climate change related health challenges.

Furthermore, the concept of capacity has been given focus in climate change literature. For instance, Olaris (2008) evaluated the capacity of metropolitan Community Health Services in Victoria, Australia, to respond to climate change by exploring existing understandings of climate change, climate change actions, and barriers impeding response to climate change. Purcell and McGirr (2014) also examined capacity in relation to ability of health services to cope with any extreme weather event or natural disaster by providing adequate support and services.

Given the multiple and varied dimensions of ‘preparedness’ and ‘capacity’ of health institutions and professionals to respond to health-related impacts of climate change in the literature, the World Health Organization (WHO) in 2015 synthesized the two concepts in an Operational Framework for Building Climate Resilient Health Systems (WHO, 2015). The framework provides guidelines on how health systems can systematically and efficiently address the ever-increasing health challenges presented by climate change. Central to the strategy is enhancing the capacity of health systems to protect and improve population health. According to the framework, progress on preparedness and capacity should be examined along ten key components: 1) effectiveness of leadership and governance of health institutions, 2) adequacy and quality of health workforce, 3) vulnerability of local populations and health systems, capacity and adaptation readiness, 4) integrated risk monitoring and early warning systems, 5) health and climate research, 6) climate resilient and sustainable technologies and infrastructure, 7) management of environmental determinants of health, 8) implementation of climate-informed health program, 9) emergency preparedness and management, and 10) climate and health financing. These components of the framework appraise preparedness and capacity of health institutions and professionals to effectively predict future climate change health effects and act to either prevent them from occurring or reduce their impact on local populations.

This study draws on two components of the WHO framework: health workforce, and emergency preparedness and management to assess health providers' readiness and capacity to manage health related risks from climate change in Ghana. The health workforce component comprises of assessment of capacity strengthening programs for technical and professional health personnel (the interest of this study), the organizational capacity of health systems, and an institutional environment that promote collaborative and team work (WHO, 2015). The inputs considered under the health workforce component include human resource skill building, and education. Indeed, it is recommended that in-service and continuous training on climate change should be carried out for health personnel to enable them effectively to manage the changing risks to population health. Thus, the outputs measured in this component include the percentage of healthcare personnel who have attended training on climate change, and the percentage with appropriate information on climate change to help them address related health risks in their respective roles.

Furthermore, the emergency preparedness and management component suggest the building of climate resilience within health systems, development of climate-informed preparedness plans, emergency systems, and community-based disaster and emergency management systems. The WHO (2014; 2015) considers the changing climate to induce increasing disease outbreaks and health emergencies. As such, health care should be ever more prepared for emergency response. This study does not directly measure the outputs outlined under the emergency preparedness and management component. However, it draws from it to evaluate emergency response capabilities of health systems and health professionals towards potential health risks posed by climate change. In the context of Ghana, these added risks may include potential outbreaks of communicable disease and increased incidence of other climate-sensitive infectious diseases such as malaria.

5.3 Policy for Health System's Preparedness and Capacity Towards Climate-Related Health Risks in Ghana

The Ghana Health Service in their annual reports in the past decade has recognized the increasing incidence of parasitic disease in the country. For instance, the most recent report of the service has reported an increase in the proportion of out-of-patient cases suspected to be malaria (Ghana Health Service, 2017). This is in light of the over a decade implementation of a Malaria Control Program, suggesting that the impact of rising temperature due to climate change, together with other factors may be contributing to rapid growth of the malaria parasite in this context. Indeed, the World Health Organization has suggested that population increases could worsen the incidence of malaria infection even in regions with stagnating incidences in Ghana (WHO, 2014). A similar worry is expressed about increasing incidence of lymphatic filariasis, a common neglected tropical disease that has gained prominence in the disease profile of the country in the last decade (Ghana Health Service, 2017).

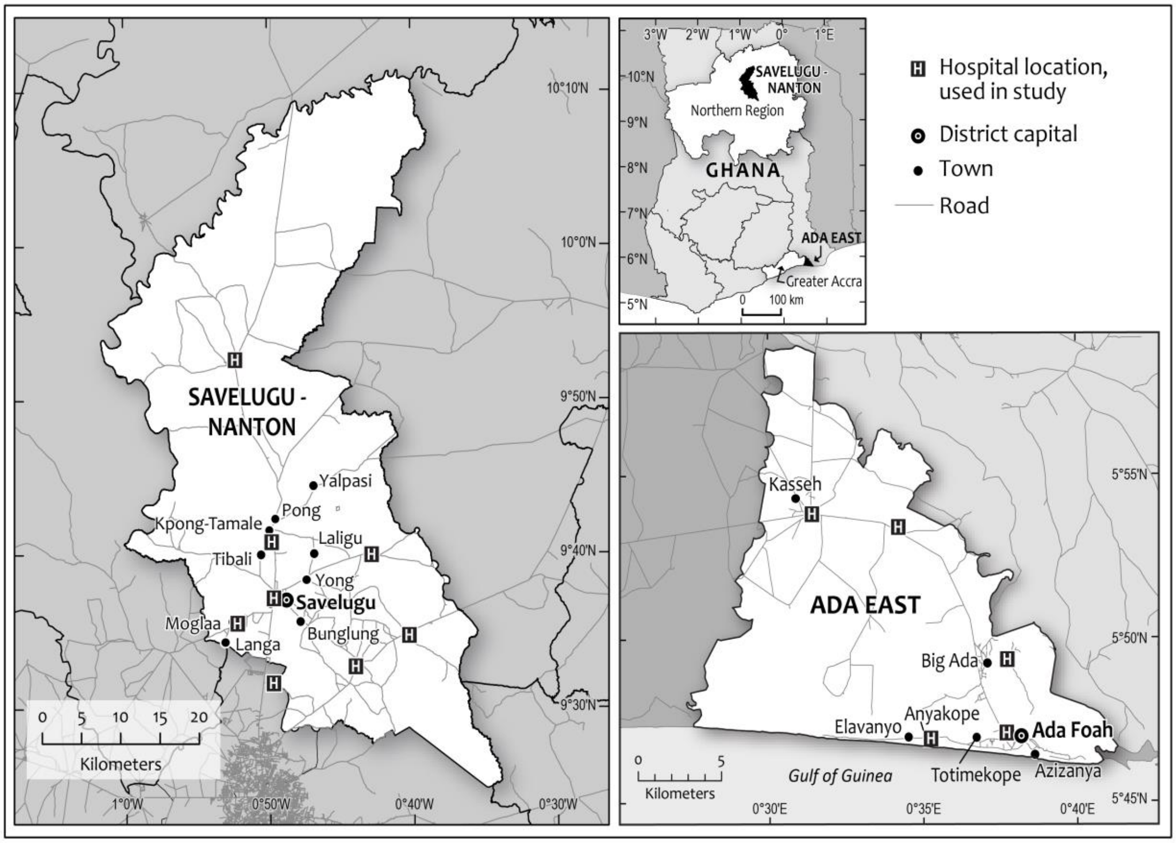
As indicated by the WHO's report on climate and health profile of Ghana, the country has signed on to international conventions and implemented programs since 1999, starting with the membership to the United Nations Framework Convention on Climate Change. Other examples of international climate change actions the country has been part of include the Kyoto Protocol in 2003, and the Paris Agreement on Climate Change in 2016. The requirements of these international agreements encouraged Ghana to identify locally relevant mitigation actions in 2010 leading to the design of a national action plan on climate change in 2011. In respect of implementation of programs, plans and strategies to improve resilience, adaptation and mitigation against climate change health risk, the WHO reports that Ghana had undertaken the following: 1) submitted a national communication strategy which includes health aspects of climate change to the UNFCCC, 2) designed a national health adaptation strategy which is approved by other relevant government agencies, 3) has been implementing projects and programs to mitigate the health effects of climate change, 4) strengthened institutional and technical capacities to address climate change health effects, 5) incorporated climate change information into an Integrated Disease Surveillance and Response system, and developed climate change health risk early warning and response systems, 6) implemented actions to improve the resilience of health infrastructure towards climate change, and 7) included health implications of climate change in a national strategy for climate change.

Although these are important actions to mitigate the health impacts of climate change at the local level, other requirements with financial commitment from the national government meant to sustain the implementation of these health-related climate change programs and projects have not been accomplished. For instance, Ghana has not established a focal point at the Ministry of Health to lead implementation of health-related climate change actions. In addition, it has not conducted a national assessment of the health-related vulnerabilities and adaptation mechanism to climate change and has not assessed the co-benefits of climate change health risk mitigation policies (WHO, 2016). Furthermore, little has been done in the area of costing and budgeting for health-related climate change actions in the country as estimated cost to implement resilience for climate change health risk is often not included in planned allocations for climate change both from domestic and international sources (WHO, 2016). This is the policy context in which we examine the preparedness and capacity of health systems and health professionals to address climate change health risk at the local level in Ghana.

5.4 Geographical Context of Study

The geographical focus of this study is two districts located in different ecological zones of Ghana (See Figure 5.1).

Figure 5.1: Map of Study Districts



Source: Data for study locations provided by Author.
Cartographer: Karen Vankerkoerle, Geography Department, Western University.

The first, Savelugu-Nanton, is located in the northern savannah belt and has extreme seasonal variations in temperature. It shares boundaries with West Mamprusi to the North, Karaga to the East, Kumbungu to the West and Tamale Metropolitan Assembly to the South. The Municipality has a total population of 139, 283, a total land area of about 2,022.6 km^2, with the population density estimated at 68.9 persons per km^2 (Ghana Statistical Service, 2014a). Average annual rainfall for the Municipal is around 600mm, while average annual temperature stands at 34^oC (maximum = 42^oC; and minimum = 16^oC). The low temperatures are experienced from

December to late February, when the North-East Trade winds (Harmattan) greatly impact the Municipality. The Municipality is located in the Guinea Savannah ecological zone, characterized by Savanna woodland which can sustain large scale livestock farming, as well as the cultivation of food crops such as yams, cassava, groundnuts, maize, cowpea and sorghum (Ghana Statistical Service, 2014a).

The second geographical area of focus in this study, Ada East is located in southern Ghana along the coastal savannah belt. The Ada East District is situated within the eastern part of Ghana's Greater Accra Region, with a total land area of 289.78 km^2. The District shares boundaries with the Central Tongu District to the North, South Tongu District and Ada West to the East and West respectively. It is also bounded by the Volta River south–eastwards, extending southwards to the Gulf of Guinea (Ada East District Assembly, 2018). Rainfall is generally heavy with an annual average of about 750mm. Temperatures are high throughout the year ranging between 23°C and 28°C with a maximum temperature of 33°C during the hot season. The District is very dry during the dry (Harmattan) season when there is no rainfall. Being surrounded by water bodies, humidity is often about 60 percent. Located in the Coastal Savannah zone, the vegetation is basically of the coastal savannah type, characterized by short savannah grasses and interspersed with shrubs and short trees (Ghana Statistical Service, 2014b). The coastal Savannah zones relative to the northern Savannah zones tend to be less dry or more humid due to proximity of the ocean.

In terms of health, both districts share some similarities with regards to their top 10 causes of outpatient morbidity. Listed in the order of magnitude, in 2015, Savelugu-Nanton had: malaria, upper respiratory tract infection, anaemia, pneumonia, acute urinary tract infection, diarrhoea, hypertension, joint pains, road traffic accidents, and skin diseases (Savelugu-Nanton District Hospital, field work, 2016). Whiles that of Ada East are upper respiratory tract infection, malaria, diarrhoea, rheumatism & joint pain, skin diseases, intestinal worms, acute urinary tract infection, anaemia, acute eye infections, and septicaemia (Ada East District Assembly, 2018). Savelugu-Nanton Municipal has 14 operational Community-Based Health Planning Services (CHPS) zones, 12 CHPS compounds, 3 Health Centers, 5 Clinics, and a District Hospital (Savelugu-Nanton Municipal Assembly, 2018), with the Ada East District having 8 CHPS compounds, 3 Health Centers, 1 Clinic, and a District Hospital (Ada East District Assembly, 2018).

Although the two locations are Savannah, one is projected to face more dramatic increases in temperature from climate change. Current projections of climate change effects in Ghana vary between southern and northern parts of the country (McSweeney et al., 2012; Stanturf et al., 2011). The national mean annual temperature is projected to rise by about 4.8°C on average from 1990 to 2100 (WHO, 2016). Meanwhile, the northern part of the country is projected to experience more dire impacts with relatively higher and more rapid temperature than the coastal regions (McSweeney et al., 2012).

Ecological, climatic and socio-economic factors shape differences in disease profile and in-service utilization pattern across the geographical belts of the country. In Ghana, there is a spatially uneven regional development ('north-south' divide). The northern region is characterised by a history of underdevelopment, food insecurity, and extensive poverty compared to the southern sector (Aryeetey, Owusu, & Mensah, 2009). This uneven development has translated into underserviced and short-staffed health care system. In terms of health infrastructure, the Northern region within which the Savelugu-Nanton Municipal is located has 56 Clinics, 15 District Hospitals, 96 Health Centres and 13 Hospitals. The Greater Accra region within which the Ada East is located has 283 Clinics, 6 District Hospitals, 28 Heath Centres and 76 Hospitals. Whiles the Greater Accra region has 1,259 Medical Officers and 7,413 nurses with a population to doctor ratio of 1: 3,751 and a population to nurse ratio of 1: 637, the case is different for the Northern region: 211 Medical Officers, 4,966 nurses and a population to doctor ratio of 1: 13,877 and a population to nurse ratio of 1: 590 (GHS, 2017). Thus, these variations in regional development are likely to have diverse consequences in relation to addressing climate health-related risks in both study districts. Coupled with variations in climatic conditions and projections, they will pose significantly different challenges for local populations, health professionals and health systems in managing climate change health issues.

5.5 Methodology

5.5.1 Study Design

This study paper is part of a larger project which examined climate change-health linkages in Ghana among community members and health professionals. This study employed a mixed-method design (Creswell, 2014) by combining in-depth interviews and surveys, which enabled assessment of overlapping and different facets of health systems' preparedness for potential climate change impact. As suggested by Bryman (2006) and Creswell (2014), the combination of different methods allowed for a comprehensive understanding of health systems and health professionals' capacity and preparedness to climate change-health risks in our study districts. All participants provided informed consent to participate in the study.

5.5.2 Study Population

The sampling frame consisted of health professionals within public health facilities in the two study districts. Consistent with the objective of the study, which was to examine the preparedness of health systems for climate change impact at the local level, the study randomly selected health centres and hospitals in the two study districts. According to the Ghana Health Services, these health units at the district level are mandated to provide clinical care to local populations (Ghana Health Service, 2017). In each of the selected health facilities, the health personnel with birthday closest to the day of the survey, irrespective of the person's role in the facility and demographic characteristics, was selected. This sampling strategy promoted variability in our final data. For the in-depth interviews, medical practitioners/assistants, senior nurses, public health nurses and disease control officers in any of the randomly sampled health facilities were purposively sampled. Given that these calibre of health personnel are responsible for implementing health policies including climate change preparedness at the local level, it was important to capture their perspectives in the study. The final sample size for the study is constituted of 99 surveys and 20 in-depth interviews.

5.5.3 Data Collection

Data gathering was guided by the study design whereby both surveys and in-depth interviews were conducted concurrently to complement each other (Creswell, 2014). The survey was self-administered, and covered perceptions of public health risks associated with climate change, training of public health professionals on climate change and its health impact, perceptions of health systems and health professionals' preparedness and capacity to respond to climate-related health effects, and perception of effectiveness of reforms or actions to strengthen the health sector and health professionals to address potential climate change-health risks. Socio-demographic data on study participants were also obtained.

To evaluate the perceptions of climate change as a public health risk, three questions were asked: 1) Do you think there is a link between climate change and health? 2) Do you think climate change has impacts on human diseases or can cause changes in disease prevalence or outbreaks? 3) Do you believe climate change could impact the health sector? To operationalize capacity and preparedness, we examined the following: 1) health professionals' perception about the inclusion of climate change impact on infectious diseases in their work, 2) health professionals' perception about availability of climate change information to help them respond to the impacts of climate change on infectious diseases and health in general, and 3) training/workshop on climate change and health (e.g. impacts of climate change on infectious diseases and projected outcomes) received by health professional in their line of duty.

Qualitative in-depth interviews were used to gain a deeper understanding of existing preparedness levels and capacities of health professional and health institutions to respond to and manage climate-related health risks. Further, the interviews explored potential reforms and capacity building to better position health institutions and professional to more effectively respond to climate change risk. In-depth interviews were conducted to a point of thematic saturation (Baxter & Eyles, 1997). All interviews were audio-recorded with permission from respondents and later transcribed verbatim.

5.5.4 Data Analysis

Quantitative data was analysed using *STATA 14SE* software. Descriptive analysis of quantitative data was undertaken. Chi-square and Cramer's V statistics was performed to determine differences by location (Ada East and Savelugu-Nanton) across major questions examined in the study. To permit continuous immersion in the field data, analysis of transcribed interviews was manually conducted using hand coding which involved reading and re-reading of the transcripts along with associated field notes, and coding important texts (Miles, Huberman, & Saldana, 2014). Codes were developed and organized according to emergent themes.

5.6 Results

5.6.1 Quantitative Results

5.6.1.1 Sample Characteristics

The survey results show that, most respondents were nurses, aged between 18 to 30years, with a training college/Diploma degree, and were junior staff. A large majority was also specialized in general nursing practice. Most of them had worked in the health sector for less than 5 years. Men and women respondents were about the same number in our study sample. Respondents in Ada East District and those residents in rural areas were slightly more in the study (Table 5.1).

5.6.1.2 Climate Change as a Public Health Risk

Participants believed climate change has implications for human health. Approximately 95% of health professionals in both study districts explained a health risk: climate change poses potential threat to local populations. Over 90% of respondents in both districts agreed with the statement: climate change has impacts on human diseases or can cause changes in disease prevalence or outbreaks. Also, approximately 85% of respondents indicated that climate change could impact the health sector (Table 5.2).

Table 5.1: Participants Demographics

Characteristic	***N***	**(%)**	**Ada East District**	**Savelugu-Nanton District**
Gender				
Male	51	(51.52)	22 (43.14)	29 (56.86)
Female	48	(48.48)	30 (62.50)	18 (37.50
Age				
18-30	61	(61.62)	30 (49.18)	31 (50.82)
31-45	30	(30.30)	19 (63.33)	11 (36.67)
46-60	8	(8.08)	3 (37.50)	5 (62.50)
Education				
Training College /Diploma	79	(79.80)	44 (55.70)	35 (44.30)
Bachelors degree	16	(16.16)	6 (37.50)	10 (62.50)
Masters degree	4	(4.04)	2 (50)	2 (50)
Position in Health Facility				
Nurse	72	(72.73)	38 (52.78)	34 (47.22)
Community Health Officer	9	(9.09)	4 (44.44)	5 (55.56)
Midwife	8	(8.08)	3 (37.50)	5 (55.56)
Medical Officer/ Physician Assistant	7	(7.07)	5 (71.43)	2 (28.57)
Ward Assistant	3	(3.03)	2 (66.67)	1 (33.33)
Professional level within the position				
Junior	46	(46.46)	20 (43.48)	26 (56.52)
Intermediate	16	(16.16)	11 (68.75)	5 (31.25)
Senior	37	(37.37)	21 (52.53)	16 (43.24)
Specialty				
General Nursing	27	(27.27)	13 (48.15)	14 (51.85)
Public health	18	(18.18)	11 (61.11)	7 (38.89)
Maternal health	14	(14.14)	5 (35.71)	9 (64.29)
Emergency response and management	13	(13.13)	7 (53.85)	6 (46.15)
Infectious disease control	10	(10.10)	6 (60)	4 (40)
Clinical nursing	1	(1.01)	1 (100)	
Others	16	(16.16)	9 (56.25)	7 (43.75)
Length of time working in Health Centre (years)				
1-5	84	(84.85)	40 (47.6)	44 (52.4)
5-10	12	(12.12)	10 (83.33)	2 (16.67)
10-20	2	(2.02)	1 (50)	1 (50)
>20	1	(1.01)	1 (100)	
Length of time working in health sector (years)				
1-5	67	(67.68)	30 (44.78)	37 (55.22)
5-10	23	(23.23)	18 (78.26)	5 (21.74)
10-20	7	(7.07)	4 (57.14)	3 (42.86)
>20	2	(2.02)		2 (100)
Residential Locality				
Urban	44	(44.44)	20 (45.45)	24 (54.55)
Rural	55	(55.56)	32 (58.18)	23 (41.82)
Study Area				
Savelugu-Nanton (Northern Region)	47	(47.47)		
Ada East (Greater Accra Region)	52	(52.53)		
Observations				**99**

Table 5.2: Perceptions of Climate Change as A Public Health Risk

	Ada East District		Savelugu-Nanton Municipal		Statistics
Statements on climate change as a public health risk	**No (%)**	**Yes (%)**	**No (%)**	**Yes (%)**	**X^2 (df), Cramer's V**
Do you think there is a link between climate change and health?	2 (3.85)	50 (96.15)	1 (2.13)	46 (97.87)	(1) = 0.2481, Pr = 0.618 Cramer's V=0.0501
Do you think climate change have impacts on human diseases or can cause changes in their prevalence or outbreaks?	4 (7.69)	48 (92.31)	4 (8.51)	43 (91.49)	(2) = 0.0223, Pr = 0.881 Cramer's V=-0.0150
Do you believe climate change could impact the health sector?	8 (15.38)	44 (84.62)	7 (14.89)	40 (85.11)	(2) = 0.0046, Pr = 0.946 Cramer's V= 0.0068

5.6.1.3 Preparedness and Capacity

As shown in Table 5.3, most health professionals indicated they had incorporated concerns about potential impact of climate change on health in their work but had not carried out any research related to the phenomenon. For instance, while 63% of respondents in Ada East District, and 72% in Savelugu-Nanton Municipal indicated they have considered climate change-health information in their work, less than 10% of respondents in both study districts indicated carrying out climate change-health related research and how they can integrate in their work.

Moreover, 81% of respondents in the Ada East District and 91% in Savelugu-Nanton Municipal, reported not receiving training/workshop targeted towards climate change-related health risks. Given the limited training/workshop, it is not particularly striking that over two-thirds (65%) of professionals in each district reported not having enough information to respond to climate-related public health issues.

Overall, from the quantitative results, it emerged that there was no significant difference among the respondents across the two study districts in terms of the issues that this study examined based on the statistical analysis carried.

Table 5.3: Perceptions of Preparedness and Capacity Towards Climate Change

	Ada East District			Savelugu-Nanton Municipal			Statistics
Statement	**Not considered**	**Considered but haven't conducted related research**	**Considered and conducted related research**	**Not considered**	**Considered but haven't conducted related research**	**Considered and conducted related research**	**X^2 (df), Cramer's V**
Have you considered the impact of climate change on climate sensitive-infectious diseases in your work?	14 (26.92)	34 (63.04)	4 (7.69)	9 (19.15)	34 (72.34)	4 (8.51)	(2) =0.8366, Pr = 0.658 Cramer's V= 0.0919
Statement	**No (%)**	**Yes (%)**			**No (%)**	**Yes (%)**	
Do you think that you have the information necessary to prepare for the impacts of climate change on infectious diseases and health in general?	36 (69.23)	16 (30.77)			31 (65.96)	16 (34.04)	(1) =0.1209, Pr = 0.728 Cramer's V= 0.0349
Have you received any training/workshop with regards to climate change and health issues (e.g. impacts of climate change on infectious diseases) in your line of duty?	42 (80.77)	10 (19.23)			43 (91.49)	4 (8.51)	(1) =2.3366, Pr = 0.126 Cramer's V= -0.1536

5.6.2 Qualitative Findings

Participants in our qualitative interviews were 12 males and eight females, aged between 30 to 55 years. The qualitative component of this study was used to gain a deeper understanding of health professionals' training on climate change and health, and their perceptions about the capacities as well as challenges faced by health systems in addressing and managing potential climate related emergencies and climate-sensitive infectious diseases. The qualitative component of the research was also to document potential reforms to equip health systems and professionals for future climate change related emergencies as well as improve climate change health outcomes in general. The research findings are presented under three broad areas: health training, perceived preparedness and capacities to manage climate change related emergencies and reforms or actions required. To ensure confidentiality of participants, quotes used are labelled with pseudonyms.

5.6.2.1 Climate Change-Health Training and Skill Building: Divided Perspectives

Training and capacity building is one important strategy for improving the preparedness and capacities of the health professionals to respond to the health implication of climate change (WHO, 2015). In examining this area in our study, we found varied, and somewhat divided perspectives about trainings on climate change received by participants. These perspectives covered three themes ranging from no training to adequate training received. The themes are presented below.

No training, shallow understanding, weak and poor response systems

A number of respondents, mostly from the Savelugu-Nanton Municipal, emphatically expressed the view that health professionals in the country were not being trained on the health implications of climate change. They hinted at a situation whereby disasters (e.g. floods) and increasing incidence of diseases (e.g. malaria) are often blamed on the usual causes – poor sanitation and low investment in infrastructure and environmental health. Participants explained that most health professional continue to address the clinical component of poor health in their communities because they had received no training on the implications of climate change on health, and as a result, they had limited understanding of the role of climate change on the changing health profiles of their communities. A senior nurse in one of the health centres in Savelugu-Nanton Municipal summarised his views about the trainings as follows:

> "There is no training on climate change for us. Workshops or dissemination of information [on climate change] to staffs is not happening. The last time I remember we received training was on Ebola. They came and talked about an hour about how to handle people and to protect ourselves from getting the infections, and in case we have a reported case how we can handle it. Apart from that, I have been working here for a long time but have not seen any training in this regard" [John-Savelugu-Nanton Municipal: 5 years in institution].

A participant from Ada East District echoed a similar sentiment:

> "As of now, we have not received any training [on climate change]. So, maybe they are yet to come with such trainings. We have had meetings in the District capital on health promotion, HIV, TB and others but not on climate change. Do you think we are supposed to be trained on that one at all?" [Akua-Ada East District: 2 years in institution].

According to this group of respondents, not having training on climate change have narrowed their understanding of the causes of poor health in their communities, and also impacted on how they plan and implement health services. A disease control office expressed this perspective:

> "… we have not received any training on climate change. Because of that we are doing our usual activities. Even though we know things might be changing because of climate change, it is not part of the plans since we do not clearly understand how it impact on health of our people" [Salifu-Savelugu-Nanton Municipal: 2 years in institution].

Little training, little impact

Although most participants reported never receiving training, others indicated they had been offered some training, which were not directly linked to climate change and health. A senior nurse in one of the health facilities had this to say:

> "We have not received training from outside our jurisdiction, but we mostly have workshop on health. In those workshops, they tell us the pattern of diseases. Then we will just incorporate that information into our work. But as an environmental person, an outside person coming to tell me about the climatic changes, no we haven't. But within the health sector when you go to a workshop, then they will look at the number of cases that you had within a particular month and how it is being reduced or increased. Then they will tell you that the weather also influences the increase or decrease of diseases. But we do not have an outside expert train us on the implications of climate change" [Abdullai, Savelugu-Nanton Municipal: 3 years in institution].

The impact of these type of workshops on the preparedness and capacities of health professional to respond to climate change health risk in local communities is very minimal, if any. As suggested above, there is not much difference between this group that believe they received some training and those that reported never receiving training on climate change in respect of how the training impact on health delivery in their districts towards potential climate change risks.

Unstructured training, minimal impact

The study found some health personnel acknowledging being given training on climate related health issues. However, these trainings were mostly carried out prior to national health programs such as national immunization campaigns or when there is an outbreak alert.

> "I will say yes. There have been, or we have been doing this education [training on climate change] with them [health personnel]. I think the knowledge is there." [Tetteh- Ada East District: working in institution for 13 years].
>
> "For instance, this meningitis, now the information has come from the regional to the sub-district. We have gone to the workshop, so our plan is to embark on intensive massive public education to explain the effect of the climate and the hot weather on the occurrence of these meningitis cases." [Kwame- Ada East District: 2 years in institution].
>
> "Yes, anytime there is an outbreak alert, there is sensitization of the staff on what to do and what to look out for. How to prevent re-infection and infection. We are all sensitized accordingly by the district health directorate. So, education is always ongoing for us. For instance, when the rainy season starts, they [district health directorate] start hammering on cholera issues because cholera is known to spread more quickly during the rainy season [Lydia- Ada East District: 5 years in institution].

As highlighted, workshops are often irregular, and the training modules are mostly focused on a specific disease outbreak. Even with that, the training assumes a clinical perspective with little emphasis on climate change effect. We found that respondents who reported having received some sort of training on climate related health effects indicated how they were also going to train other health personnel or embark on one-time activities such as immunization. Thus, the impact of these trainings on preparedness and capacity of health institutions and professionals to respond to climate change is minimal as they are not necessarily geared towards climate change and its health risks.

5.6.2.2 Climate Change-Induced Health Emergencies: Perceptions of Preparedness and Capacity

In assessing perceived preparedness and capacity towards climate change-health threats, the following scenario was presented to respondents: current climate change predictions indicate severe impacts on climate-sensitive infectious diseases such as malaria and cholera which are already of concern in Ghana. Thus, frequent and severe outbreaks of diseases, increased incidence of reported cases and potential emergencies from climate-sensitive infectious diseases are expected. Would you say that your outfit is prepared or in the position to deal with such a situation? Responses to the scenario are presented under two broad themes: perspectives to the effect that health institutions were prepared, and those that indicated that health systems were not in a position to respond to the heightened poor health situation.

Our health institution is prepared

Within this theme, two sub-themes also emerged. These are: we are fully prepared or in a position to respond; we are prepared or in a position to respond but faces some difficulties. Some of the respondents interviewed perceived their institutions to be fully prepared to handle any potential climate-related health threats. As expressed by a respondent, they have been dealing with the health risks, and were ever ready to address them although there may be some challenges:

> "In fact, I will say yes [we're prepared for climate change health threats] in this district. Because we have knowledge and medications for all these infectious diseases, we are prepared. It may not be enough though. When the outbreak increases, maybe that is where we will be lacking. But we think that whenever anything like that comes and we put in our proper measures, we should be able to contain them. Note that, in Ghana, malaria and other diseases are something that we have long been treating. So maybe the burden will be higher on the facilities, so we need to buy more logistics, recruit more people and other things. Maybe that is where we may be lacking" [Tetteh-Ada East District: 13 years in institution].

While this group of respondents highlighted limited resources and personnel as major challenges that could impact the preparedness and capacity of health facilities to respond to climate health risk, it is also important to note the assumption that preparedness as reported was in respect of known health risks and diseases. However, as climate change would likely contribute to the emergence of new or uncommon diseases, the current purview of Ghana's health system maybe inadequate to respond to climate change health risk.

Furthermore, some respondents expressed full preparedness. They indicated having the needed support, the necessary human resources and strategies in place to help address the health threats from climate change:

> "We have a public health unit and they take such matters [climate change] into their planning. They work on things like communicable diseases, and how to respond to their epidemics. Aside that, we have a district disease control unit. The unit collects data for disease surveillance purposes; taking stock of diseases outbreaks, why these [outbreaks] are happening and where they were occurring. With the help of other units, I think we shouldn't be found wanting when there is an outbreak of diseases. We are not only trained to treat it [disease outbreak] but to find out the causes and see how best we can stop its spread" [Elinam, Ada East District: 3 years in institution].

Other respondents reiterated similar views:

> “We have adequate measures and systems in place to respond to climate change health risk, because we have trained people in a program called ETAT (Emergency Triaging Assessment and Treatment). So, we have a team in place that responds to emergency issues. I mean disease outbreaks, which need immediate attention. The team is everywhere; we have them at our patients’ department, kids' ward, female ward and then maternity ward. So, we have trained staff, and logistics, we don’t have much, but the little that we have we will be able to at least cope with outbreaks.” [Emmanuel, Savelugu-Nanton Municipal: 4 years in institution].

We are not ready for climate change health effects as yet

Health professionals also made mention that, they are not prepared to deal with potential climate emergencies:

> “We will not be able to help. Even with cholera we don’t have separate areas for patients, when we are supposed to nest them in a secluded area. We also don’t have the staff strength to be able to deal with it. Ideally, any staff that comes into contact with a cholera patient, should not attend to other patients in order to reduce the infection rate, but we don’t have the enough staff numbers to spare” [Lydia-Ada East District: 5 years in institution].

Other health professionals also bemoaned the challenges that they faced in delivering even basic health services in the country, and concluded they were not in any way going to be ready for the impact of climate change on the health of local populations. Respondents made this assertion because most of the roles that were supposed to be filled in health facility did not have qualified staff to fill them. Vacancy in positions meant that facilities were restricted and incapable to respond to the impact of climate change on health of local communities. This was articulated in an interview by a respondent in a health facility in Savelugu-Nanton District:

> "A Health Centre cannot be in a position to handle climatic change conditions. Climatic change conditions are mostly highly unpredictable, even before you realize, they are at their highest peak and you have to refer to a higher level. So, if I get the slightest sign and symptom of a meningitis case, I cannot joke with it. But if it's watery stool like diarrhoea and I am suspecting cholera, I can give the patient a first aid treatment and refer the patient elsewhere. So, at the health sector, we operate at our different levels, we have Level A, B, and C and we belong to the level B group. So, if there is a climatic change condition, I wouldn't say malaria because malaria is not all that a climatic change condition because it has been occurring for a whole time now, but real climatic conditions, I have to refer" [Yusifu, Savelugu-Nanton Municipal: 6 years in institution].

Apparent in the response of the health officer is the notion that climate change health risk is related to particular diseases, which did not include malaria and diarrhoea. This posture demonstrates poor understanding of the complexity involved in the occurrence of diseases under climate change effect, even among some heads of health institutions. Couple with limited health resources and personnel, these institutions are less prepared for health risk arising from climate change. Overall, the study found that, health professionals within the higher level of health delivery (District Hospitals) in the study districts acknowledged being prepared to deal with climate emergencies compared to those at the lower level (Health Centres). However, both levels declared they might have some challenges in addressing climate emergencies.

5.6.2.3 Perceived Reforms and Actions Required for Adequate Response to Climate Change

In spite of the contrasting views expressed about the level of training on climate change and the preparedness of health institutions to respond to climate change health risk, our study participants agreed there was an urgent need for reforms in the health sector in light of looming climate change impact on the health of local populations. The study found two major themes emerging from the interviews: knowledge and skill building, and provision of logistics and infrastructure. Most of study respondents (more than 50%) explained that, workshops, sensitization, and trainings related to climate change and its health implications were needed to help equip the capacities and preparedness levels of health professionals and institutions.

> "…. you cannot try to solve the problem [climate change-health risk] without even knowing much about it. But many of us don't know much about climate change. So, first of all, we must get some training and sensitization about it, especially about what causes it, and the effects it has on us, and the local communities we serve. I think, again, there should also be a good relationship between the hospitals and the District Health Management Teams to foster regular training and transmission of climate change information from the national to the local and vice versa" [John-Savelugu-Nanton District: 5 years in institution].

Furthermore, respondents expressed the following views about the need for provision of more logistics to address climate change health risk. As an illustrative comment, a respondent in Ada East District commented:

> "We need lots of logistics, and motivated staff to effectively address climate change. I say this because sometimes we are overwhelmed by the outbreak of diseases and other health complications. We also need modern health infrastructure and equipment's to monitor disease profiles at the local level so that we strategize to address any new cases" [Asamoah, Ada East District: 8 years in institution].

Other respondents made comments that captured the above two themes explicitly, as illustrated in the following comment:

> "We anticipate that, there should be provision of logistics. There should be more resources pushed into the health sector to carry out research. Then at the health centres and the district hospitals, there should be training of staffs on regular basis so that they can be able to carry out all the reforms needed. There should be provision of logistics, training of staffs and recruitment of staffs (relevant staffs). So, if there is recruitment of staffs and trainings, on a regular basis and the provision of resources, it would go a long way to help. I will conclude that we need a policy on climate change and health to capture all that I have mentioned already, and the policy should be implemented" [Emmanuel, Savelugu-Nanton Municipal: 4 years in institution].

Overall, health practitioners acknowledged weak preparedness and capacities to address climate-related health risks in the form of inadequate knowledge, lack of human resource, logistics and infrastructure. Health practitioners therefore called for urgent reforms and actions in these areas to help equip them and the health sector to address any potential climate-related health risks and emergencies in Ghana.

5.7 Discussion and Conclusion

The purpose of this mixed method study was to evaluate health professionals' perceptions of climate change as a public health risk, current preparedness levels and capacities of health institutions to respond to climate-related health emergencies, and potential reforms or actions required in the health sector to strengthen health systems for climate change action. Our findings demonstrate that, health professionals in our study districts perceive climate change as a public health threat. There was a near consensus that, climate change has links with health and could impact the prevalence and outbreaks of human diseases. In addition, there is a general consensus among health professionals that the increasing incidence of climate change health risks could over-stretch the already weak health sector in the country, and adversely impact health delivery.

Several possible explanations could be provided for our findings. In Ghana, most out-patient reported diseases are climate-sensitive in nature (e.g. malaria) and prevalence of these diseases has been reported to be rising in the country (GHS, 2016). Thus, it is likely health professionals anticipate more severe health threats from climatic change or climate variability on local populations and the health sector. Health providers perceiving climate change as a public health threat have been reported in prior studies in the United States (Carr et al., 2012; Roser-Renouf et al., 2016). In particular, Carr et al. (2012) found in their study that thirty-nine percent of Local Health Department Officials in New York perceived climate change as a pertinent threat to public health in the coming two decades.

Although the majority of health professionals indicated climate change is a public health threat, they reported poor knowledge on the issue. Two-thirds of our study respondents indicated not having enough information to respond to climate-related public health issues in both districts. These findings are consistent with Bedsworth (2009) study, which reported that, although most public health officers acknowledged that climate change poses a serious threat to public health, they did not feel well equipped in terms of resources and information to cope with the threat. Poor knowledge reported in our study could be because of the lack of, or insufficient knowledge and skill building activities on climate change and health. As evidenced in the surveys, a large majority of respondents indicated not receiving climate change and health trainings or workshops and this was confirmed by findings from the qualitative component of the study.

Even though our study districts are located within regions with different development levels, with its resulting health systems challenges, our study findings indicate that, health systems capacity and preparedness levels towards climate change-health risks do not differ across the study contexts. Health professionals' capacities and preparations for climate change-related health threats are limited by a number of factors as illustrated by our study findings. These include insufficient logistics, human resource, and low knowledge levels. Similar to our findings, Roser-Renouf et al. (2016) found many city and county health department directors reporting lacked expertise and resources to address the local public health impacts of climate change in the United States. Also, Polivka et al. (2012) found in their study in the U.S. that local populations perceive their public health nursing division did not have the ability or preparedness to address health-related issues due to climate change.

In addressing the impacts of climate change in Ghana, the focus has largely been on the agricultural sector with the health aspects sidelined. As of the time of our study, there was no official focal point for climate change and health in Ghana, as was acknowledged by the WHO report on climate and health country profile for Ghana (WHO, 2016). Further, a Lancet (2018) report indicates that, national assessment of climate change effects, vulnerability, and adaptation for health has not been conducted in Ghana (Watts et al., 2018). According to Watts et al. (2018), assessment of climate change vulnerabilities would help governments recognize, more precisely, the extent and magnitude of potential threats to health from climate change, the effectiveness of current adaptation and mitigation policies, and future policy and program requirements. The lack of focal point at the Ministry of Health, and lack of implementation of funding commitment for climate change heath impacts (WHO, 2016) could probably be due to the absence of a national vulnerability assessment. Also, lack of sustained skill building and strengthening of technical capabilities of health professionals on climate change and health could in part be explained by the absence of a national vulnerability assessment. Moreover, our knowledge of Ghana's climate change health vulnerabilities, and its spatial distribution has been limited. The ultimate effect of this could be witnessed in the poor preparedness and low resilience of the health system for climate change health impacts.

As with most studies, there are a number of limitations that should be considered when interpreting the results of this study. Although findings from the qualitative component confirmed and further explained findings from the surveys, they cannot be representative of all health personnel in our study districts. Also, the survey was cross sectional and as such, views reported by participants only represents the context of the study and does not represent causality.

Despite these limitations, this study has generated rich description as well as in-depth account of health professionals' preparedness and capacity to respond to climate change. By employing mixed methods, this study highlights nuances relating to Ghana's weak responsiveness towards climate change-health threats, which has been missing in the current literature. Using two distinct study sites with different ecological conditions in our study has supported the suggestion about capturing the views of health professionals in diverse contexts and environments, which have health policy imperatives. Our findings serve as important basis for the development of climate change-health adaptation and health sector resilience building programs in Ghana.

First, this study calls for an urgent need to strengthen the technical and professional capacity of health professionals on climate change and health through training programs and workshops. The lack of adequate information and training on climate change and health reported in the study is of great concern to sustenance of public health in Ghana. Especially, in the face of climate change and with recommendations from WHO for proactive policies on climate change health risks, Ghana urgently needs a comprehensive policy on climate change and health. Among the many components of the policy should be the development and implementation of emergency response, training and capacity development of health professional, infrastructural and logistical development, climate change research, and sustainable funding mechanisms for climate change and health. These in part would contribute towards the achievement of existing international agreements such as the Paris Climate Change Accord, and also protect and sustain health of local populations in the country.

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CHAPTER SIX

PRIORITIZING CLIMATE-SENSITIVE INFECTIOUS DISEASES UNDER A CHANGING CLIMATE: A MULTICRITERIA EVALUATION ANALYSIS APPROACH

Abstract

Globally, climate change is impacting the incidence and distribution of climate sensitive infectious diseases (CSIDs). The effects of climate change on infectious diseases are an important public health concern and necessitate effective prioritizing of resources for optimal responses. This is especially for the developing world context where basic health services and capacities are challenged. Currently, this prioritization of resources for effective response is a major challenge to public health. To develop a coherent response to the potential incidence of climate-related outbreaks, and to longer-term altering disease patterns, there is the need for improved information upon which to base the mainstreaming of climate change into health planning. An essential way through which such information can be generated is prioritizing disease risks vis-à-vis public health threats under climate change. Using Ghana as a case study, a multicriteria evaluation (MCE) approach was used to assess CSIDs that present the greatest risks and threats to public health under climate change based on a set of disease prioritization criteria. MCE provides a standardized and a transparent way and reduces the complexities involved in the process. Expert opinion, morbidity data on CSIDs and data from literature was utilized to undertake the disease prioritization. From the assessment, it emerged that epidemic prone CSIDs: diarrhoea, cholera and meningitis pose the greatest risks to public health. This prioritization provides a glimpse of the risks and threats that prevailing CSIDs would pose to public health under climate change. Further, it provides a preliminary model that can guide public health decisions in Ghana and other similar contexts in the developing world.

6.1 Introduction

In the last two decades, climate change has featured prominently on the global agenda and is arguably one of the extreme environmental challenges in recent history. One of the major areas that has garnered public attention in relation to climate change impacts is health (Costello et al., 2009). Many human health effects have been predicted to result directly or indirectly from climate change. The prediction is based on the fact that infectious agents, vector organisms, non-human reservoir species, and rate of pathogen replication are sensitive to climatic conditions (Githeko et al., 2000; Khasnis & Nettleman, 2005). Human health and well-being are particularly vulnerable because of the expected increase in incidence and geographic spread of climate sensitive infectious diseases (CSIDs). Indeed, projected increases of vector-borne and diarrhoeal diseases, emergence of new infectious diseases and re-emergence of old ones have been well outlined (Costello et al., 2009; IPCC, 2014; WHO, 2014). Overall, global climate change is projected to trigger the spread of infectious diseases into new regions and increase the intensity of diseases in regions where they are endemic.

Climate change impacts on infectious diseases is a major concern because infectious diseases already account for a significant share of the global burden of diseases, especially in low- and middle-income countries (Abubakar, Tillmann, & Banerjee, 2015). The consequences of the multi-dimensional and complex health burdens from climate change impacts on infectious diseases are enormous and would pose significant challenges to both human health and health systems. It will also cause societal impacts as well as economic strain that may deflect public resources from other pressing health challenges (Khasnis & Nettleman, 2005).

In most developing countries, basic public health services, capacity, and resources are already a major challenge for their health systems. As such, addressing the extra disease risks and burdens from CSIDs under a changing climate would further challenge the health systems in these countries. However, the anticipated increases in the occurrence of infectious diseases call for prioritization of resources for optimal response and right choices (Kapiriri & Martin, 2007). In most developing countries, choices must be made within the context of limited financial and health care resources. Thus, to inform strategic planning by enabling effective resource allocation to manage disease risks from climate change impacts, disease prioritization is vital. Prioritization frequently aids as an initial step in aligning efforts and guiding public health decisions (Hongoh et al., 2017). Prioritization is also needed to enable decision makers to make the best use of limited human and financial resources for disease surveillance, prevention and control. And disease prevention and control are important in order to reduce adverse consequences of climate-related risks on human population. Effective disease control and prevention measures entail prioritizing potential disease risks and identifying those of national relevance, which by and large varies based on disease threats and burdens, endemicity, vulnerability and adaptive capacities to them.

Given the observed and predicted detrimental health impacts of climate change on infectious diseases and its potential consequences now and in the future, attempts have been made to identify and prioritise infectious pathogens in the context of climate change. For instance, Cox, Sanchez, and Revie (2013) have documented the emergence or re-emergence of infectious diseases in Canada in the era of climate change. Others include, Hongoh et al. (2016) who undertook prioritization of the public health impact of CSIDs in Quebec and Burkina Faso.

Studies have already acknowledged the impact of climate change on infectious diseases in many developing countries (Chaves & Koenraadt, 2010; Pascual et al., 2006). What is unknown is how risks and burdens to human population and health systems will be of differing values. In many developing countries, infectious diseases remain a threat to health system and human productivity. In Ghana for instance, epidemics of cerebrospinal meningitis and diarrhoeal diseases, lymphatic filariasis, onchocerciasis, schistosomiasis and human African trypanosomiasis continues to pose an immense public health challenge (Ghana Health Service [GHS], 2016, 2017). As well, malaria continues to rank first among the top twenty causes of outpatient morbidity as well as the top ten causes of all admissions nationally (GHS, 2017).

Against this backdrop, there is the need to identify those diseases with the likelihood of posing a major risk to public health under a changing climate conditions in order to minimize their risks and burdens. Although, studies on climate change-infectious disease nexus is growing steadily in developing countries (e.g. Codjoe & Larbi, 2015; Ayanlade, Adeoye, & Babatimehin, 2010; Adu-Prah & Tetteh, 2014), prioritization of infectious diseases within the context of climate change is missing in the current scholarly works.

Using Ghana as a case study, this study seeks to prioritize CSIDs within a developing world context for policy attention by identifying diseases of national relevance to public health under climate change. Specifically, the study addressed the following questions: (1) which CSIDs are likely to pose the greatest health risks to public health in Ghana under climate change conditions? And (2) what is the efficacy of multicriteria decision making/evaluation method in prioritizing CSIDs for policy attention? The study aims at identifying CSIDs that might pose the greatest risk and threats to public health due to climate change inducements, based on a set of disease prioritization factors. This prioritization would assist to inform and structure decisions during the planning process of public health adaptation strategies towards climate change infectious disease risks in Ghana and elsewhere in the developing world.

For effective management of CSIDs, policy makers and health systems need to prioritise disease risks that would need immediate planning and adaptation. Rational priority setting necessitates understanding of a multifaceted system, as diverse criteria and priorities will impact the choice to address a specific disease threat under a changing climate. Objective methods are required to address this multi-dimensional problem, and multicriteria decision making and evaluation techniques is suitable for addressing these challenges. Multicriteria decision making and evaluation methods provide a systematic way to integrate information from a range of sources, taking the various criteria into account simultaneously and a structured method of comparing and ranking alternative decisions (infectious diseases). Further, the evaluation process of prioritizing CSIDs with the greatest risks and burdens to public health under climate change impacts calls for a multi-sectoral approach, as multiple stakeholders and experts share responsibilities with regards to public health actions for disease control and prevention. Multicriteria decision making and evaluation methods can incorporate this multiple stakeholder/ expert perspectives and intelligence into the decision-making/evaluation process. As a result, future actions such as policies and interventions that would arise out of the prioritization process are comprehensive and justified as they reflect intelligence from different stakeholders and experts with different agendas.

CSIDs as used in this study entail "communicable diseases, usually vector-borne, waterborne, foodborne, or airborne diseases, with a component of their transmission that is sensitive to changes in temperature or precipitation and related environmental variables (e.g. humidity, length of growing season)" (Michel, 2016:6).

The next session gives a brief overview of multicriteria evaluation/decision analysis. This is followed by the framework guiding the disease prioritization, a discussion of results and policy recommendations.

6.2 Multicriteria Decision Analysis/Evaluation Method

Multicriteria decision analysis (MCDA) is a family of techniques that aid decision makers in formally structuring multi-faceted decisions and evaluating the alternatives (Greene, Devillers, Luther, & Eddy, 2011). MCDA is "a collection of formal approaches that seek to take explicit account of (key factors) in helping individuals or groups explore decisions that matter" (Belton & Stewart, 2002: 2). MCDA aids decision makers in analysing potential actions or alternatives based on multiple incommensurable factors ⁄ criteria, using decision rules to aggregate those criteria to rate or rank the alternatives (Malczewski, 1999). MCDA helps to deal with the difficulties that human decision-makers have in handling large amounts of complex information in a consistent way.

MCDA can be performed with a single actor or decision-maker involved in the process or can be extended for use in a group decision context with multiple stakeholders (Belton & Stewart 2002; Malczewski & Rinner, 2015; Hussey & Malczewski, 2018). MCDA provides transparency and support for multiple stakeholder participation in order to evaluate a set of alternatives using both quantitative and qualitative criteria. Belton and Stewart (2002) classified MCDA into three main stages: problem identification and structuring; model building and use; and the development of action plans. The problem identification and structuring phase consist of the various stakeholders and experts who develop a common understanding of the problem, of the decisions that must be made, and of the criteria by which such decisions are to be judged and evaluated. Model building and use phase involves development of formal models of decision maker preferences, value tradeoffs, goals, and so forth, so that the alternative policies or actions under consideration can be compared relative to each other in a systematic and transparent manner. The final phase of development of action plans involves the implementation of results; that is, translating the analysis into specific plans of action.

Although MCDA techniques have found wide application in several areas over the last few decades, their use is still limited and relatively recent in public health fields (Hongoh et al., 2011). In public health and epidemiological research, studies have used MCDA to study a compilation of decision problems including assessing vulnerabilities to infectious diseases (Vinhaes et al., 2014; Tran et al., 2013; de Oliveira et al., 2015), and prioritisation of health intervention to infectious diseases (Aenishaenslin et al., 2013). Currently, one of the emerging application areas under public health relates to climate change and health. Under this theme, Cox et al. (2013) used

MCDA to prioritize emerging and re-emerging infectious diseases with regards to climate change in Canada, whiles Hongoh et al. (2016) used the method in prioritization of the public health impact of CSIDs in Quebec and Burkina Faso.

Despite its evolving application within the field of epidemiology and public health, studies have not integrated multicriteria evaluation methods within this area of research. For instance, within the climate change and health field, the MCDA methods adopted for the assessment includes PROMETHEE (Preference Ranking Organization METHod for Enrichment of Evaluations) and MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) which uses an additive aggregation approach (Cox et al., 2013; Hongoh et al., 2016).

In the present study, we draw on another MCDA method, Analytic Hierarchy Process (AHP). The AHP method allows structuring of the decision problems to enable capturing of the complexities between evaluation criteria to be used for the assessment. An important benefit that AHP has relative to other methods is its practicability to consider decision processes adequate to reality; that is, with multiple actors (Ossadnik, Schinke & Kaspa, 2016).

6.2.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is one of the most comprehensive methods of multicriteria decision analysis developed by Saaty (1980). AHP is used to derive relative priorities on absolute scales from both discrete and continuous paired comparisons in multilevel hierarchic structures (Saaty, 2006). AHP method adopts a hierarchical structuring of the decision or evaluation problem. AHP is based on three principles: principle of *decomposition* (problem structuring), *comparative judgment* (pairwise comparisons), and *synthesis* of priorities (Malczewski & Rinner, 2015). The decomposition principle necessitates that a decision problem be decomposed into a hierarchy that captures the essential elements of the problem. The principle of comparative judgment requires assessment of pairwise comparisons of the elements within a given level of the hierarchical structure, with respect to their parent in the next-higher level. The synthesis principle takes each ratio scale derived local priorities from the various hierarchical levels and constructs a global set of priorities for the alternatives at the lowest level of the hierarchy (Malczewski, 1999; Malczewski & Rinner, 2015). Based on these principles, there are three major steps that are involved in AHP: developing a hierarchy, assigning weights to decision alternatives based on pairwise comparison and constructing the overall priority of the alternatives.

Based on these steps, the AHP procedure requires that first; the decision problem is decomposed into a hierarchy that consists of the most important elements of the decision situation. Usually, the hierarchical structure consists of four levels: goals, objectives, attributes and alternatives. The top element of the hierarchy is the overall goal for a decision; multiple criteria that define alternatives are in the middle, with competing alternatives listed in the bottom level of the hierarchy (Yoon & Hwang, 1995). This is the level at which decision alternatives are evaluated. When criteria are highly abstract, sub-criteria, and sub sub-criteria are generated sequentially through a multilevel hierarchy.

The next step involves comparing the decision elements on a pairwise base. Pairwise comparison is the basic measurement mode adopted in AHP. Pairwise comparisons are easier to make than comparing criteria simultaneously. They are made based on a nine-point intensity scale of importance between two elements (Saaty, 2006). The points on this scale are defined quantitatively and then translated using a standard scheme into numerical measures of the relative degree of preference of A with respect to B. Specifically, the quantitative descriptions of preferences and corresponding numerical measures are: 1 (equal importance), 3 (moderate importance), 5 (strong importance), 7 (very strong importance), and 9 (extreme importance). If there is a need, then one can use intermediate scores and corresponding descriptions of preferences; that is, 2 (weak importance), 4 (moderate plus importance), 6 (strong plus importance), and 8 (very, very importance). The pairwise comparison procedure involves development of a comparison matrix at each level of the decision hierarchy (this matrix is reciprocal, and all its diagonal elements are unity), computation of the weights for each element by retrieving the weights of each element in the matrix (one of the most often used approach is the procedure of averaging over normalized columns) and estimating the consistency ratio (Malczewski, 1999). The process of estimating consistency ratio assumes that, decision maker's values and judgements regarding the decision criteria and alternatives might be inconsistent. The pairwise comparison method allows for same degree of inconsistency in a set of comparisons. The consistency ratio can be defined as follows: $CR = (\lambda_{max} - n)/ (RI (n - 1)$; where, *RI* is the random index - the consistency index of a randomly generated pairwise comparison matrix. It can be shown that *RI* depends on the number of items being compared. For example, for n = 2, 3, 4, 5, 6, 7, and 8, RI = 0.00, 0.52, 0.89, 1.11, 1.25, 1.35, and 1.40, respectively (Saaty, 1980; Saaty, 2008). The consistency ratio $CR < 0.10$ indicates a reasonable level of consistency in the pairwise comparisons; if, however, $CR \geq 0.10$, then the value of the ratio is suggestive of inconsistent judgments. In such cases, the decision maker needs to reconsider and revise the original values in the pairwise comparison matrix.

The final stage of AHP is to aggregate the relative weights of the pairwise comparisons to produce composite weights. This process involves using the priorities obtained from the comparisons to weight the priorities in the level immediately below. This is done for every element. Then each element in the level below, the weighed values are added and then obtain its overall or global priority. Process of weighting and adding is continued until the final priorities of the alternatives in the bottom most level is obtained (Malczewski, 1999).

AHP as a multicriteria method is aimed at supporting decision-making processes in individual and group contexts. The decision problem evaluated within this study falls under group decision making. A group decision making problem is defined as a "decision problem where a group of decision makers express their judgments on a finite set of alternatives to achieve a common solution" (Dong & Saaty, 2014: 362).

6.3 Study Area

The geographical setting of this study is Ghana. Ghana has a tropical climate with temperatures and rainfall patterns that vary according to distance from the coast and elevation. The eastern coastal area is relatively dry, the southwestern corner is hot and humid, and the north of the country is hot and dry. The average annual temperature is typically high about 26ºC (GSS, GHS, & ICF, 2015). Seasonal variations in temperature in Ghana are greatest in the northern part of the country, with highest temperatures in the hot, dry season (February to May) averaging 27-32^{0}C, while the lowest (25-27ºC) is recorded in July through September. However, in the southern part of the country, temperatures range between 22^{0}C to 28^{0}C (McSweeney et al., 2012; Stanturf et al., 2011).

There are two distinct rainy seasons in the southern and middle parts of the country, from April to June and September to November. The North is characterised by one rainfall season that begins in May, peaks in August, and lasts until September. Annual rainfall ranges from about 1,015 millimetres in the North to about 2,030 millimetres in the Southwest (GSS, GHS, & ICF, 2015). Rainfall variability increases while amount decreases from the southern to the northern part of the country. The wettest zone is the southwest corner of the country, where annual rainfall reaches 2000 mm. In contrast, the annual rainfall in the dry savannah zone in the northern part of the country is well below 1100mm (EPA Ghana, 2011).

Climate models and projections show signs of climate change in Ghana and confirms the country's vulnerability. An increase of 1^0C has been observed over the past 30years (EPA Ghana, 2011). The national mean annual temperature is projected to rise by about 4.8°C on average from 1990 to 2100 (WHO, 2016). Projections of mean annual rainfall average indicate a wide range of changes in precipitation for Ghana. Seasonally, the rainfall projections lean towards decreases in January, February, March and April, May, June rainfall and increases in July, August, September and October, November, December rainfall (McSweeney et al., 2012). These climate projections for the country are likely to have diverse consequences in relation to climate health-related risks especially for CSIDs.

6.4 Methodology

This study is part of a larger project which examined climate change-health linkages in Ghana, focussing on community members and health professionals. The methodological approach used to prioritize CSIDs within this study involved four general steps. The first was the identification of diseases to be used in the prioritization, followed by identification of evaluation criteria to be used. The third involved data collection, and finally, determination of priorities and ranks for the CSIDs using the AHP multicriteria method.

6.4.1 Identification of Infectious Diseases

Based on the focus of this prioritization exercise, nine CSIDs prevalent within the Ghanaian context were selected: malaria, diarrhoea, typhoid fever, schistosomiasis, cholera, meningitis, trypanosomiasis, onchocerciasis and yellow fever. These diseases were of interest because, they are of public health significance in Ghana with some (e.g. malaria and diarrhoeal) having extremely high burdens (GHS, 2017; GHS/MoH, 2015). In addition, these diseases have been projected to be potentially induced by climate change (Costello et al, 2009; IPCC 2014). See supplementary material (Appendix C: 6.1) for disease characteristics.

6.4.2 Identification of Evaluating Criteria

Informed by previous disease prioritization literature (e.g., Cox, et al., 2013; Krause, 2008), a set of the most commonly used prioritization criteria relevant in the context of climate change and applicable in the Ghanaian setting were selected (Table 6.1). The identified criteria included a comprehensive list of 15 criteria spread across five general categories: Disease Epidemiology (3 criteria); Disease Burden (3 criteria); Epidemiological Dynamic (2 criteria); Health Gain Opportunity (4 criteria); and Impacts (3 criteria).

Table 6.1: Evaluation Criteria for Prioritization of Climate Sensitive Diseases in Ghana

CRITERIA CATEGORIES	ATTRIBUTES
A. Disease Epidemiology	
A1. Endemicity	Endemic levels of disease in Ghana
A2. Mode of Transmission	Direct, indirect via environmental reservoir or vector-borne.
A3. Geographic Distribution	Geographical coverage of disease in Ghana
B. Disease Burden	
B1. Incidence	Current incidence of human disease in Ghana -average number of new cases in the last 5 years.
B2. Severity	Severity of disease in the general human population (mild, moderate or severe); loss of worktime and disability associated with disease).
B3. Mortality/Human Case Fatality	Average number of deaths associated with disease as a percentage of recorded diseases per year
C. Epidemiological Dynamic	
C1. Trend	Looking at disease incidence for the past five years-whether cases are diminishing, increasing etc.
C2. Outbreak Potential	Outbreak potential of disease if climate change induced and its ability to spread rapidly.
D. Health Gain Opportunity (Monitoring, Treatment and Diagnosis)	
D1. Treatability	Ability to treat disease in humans in Ghana (availability and effectiveness of treatment- that would enable ability to deal with exacerbation of cases due to climate change).
D2. Preventability	Ability to prevent disease in Ghana (e.g. by vaccination or public health education).
D3. Surveillance	Effectiveness of national surveillance
D4. Ability to Diagnose	Ability to diagnose disease in Ghana (availability and sensitivity of diagnostic tests).
E. Impacts	
E1. Economic	Potential economic impact (e.g. cost for control, health care, etc.)
E2. Environment	Potential environmental impact in terms of disease control (e.g. impact on air, water, soil, landscape and biodiversity).
E3. Social	Potential societal impact, (e.g. level of anxiety of the general population, impact on social gatherings and activities, changes in behavior).

6.4.3 Measuring and Collecting Data

Both primary and secondary data were collected and used in the prioritization procedure. Secondary data consisted of morbidity data on the selected CSIDs (Supplementary materials: Appendix C: 6.2). Primary data were collected through a survey (expert opinion). A questionnaire was designed to obtain weighted scores for each evaluation criterion and disease. The questionnaire is made up of Likert scale questions for assessing the CSIDs on the criteria attributes and a pairwise comparison scale for evaluating the criteria based on the AHP method. A measurement scale as used by previous studies (Cox et al., 2013; Hongoh et al., 2016; Krause, 2008) were developed and presented to the research participants to help them better evaluate these criteria. The questionnaire was administered to experts who were asked to evaluate the criteria according to their importance in prioritising CSIDs in Ghana. A description was provided to each criterion attribute to provide a clear definition, in order to minimise the variability in interpretation of criteria between experts. Experts were also asked to assess the selected CSIDs on a list of criteria attributes according to their public health threats.

A questionnaire was used to obtain the expert opinion (value judgement) instead of other methods like a focus group. This was because, individually handing out survey questionnaires to experts allows for honest opinions to be conveyed without influence from other experts. It also gives the experts the advantage of completing the survey at their convenience (Sahin, Mohamed, Warnken, & Rahman, 2013). Experts in infectious disease epidemiology and climate change research were identified in three ways: through an internet search on relevant organizations' websites; recommendations from other participants; and literature search.

Experts are defined as any individual whose disciplinary and professional background (work, research, or expertise) contains the subject under investigation (infectious disease epidemiology and research, and/ or climate change). Experts were recruited to take part in the research through an email or telephone call (where contact details were available) and personal contact. The aim, method and use of the study were explained to the research participants. After follow-up calls and emails, seven experts completed and returned the questionnaire. Experts that completed the questionnaire had backgrounds in epidemiology, public health/environmental research, health research, medical research/ enteric viruses & molecular biology, and biomedical research (epidemiological disease control) and were from academic and/ research institutions and background, and a non-governmental organization. The experts involved included professors and scientists from leading universities and research institutes in Ghana, including University of Ghana, Noguchi Memorial Institute for Medical Research and World Health Organization (see Supplementary materials: Appendix C:6.3 for experts' characteristics).

6.4.4 Determination of Weights of Evaluation Criteria and Priorities of CSIDs

Multicriteria evaluation (MCE) method was employed for the determination of weights of evaluation criteria and prioritization of the CSIDs. MCE is employed as it provides transparency and support for multiple experts' participation in order to evaluate the CSIDs using both quantitative and qualitative criteria. MCE allows both normative and technical expertise in the assessment procedure. The AHP method was used to determine the evaluation criterion scores and CSIDs that would be of priority to public health in Ghana under a changing climate by ranking them based on the evaluation criteria. The determination of criteria weights and the ranks of the CSIDs followed the AHP three main steps (Section 6.2.1).

6.4.4.1 Problem Structuring

The experts were assumed to be homogenous with a single goal or common objective (prioritizing CSIDs under changing climate). Hence, a single problem structure was used. The decision problem (prioritizing CSIDs in Ghana) is decomposed into a hierarchy. Figures 6.1 and 6.2 show the hierarchical structure for the evaluation criteria and the prioritization of the CSIDs. The evaluation criteria hierarchical structure is a three-level hierarchy. The top element consists of the overall goal of the decision problem (prioritizing the attributes). That is, which is the most important attribute under each criterion when prioritizing CSIDs within Ghana? The group of criteria is in the middle, with the criteria attributes (alternatives) listed at the bottom level.

For the disease prioritization hierarchical structure (Figure 6.2), not all the criteria prioritized were used due to data constraints. The first level of the hierarchy consists of the goal of the decision problem (prioritization of CSIDs) to be achieved, the second level represents the main criteria based on which the CSIDs are evaluated (risk and public health). The risk criterion considers potential climate change influence on the CSIDs within the Ghanaian context. Due to the goal of the decision problem and the core considerations of the prioritization, the evaluation is limited to these two criteria groups. The two criteria for the evaluation are decomposed into multiple criteria (sub-criteria) and are located at the third level of the hierarchy. The sub sub-criteria that define the alternatives follows, with the criteria attributes defined at the next level with a rating scale (see Supplementary material: Appendix C: 6.4 for a definition of the rating scales). The competing alternatives (CSIDs) are placed at the bottom level of the hierarchy.

Figure 6.1: Evaluation Criteria Hierarchical Structure for Prioritizing CSIDs

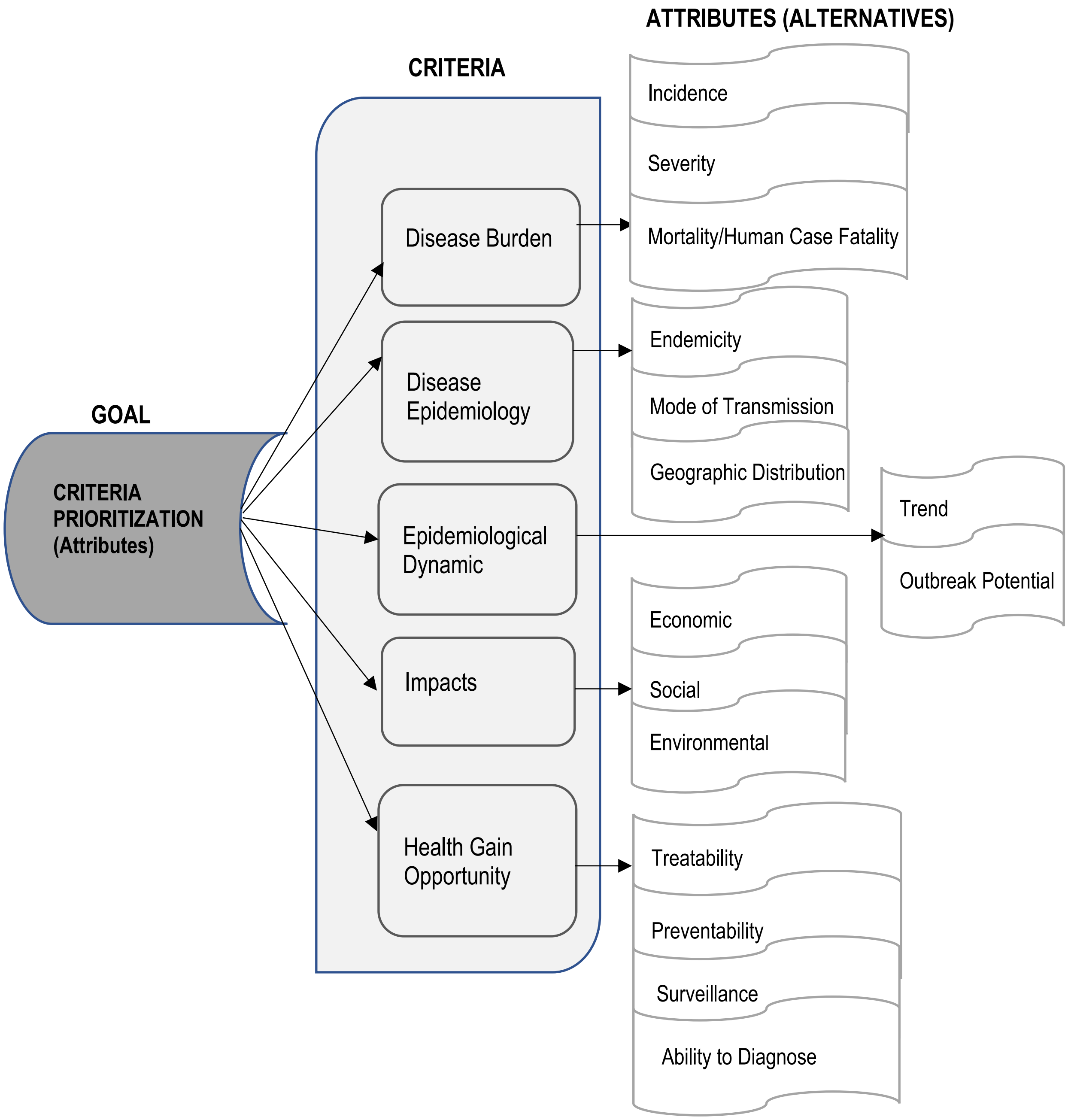
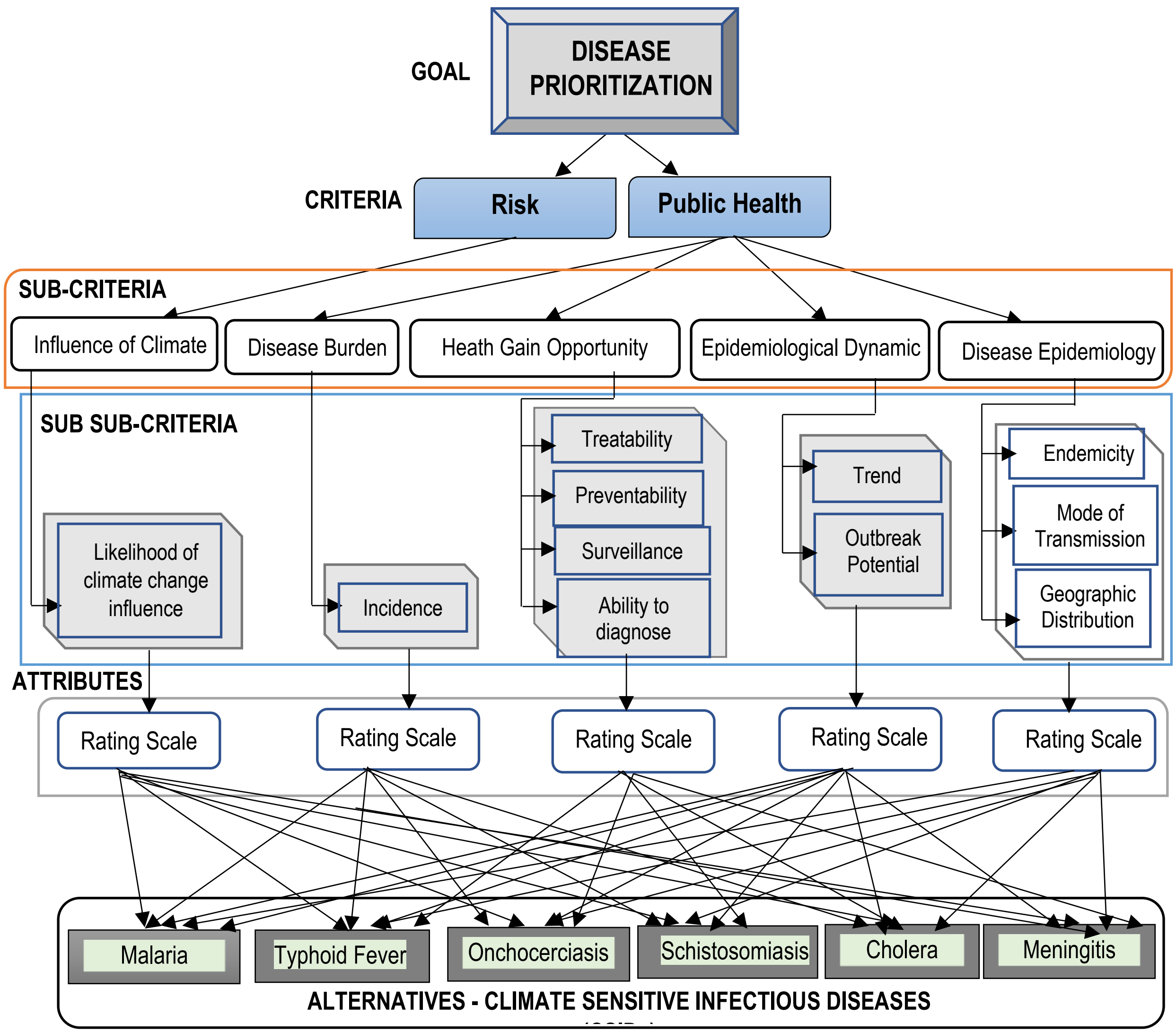


Figure 6.2: Disease Prioritization Hierarchical Structure for AHP



6.4.4.2 Comparative Judgment of Elements

This step involves comparing the decision elements on a pairwise base and assigning weights of importance to each element of the hierarchical structure. The comparisons are made using Saaty's nine-point intensity scale of importance between two elements (Section 6.2.1). Two major approaches are used in the pairwise comparisons: relative and absolute (rating) measurements. With the relative measurement, each alternative is compared with many other alternatives and in the absolute measurement, each alternative is compared with one ideal alternative, a process called rating alternatives (Saaty, 2006).

The first aspect of the comparative judgement relates to criteria evaluation. This comparison made use of the relative measurement approach. Weights of importance for each criterion attribute were elicited from the experts according to their importance in prioritizing CSIDs in Ghana. This comparison was made using the pairwise comparison scale. The generic question of the comparative judgment of the attributes was formulated as: what criteria attribute do you consider more important with regards to CSIDs prioritization in the case of climate change influence in Ghana and by how much? For example, an expert assigning a score of 3 to *Outbreak Potential* in comparison to *Trend* under the epidemiological dynamic category implies that, *Outbreak Potential* is moderately important than *Trend* when comparing them for CSIDs prioritization in Ghana. Based on the principle of reciprocal relationship of the pairwise comparison, it is assumed that *Trend* is 1/3 (or 0.3) as important as *Outbreak Potential*.

The second aspect of the comparative judgement involved weighting the CSIDs under the various criteria attributes of the disease prioritization model. Both experts' judgments, data from literature and secondary data (morbidity data of selected CSIDs) informed the weights assigned to the diseases under the sub sub-criteria (Figure 6.2). Based on the nature of this assessment (use of Likert scales) the absolute/rating measurement was adopted. The absolute/rating method involves making paired comparisons, but intensities (varied in type and number) or degrees of variation of quality on a criterion are assigned to the criteria just above the alternatives, known as the covering criteria (Saaty, 2008). Rating categories are established for each covering criterion and they are prioritized by pairwise comparing them for preference. For instance, under the criteria category Health Gain Opportunity, *Treatability* was assessed on a three Likert scale item and comprised the rating scale under *Treatability*. The Likert scales were converted to scores on the pairwise comparison scale (see Supplementary material: Appendix C: 6.4).

The pairwise comparisons in this paper were all carried out using the *SuperDecisions* software (version 2.8) (Creative Decisions Foundation, 2018). The questionnaire input interface was used for the relative measurement and the direct entry mode was used for the absolute measurement. The converted Likert scales (pairwise scores) used for the ratings were entered for the various categories under each criterion, which created the pairwise comparisons and their resultant weights used for rating the CSIDs.

6.4.5 Synthesis of Priorities

After problem structuring and deriving weights for criteria and alternatives (CSIDs) through pairwise comparisons, the final stage is to aggregate the weights of the pairwise comparison to obtain the final priorities (composite weight and ranks) for each criterion attribute and the CSIDs. When more than one individual engages in a decision process, there is a need to aggregate the information (judgments in the comparison process). In the context of AHP, a group decision framework suggests that instead of one judgmental comparison matrix at a given point in the hierarchy, there are many of them as more than one decision maker is involved. In AHP group decision making (as adopted in this study), there are several ways through which the individual judgments are aggregated to produce the final priorities (Forman & Peniwati, 1998; Ossadnik et al., 2016). Two of the methods that have been found to be most useful are the aggregation of individual judgments (AIJ) and the aggregation of individual priorities (AIP). Under these two broad methods, the individual judgements are aggregated by using the geometric mean or the arithmetic mean procedures (Ossadnik et al., 2016).

The aggregation of individual priorities (AIP) method was used for the aggregation procedure in this study as it preserves the personal rankings of individuals (Ossadnik et al., 2016). In AIP, local priorities of each individual are first calculated, and group priorities are attained using geometric or arithmetic mean (Altuzarra et al., 2007). Within this study, each expert's judgement priorities were aggregated to a final group preference using the simple arithmetic mean rather than the weighted arithmetic mean since all experts were weighted equally. The *SuperDecision* software used does not allow for more than one instance of data input per data model. Thus, each expert's survey instrument was entered as a separate instance. After, each expert's priorities from the judgmental comparison matrix made with the *SuperDecision* software were exported into text files and uploaded into Microsoft Excel for the aggregation.

6.5 Results and Sensitivity Analysis

The results of the empirical analysis carried out are presented under two headings: importance of evaluation criteria and ranking of CSIDs. The results are summarized in Tables 6.2, 6.3 and 6.4.

6.5.1 Importance of Criteria for Evaluating CSIDs

The results of the experts' criteria prioritization are reported under two themes: local and global priorities. The local priorities accounts for assessments under each of the criteria categories (e.g. disease burden). Whiles the global priorities consider the overall assessment: each of the 15 attributes (alternatives) from Figure 6.1 were pairwise compared regarding their importance in prioritizing CSIDs under climate change in Ghana.

Local priorities: under disease burden, incidence was ranked 1st, followed by mortality/human case fatality and severity (Table 6.2). For the disease epidemiology category, geographic distribution was assessed to be more important when considering the epidemiology of CSIDs for prioritization. The mode of transmission was assessed to be the next important with endemicity coming third. Experts also perceived outbreak potential of CSIDs to be a priority compared to their trend when considering the epidemiological dynamic of the infectious diseases. Under the impacts category, the preferences assigned by the experts prioritized environmental impacts that the CSIDs would have in terms of disease control to be of importance first, followed by their economic and then social impacts. For the health gain opportunity category that considered monitoring, treatability and ability to diagnose the infectious diseases in Ghana, preventability of the disease emerged 1st, ability to diagnose 2nd, availability of surveillance systems for the diseases in Ghana came 3rd and treatability ranked 4th.

Global Priorities: the results from the global priorities are reported in Table 6.3. From the aggregation carried out, it emerged that the top five criteria attributes (alternatives) of importance to CSIDs prioritization according to the experts who participated are: endemicity 1st, mode of transmission 2nd, outbreak potential 3rd, geographic distribution 4th with trend ranking 5th. The sub-criteria belonging to the impacts category ranked lowest with economic impacts 13th, social impacts 14th and environmental impacts 15th. From the preferences, it is observed that the top five criteria attributes belong to the disease epidemiology and epidemiological dynamic criterion groups.

6.5.2 Evaluation of Climate Sensitive Infectious Diseases

Table 6.4 presents the results of how the CSIDs fared through the evaluation. *Model 1 (Neutral Scenario*) presents the results of the evaluation whereby both the *Public Health* and *Risk* criteria were accorded equal importance (weighted equally 0.5/50% each). For Model 1, the importance of CSIDs in decreasing order of posing public health threat under climate inducements are diarrhoea, cholera, meningitis, malaria, onchocerciasis, yellow fever, typhoid fever, schistosomiasis and human African trypanosomiasis. Overall, the difference in priorities between the top (diarrhoea) and second ranked (cholera) is near negligible, indicating that both are of the same concern and one cannot be relegated in addressing of the other.

6.5.2.1 Sensitivity Analysis

As part of the decision process, a sensitivity analysis can be carried out, where the input data is slightly modified to observe the impact on the results. As complex decision models are often inherently ill defined, the sensitivity analysis allows different scenarios to be generated. Sensitivity analysis is done to confirm the robustness of the results. In this study, sensitivity analysis was conducted to explore how changes in the weights assigned to the criteria would influence the rank order of the alternatives (CSIDs). A ‘‘what-if’’ analysis is carried out at the criteria level. The aim of the analysis is to see how changes in the criteria weighting (relative importance of the criterion) affect the rank orderings of CSIDs in terms of their public health risk under a changing climate in Ghana. Two scenarios are generated by changing the weight assigned to the two evaluation criteria.

Scenario 1: *Public Health scenario;* the public health criteria was weighted 0.7 (70%) compared to 0.3 (30%) assigned to the risk criteria. The 0.7 weight assigned to the public health criteria was further weighted to the respective sub sub-criteria. This re-weighting was based on how the sub sub-criteria fared in the expert global weighting. That is how their attributes ranked. Disease Epidemiology was assigned

[2.5] because most of its attributes were ranked among the top 5; Epidemiological Dynamic [2.0]; Disease Burden [1.5]; and Health Gain Opportunity [1.0].

Scenario 2: Risk scenario; the risk criteria (climate change influence) was weighted more compared to the public health criteria. This was done to determine which diseases would pose more risk if prioritization to respond to the public health threats of the selected CSIDs had a focus more on climate influence compared to their public health characteristics. The risk criterion was weighted 6.0 (60%) and the public health criterion 4.0 (40%). The public health weight was re-weighted to its sub-criteria equally (1.0 each).

From the sensitivity analysis carried out (Model 2), it can be observed that the rankings do change for some CSIDs when the public health criterion is given more importance (Table 6.4). For instance, malaria moved from 4th to 6th, whiles meningitis changed from 3rd in the neutral scenario to 2nd, onchocerciasis moved from 6th to 7th, cholera moved from 2nd to 3rd, typhoid fever moved from 7th to 5th, with yellow fever moving from 5th to 4th. Despite these changes, diarrhoea maintained its 1st position with trypanosomiasis keeping the last rank. However, the disease rankings did not change markedly when climate influence was given prominence, except for onchocerciasis, schistosomiasis, typhoid fever, and yellow fever. Whiles onchocerciasis and schistosomiasis reduced ranks, typhoid fever and yellow fever moved up from their previous ranks in Model 1. From Model 3, it can be observed that the rankings are quite similar to Model 1. When all the three models are examined, irrespective of the criterion that is given prominence, diarrhoeal disease continues to rank 1st whiles African trypanosomiasis continually ranked 9th. From the scenario analysis carried out, it emerged that both the public health and the risk criteria play a significant impact on the disease rankings. However, the public health criterion seems to have a greater influence and would play a major role in the risks and threats that infectious diseases would pose in case of climate change impacts.

Table 6.2: Evaluation Criteria Prioritization: Local Priorities

CRITERIA	EXPERT 1 Normalized Scores	EXPERT 2 Normalized Scores	EXPERT 3 Normalized Scores	EXPERT 4 Normalized Scores	EXPERT 5 Normalized Scores	EXPERT 6 Normalized Scores	EXPERT 7 Normalized Scores	AGGREGATED Normalized Scores	Rank
DISEASE BURDEN									
Incidence	0.174	0.474	0.667	0.333	0.177	0.778	0.778	0.483	1
Mortality/Human Case Fatality	0.783	0.474	0.167	0.333	0.519	0.180	0.180	0.376	2
Severity	0.043	0.053	0.167	0.333	0.304	0.042	0.042	0.140	3
DISEASE EPIDEMIOLOGY									
Endemicity	0.271	0.056	0.255	0.333	0.333	0.053	0.053	0.193	3
Geographic Distribution	0.343	0.463	0.643	0.333	0.333	0.474	0.474	0.438	1
Mode of Transmission	0.386	0.481	0.101	0.333	0.333	0.474	0.474	0.369	2
EPIDEMIOLOGICAL DYNAMIC									
Outbreak Potential	0.9	0.9	0.833	0.5	0.833	0.5	0.5	0.710	1
Trend	0.1	0.1	0.167	0.5	0.167	0.5	0.5	0.290	2
IMPACTS									
Economic	0.043	0.444	0.693	0.033	0.224	0.333	0.333	0.301	2
Environmental	0.783	0.472	0.220	0.033	0.407	0.333	0.333	0.369	1
Social	0.174	0.084	0.087	0.033	0.370	0.333	0.333	0.202	3
HEALTH GAIN OPPORTUNITY *(Monitoring, Treatment & Diagnosis)*									
Ability to Diagnose	0.653	0.215	0.158	0.25	0.211	0.225	0.225	0.277	2
Preventability	0.233	0.440	0.275	0.25	0.229	0.675	0.675	0.397	1
Surveillance	0.086	0.131	0.475	0.25	0.246	0.025	0.025	0.177	3
Treatability	0.028	0.215	0.092	0.25	0.314	0.075	0.075	0.150	4

Table 6.3: Evaluation Criteria Prioritization: Global Priorities

CRITERIA GROUP	NORMALIZED WEIGHTS	RANK
A. Disease Epidemiology		
A1. Endemicity	0.128253	1
A2. Mode of Transmission	0.121003	2
A3. Geographic Distribution	0.107683	4
B. Disease Burden		
B1. Incidence	0.07008	6
B2. Severity	0.059385	8
B3. Mortality/Human Case Fatality	0.062913	7
C. Epidemiological Dynamic		
C1. Trend	0.08956	5
C2. Outbreak Potential	0.11181	3
D. Health Gain Opportunity (Monitoring, Treatment and Diagnosis)		
D1. Treatability	0.043818	10
D2. Preventability	0.054478	9
D3. Surveillance	0.035473	12
D4. Ability to Diagnose	0.038065	11
E. Impacts		
E1. Economic	0.033218	13
E2. Environment	0.021615	15
E3. Social	0.02265	14

Table 6.4: Results from the Prioritization of Climate Sensitive Infectious Diseases

DISEASES	**Expert 1** Normalized Score	**Expert 2** Normalized Score	**Expert 3** Normalized Score	**Expert 4** Normalized Score	**Expert 5** Normalized Score	**Expert 6** Normalized Score	**Expert 7** Normalized Score	**Aggregated** Normalized Score	**Rank**
SCENARIO 1-RISK AND PUBLIC HEALTH CRITERIA WEIGTHED EQUALLY (50/50)									
African Trypanosomiases	0.112	0.097	0.090	0.096	0.092	0.075	0.077	0.091	9
Diarrhoeal	0.102	0.125	0.134	0.125	0.124	0.119	0.117	0.121	1
Malaria	0.111	0.116	0.124	0.117	0.100	0.112	0.123	0.115	4
Meningitis	0.117	0.109	0.098	0.122	0.125	0.119	0.134	0.118	3
Onchocerciasis-River Blindness	0.110	0.113	0.132	0.100	0.097	0.111	0.106	0.110	6
Schistosomiasis	0.110	0.097	0.090	0.116	0.116	0.110	0.107	0.106	8
Cholera	0.119	0.120	0.136	0.107	0.127	0.117	0.119	0.121	2
Typhoid fever	0.105	0.120	0.097	0.110	0.097	0.119	0.101	0.107	7
Yellow Fever	0.114	0.103	0.100	0.107	0.122	0.118	0.117	0.112	5
SCENARIO 2- PUBLIC HEALTH CRITERIA WEIGTHED MORE – PUBLIC HEALTH (70%) & RISK (30%)									
African Trypanosomiases	0.105	0.096	0.092	0.095	0.092	0.083	0.084	0.092	9
Diarrhoeal	0.110	0.124	0.127	0.124	0.123	0.120	0.118	0.121	1
Malaria	0.109	0.112	0.115	0.113	0.103	0.109	0.116	0.111	6
Meningitis	0.118	0.114	0.108	0.121	0.123	0.120	0.129	0.119	2
Onchocerciasis-River Blindness	0.105	0.107	0.118	0.099	0.097	0.106	0.102	0.105	7
Schistosomiasis	0.107	0.098	0.095	0.111	0.110	0.106	0.105	0.105	8
Cholera	0.118	0.119	0.127	0.111	0.123	0.117	0.118	0.119	3
Typhoid fever	0.112	0.120	0.107	0.115	0.108	0.120	0.109	0.113	5
Yellow Fever	0.116	0.110	0.110	0.112	0.121	0.119	0.118	0.115	4
SCENARIO 3- RISK CRITERIA WEIGTHED MORE – RISK (60%) & PUBLIC HEALTH (40%)									
African Trypanosomiases	0.113	0.097	0.087	0.097	0.093	0.070	0.071	0.090	9
Diarrhoeal	0.099	0.125	0.139	0.126	0.126	0.119	0.116	0.121	1
Malaria	0.113	0.118	0.131	0.119	0.099	0.113	0.128	0.117	4
Meningitis	0.117	0.106	0.093	0.123	0.126	0.119	0.137	0.117	3
Onchocerciasis-River Blindness	0.112	0.115	0.137	0.099	0.096	0.113	0.108	0.111	5
Schistosomiasis	0.112	0.096	0.086	0.119	0.119	0.111	0.109	0.107	7
Cholera	0.119	0.121	0.140	0.105	0.128	0.118	0.118	0.121	2
Typhoid fever	0.101	0.121	0.092	0.108	0.089	0.119	0.097	0.104	8
Yellow Fever	0.115	0.102	0.095	0.105	0.124	0.118	0.116	0.111	6

6.6 Discussion

This study aimed at evaluating CSIDs common within the context of developing world, with a focus on Ghana for policy attention based on their threats to public health due to climate change inducement and classifying those with the greatest threats. As part of this assessment, the criteria used for the evaluation were also assessed for their importance in prioritizing CSIDs in Ghana. Although our study included categories of criteria similar to previous prioritization exercises, detailed direct comparisons cannot be made between studies since the prioritization objectives and approaches varied.

Based on the global criteria evaluation to determine their importance in prioritizing CSIDs in Ghana under climate change, it emerged that the criteria attributes under disease epidemiology were of very much importance. The three attributes used to operationalize this criteria category were all ranked within the top five. Thus, in prioritizing CSIDs in Ghana for policy attention, the epidemiology of the disease (endemicity, mode of transmission and geographic distribution) need to be critically considered. Overall, from the experts ranking of the criteria attributes, disease epidemiology was perceived to be of great importance, followed by epidemiological dynamic which looked at disease trend and outbreak potential in the country. The burden of disease and health gain opportunity followed, with the lowest importance assigned to the impacts criteria.

The ranking of the attributes under the disease epidemiology category as more important when prioritizing CSIDs in Ghana is appropriate. In fact, the attributes under this criterion covers some of the most critical aspects that need consideration in CSIDs prioritization taking the predicted climate change impacts on infectious diseases into account. Current climate change impacts on infectious diseases have been postulated to result in changes in geographic distributions and increased disease intensity in endemic areas. With these projections, it is important to know the current geographic distribution of diseases in order to help in projecting where the likely expansion areas would be under a changing climate. With the predictions also favoring increment in cases of endemic diseases, it is worthwhile to account for the current endemicity status of the CSIDs when carrying out any prioritization. Presently, most of the CSIDs in Ghana have a nationwide endemicity status, as such, endemicity is an important criterion to be accounted for.

The mode of transmission of CSIDs is also a very important criterion to be measured. Thus, it is not surprising that the experts weighted it among the top five in the global prioritization of the criteria attributes. The pathways through which climate change is anticipated to impact infectious disease vectors and pathogens is through their mode of transmission. For instance, most of the current CSIDs in Ghana are transmitted through vectors (vector borne diseases). Climatic conditions affect the transmission of vector-borne diseases by altering the distribution of vector species and their reproductive cycles and influencing the reproduction of the pathogens within the vector organism, known as the external incubation period (Zhang, Bi, & Hiller, 2008). Temperature, precipitation, humidity, and other climatic factors are known to affect the reproduction, development, behavior, and population dynamics of the arthropod vectors of vector borne diseases as well as their abilities to transmit disease agents (Gage, Burkot, Eisen, & Hayes, 2008; Martens et al., 1999). Mosquito species such as the *female Anopheles* and *Aedes aegypti* which are responsible for transmission of vector-borne diseases like malaria and yellow fever are sensitive to temperature changes. For example, temperature influences both the speed of development of the malaria parasite in the mosquito vector and the rate of development of the mosquito (the number of potential mosquito generations per season and, therefore, vector abundance) (Gage, et al., 2008). Food and water-borne diseases are usually manifested by diarrhoeal syndromes and are very sensitive to climate variability. Climate change can alter the incidence of enteric infections either directly, via effects on climatic variables (temperature, precipitation and humidity) on organism proliferation or survival, or indirectly via effects on water quality. Indirectly, climate can affect rates of diarrheoal diseases particularly through extreme events (e.g. flooding, and severe storms) which can overload the capacity of sanitation systems, contaminate or reduce the availability of safe drinking water (Harley, Swaminathan, & McMichael, 2011).

From the prioritization carried out, it emerged that although climate change has been predicted to impact CSIDs, their burdens and impacts to human population and health systems would be of differing values. Hence, public health adaptation to CSIDs cannot adopt a general approach but rather, the specific threats and burdens from the various CSIDs needs to be identified and considered. From the CSIDs prioritization, diarrhoea emerged as the one with the greatest threat to public health under a changing climate in Ghana. Cholera and meningitis then follow as the next diseases to pose threats and are of national relevance. These top three diseases are currently of public health significance in Ghana. As a result, their emergence among the top three should be of concern and requires action. Diarrhoea and cholera are among the top 20 causes of outpatient morbidity in Ghana from 2002-2016 (GHS, 2017). Diarrhoea has consistently ranked among the top five diseases with positions fluctuating between 3rd and 4th. Meningitis, although not among the top causes of outpatient morbidity, has a severe human fatality case during outbreaks with almost yearly occurrences. Like meningitis, cholera also has an almost yearly outbreak in Ghana with a wide geographical spread in recent times. In 2014, Ghana was hit by a massive outbreak recording the highest caseloads over the last 30years. There was nationwide reporting of cases from all the 10 administrative regions covering 130 out of the 216 districts at the time, and an outbreak in 2016 covering seven out of the ten regions (GHS 2017; GHS/Ministry of Health [MoH], 2016). The GHS/MoH (2016) report on public health risk mapping and capacities assessment in Ghana declared cholera and meningitis as biological hazards of public health concern in 2016, with a high potential of resulting in public health emergency. Cholera and meningitis were ranked at 2nd and 3rd positions in the hazard risk mapping carried out. These current high health burdens from the top three ranked diseases from the prioritization provides a glimpse of the challenges public health in Ghana will have to confront on a large scale under climate change. With outbreak of infectious diseases emerging as a likely yearly phenomenon for some diseases currently, it is not surprising that the experts ranked the outbreaks potential attribute 3rd according to its importance in prioritizing CSIDs under climate change in the global assessment and 1st under the local assessment.

Based on the disease prioritization carried out, it was evident that epidemic prone diseases would be of major public health threat in the case of climate change inducements on infectious diseases in Ghana. Further, it came to the fore that water and food related infectious diseases (cholera and diarrhoea) would be of concern to public health in Ghana under a changing climate. Currently at the national level, only 39.9 per cent of households have access to piped borne water supply with a large proportion of households (42%) not having access to good and safe drinking water (GSS, 2012). With issues of water and its quality being a critical issue in Ghana, these water-related diseases with climate inducements would result in great catastrophes. Meningitis is greatly influenced by temperature variability, and temperature predictions in Ghana under climate change is projected to be severe for the northern sector of the country, which happens to be the endemic area of the disease (meningitis belt) and with the highest prevalence (GHS/MoH, 2016). Hence, public health attention needs to be directed to the disease to help curb any menace.

Decision making towards addressing the health risks from CSIDs under climate change is a multi-dimensional problem which calls for a multi-sectoral approach. As such, different experts and stakeholders' opinion needs to be considered as well as factors to help develop a comprehensive policy. In a developing country context where resources are limited and the vulnerability to climate change is very high, it is difficult to implement planned adaptation measures at the same time for all potential CSIDs. From this study, it came to bear the capabilities of MCE to help with such an effort. MCE approach helps decision makers in prioritizing adaptation options for each CSIDs by considering all the threats and burdens posed by the diseases through inclusion of a broad range of considerations which are factored into the prioritization models. The MCE methodology does not only ensure transparency and multidimensionality by considering multiple criteria and stakeholder preferences but also includes experts' judgements. It emerged that MCE is an important decision-making technique that can support public health decision-making in developing measures and prioritizing resources to help address the extra health risks to be posed by specific CSIDs under climate change.

If compared to the previous studies, this study's assessment involved CSIDs that are currently in existence within the context where the research was carried out. In addition, our study focused on assessing the CSIDs that would be of concern to public health in Ghana under climate inducements by ranking them based on their relative risks and threats posed. Even though Hongoh et al. (2016) study prioritized CSIDS in Quebec and Burkina Faso, they concentrated solely on climate-sensitive vector borne diseases. In addition, Hongoh et al. (2016) study focus was more on criteria selection for CSIDs priority setting, with the diseases used as a pilot tool to find out how the criteria weighting by stakeholders impact the disease ranking. Cox et al. (2013) on the other hand focused on potential emerging and re-emerging infectious diseases in Canada under climate change. Similar to Hongoh et al. (2016), the diseases were used as a trial for their developed pathogen prioritization tools.

As with every study, there are some limitations. The first relates to the evaluation criteria used. Some criteria and criteria attributes like impact and human case fatality under disease burden category were excluded in the disease prioritization exercise due to insufficient data. In addition, the list of criteria evaluated by the experts were based on a review of the literature by the authors and would likely have differed if the criteria had been solely identified by experts. Future studies are encouraged to elicit expert views in selecting the evaluation criteria to find out which others they might suggest as important for the Ghanaian context. A multi-stakeholder engagement and a wider range of experts and criteria can be used to help broaden the scope of analysis and ensure that a broad set of value perspectives are considered, which was not fully captured in this study due to the limited number of experts who responded to the survey. Also, the weighting of the evaluation criteria and diseases were individually done by the experts. Adopting alternative ways, such as a focus group discussion with the experts to determine the weights/scores could have altered the rankings of the evaluation criteria and diseases and may be worth exploring in future studies.

6.7 Conclusion

Given the anticipated adverse climate change impacts on health (infectious diseases), evidence from research is needed to guide policy decision making. In order to develop coherent responses to the potential increasing incidence of climate-related outbreaks, and to longer-term altering disease patterns, there is the need for improved information upon which to base the mainstreaming of climate change into health systems planning, including disease prevention and control measures. In particular, evidence-based tools are needed to help support decision making and policy process. MCE provides such a standardized approach to prioritize climate-sensitive diseases. MCE aid decision making by providing an evidence-based decision framework that employs a coherent, consistent and a transparent approach (Baltussen & Niessen, 2006).

This study prioritized CSIDs for climate-health policy attention in Ghana by assessing their relative importance to public health under a changing climate using MCE. This assessment is a first attempt at prioritizing CSIDs in Ghana under changing climate and it serves as a useful foundation for future research and health system management. It creates a sense and a better understanding of the risks that the assessed CSIDs pose to human population and health systems under climate change inducements conditions.

Although the present study uses Ghana as a context for the prioritization exercise, methods and multicriteria approach employed in this study provide insights into the prioritization of CSIDs under climate change situation and can be a useful starting point for public health prioritization exercises in other related developing world contexts.

Based on the prioritization scenarios presented in this study, the following recommendations are offered. First, public health adaptation to climate change health risks needs to include strengthening of disease surveillance systems, especially for epidemic prone diseases, as we see that the top three ranked diseases are all epidemic prone with risks and severe threats to public health currently. Present response capacity of the health sector to epidemic prone CSIDs would need to move from being reactive towards being more anticipatory, deliberate and systematic. The 2016 Ghana Health Service annual report has acknowledged inadequacies of frontline staff in outbreak investigation and control (GHS, 2017). With epidemic prone CSIDs likely to be of great concern to public health in Ghana under climate change, preparedness and capacity towards climate change health risks need to include strengthening national health systems and building of the technical capacity of health personnel towards control of health emergencies and risks.

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CHAPTER SEVEN

DISSERTATION OVERVIEW, SUMMARY AND CONCLUSION

7.1 Introduction

This dissertation examined climate change-health linkages in Ghana and this Chapter completes this research effort by integrating and contextualizing the study findings. The first section offers a summary of the key findings of the thesis based on the objectives outlined in Chapter One. In the next section, the overall contributions of the dissertation and the implications of study findings are explicated. This is followed by the limitations of the study and pointers for future research, which concludes the Chapter.

7.2 Outcome of Research Objectives

Climate change is increasingly recognized as a significant threat facing society and one of the greatest threats to human health in the 21st century. Scholarship on climate change and human health has typically focused on the physical aspects such as modelling climate change dynamics and linking them with human health, as well as predictions of health risks for the future under different climate scenarios. However, due to the complex interrelationships between humans, ecosystems and climate, climate change and health research is progressively shifting to include the social aspects such as perception, understanding and knowledge of climate change as well as its human health risks.

Health is inextricably linked to climate, and as such, human health is one of the most threatened aspects by climate change. Due to the complex risks that climate change presents to public health including the potential of reversing the health gains over the previous decades, the health community has a vital role to play in accelerating progress to tackle climate change. The nature and impact of likely climate-sensitive health outcomes depends on the extent to which health systems are prepared to manage those risks. In line with that, scholarship on climate change and health has thus focused on assessing the readiness and capacity of health systems and professionals to carrying out their roles of protecting health under a changing climate.

What is missing from these current scholarships and serve as a fundamental motivation for this study is that, perceptions of climate change as a health risk as well as how such linkages are conceptualized have not been empirically contrasted between the public and health experts, even though risk perception studies have acknowledged differences in experts and the public risk perception and assessments. As argued by Hathaway and Maibach (2018) there is a clear relative paucity of assessment research aimed at illuminating health professional and public understanding of the health risks posed by climate change. In addition, current studies have basically made the individual list or choose from a bunch of health risks but have not really paid attention to how they link the health risks to climate change. Furthermore, scholarship on health systems readiness and capacity to address the additional potential health risks from climate change through empirical research is very limited in the context of Africa. The available scholarship reflects perspectives from the developed world and lack outlooks from developing world context.

Ghana is vulnerable to climate change and its effects because of its geographical location, climate, among others. Currently, research on climate change and health are limited within the Ghanaian context with studies empirically assessing health systems capacity and perceptions towards climate change and its health risks being almost non-existent. This dissertation attempted to provide a comprehensive account of climate change-health linkages in Ghana by appraising three distinct but interrelated issues: current knowledge on climate change and its health risks, the ability of health systems to respond effectively to potential climate-related adverse health outcomes and identify priority climate-sensitive infectious diseases to public health under a changing climate. The overarching reaching question that was investigated is: What is the current knowledge on and capacity towards addressing climate change health risks in Ghana? To answer this question, the following specific objectives were pursued:

1. Examine climate change-health knowledge among the public and health experts in Ghana;
2. Assess the preparedness and institutional capabilities of health systems and professionals towards climate change health risks; and

3. Prioritize climate sensitive infectious diseases for policy attention in Ghana under climate change inducements based on their cumulative threat and burdens to human populations and health-care systems.

Table 7.1 provides a summary of the wide range of themes addressed in this pursuit. It shows the key findings from the empirical studies and summarizes some of the salient arguments advanced in the specific manuscripts and the dissertation. Although few of the findings are crosscutting between some manuscripts in the dissertation, many are peculiar to the individual manuscripts. In the next sub-sections, the research objectives are revisited in light of the results of the empirical studies.

Table 7.1: Summary of Key Findings from the Three Empirical Chapters (Manuscripts)

Summary of Empirical Studies		
Manuscript 1: Examined knowledge and perception of climate change health linkages in Ghana among health experts and the general public. **Key issues:** • What are the perceptions on climate-related health risks in Ghana? • How do these perceptions differ between experts and the general public? • What factors predict perceptions and knowledge of climate-related health risks in Ghana? **Data:** Primary data: Quantitative data (surveys) and Qualitative data (in-depth interviews) **Method:** Bivariate & Multivariate analysis; Thematic analysis **Key Findings (see below): [**1-5]	**Manuscript 2:** Assessed health-care systems and professionals' capacity and preparedness towards climate change health risks. **Key issues:** • What are health professionals' perceptions of climate change as a public health risk? • How prepared are health service providers to respond to climate-related health emergencies? • What potential reforms or actions do health professionals perceive they need to equip them and the health sector to carry out their role as frontline respondents effectively? **Data:** Primary data: Quantitative data (surveys) and Qualitative data (in-depth interviews); **Method:** Descriptive Analysis; Chi-square & Cramer's V; Thematic analysis **Key Findings (see below):** [6-9]	**Manuscript 3:** Prioritized CSIDs within a developing world context for policy attention. **Key issues:** • Which CSIDs are likely to pose the greatest health risks to public health in Ghana under climate change conditions? • What is the efficacy of multicriteria decision making method in prioritizing CSIDS for policy attention? **Data:** Quantitative data (surveys) and Secondary data-morbidity data; review of literature **Method:** Multicriteria Evaluation Analysis (Analytic Hierarchy Process) **Key Findings (see below):** [10-12]

Key findings and associated arguments:

1. Limited knowledge about climate change and health related risks, especially among the public. 26% of health experts and 44% of the public lacked knowledge of the underlying cause of climate change. In addition, heath experts were more likely to link health-related risks to climate change compared to the public.
2. Both public and health experts mention diseases as health risks related to climate change. Health risks reported among the general public stemmed from personal experiences with extreme weather and climate events. Exactly as to how the effects would manifest or be triggered could not be explained by some respondents, especially among the public which suggests limited knowledge about the underwriting mechanisms linking climate variability to health risks in the Ghanaian context.
3. Health concerns reported involved vector borne diseases, and other more common health issues such as malaria. Other well documented health effects of climate change such as air pollution related, and increasing allergens (e.g. respiratory allergies, asthma) and severe weather-related effects (injuries, fatalities, mental health impacts) were not reported much especially among the public. Health experts reported an increasing prevalence of air pollution, and asthma, indicating disparities in knowledge of climate change related health effects between health experts and the public.

4. Discourses on climate change-health links from health experts and the public converge on basic knowledge of climate change and diverged on the conceptualization of underpinning factors driving climate change. One other area of commonality in narratives was reporting of climate variability and its subsequent relations to health risks. Discourses however diverged in terms of the knowledge used in the conceptualizations. The narratives of the health experts were found to have some level of scientific underpinnings, which was missing among most of the public. It was revealed that the public narratives were influenced by local knowledge, which was grounded in embodied experiences. 5. Although the health experts' conceptualization was underpinned by scientific understandings, they also demonstrated little understandings of climate change science.
6. Health professionals perceived climate change as a public health risk but indicated not having adequate information on climate change and health connections. >90% perceived climate change as a health risk, but approximately two-thirds indicated relatively low knowledge on the subject. 7. Capacity and preparedness to respond to climate change related health emergencies were weak in the study districts. Even though study districts are located within regions with different developmental levels, with its resulting health-care systems challenges, study findings indicate that, health-care systems capacity and preparedness levels towards climate change-health risks do not differ across the study contexts. 8. Health professionals within the higher level of health delivery (District Hospitals) acknowledged some level of preparedness to deal with climate emergencies compared to those at the lower level (Health Centres). Both levels nevertheless declared they might have challenges in addressing climate emergencies. 9. There is an urgent need for reforms in the health sector considering looming climate change impact on the health of local populations around knowledge and skill building and provision of logistics and infrastructure.
10. Prioritizing of climate sensitive infectious diseases (CSIDs) for policy attention in developing world contexts needs to critically consider the epidemiology of the disease (endemicity, mode of transmission and geographic distribution). From the experts ranking of the criteria attributes, disease epidemiology was perceived to be of great importance, followed by epidemiological dynamic which looked at disease trend and outbreak potential in the country. The burden of disease and health gain opportunity followed, with the lowest importance assigned to the impacts criteria. 11. Although climate change has been projected to impact CSIDs, their burdens and impacts to human population and health systems would be of differing values. In the Ghanaian context, epidemic prone diseases would be of major public health threat in the case of climate change inducements on infectious diseases. Epidemic prone CSIDs: diarrhoea, cholera and meningitis pose the greatest risks to public health. Further, water and food related infectious diseases (cholera and diarrhoea) would be of concern to public health in Ghana under a changing climate. 12. Multicriteria evaluation/decision analysis (MCDA) provides a standardized and transparent approach to prioritize climate-sensitive diseases for policy attention under climate change inducement. Multicriteria evaluation analysis is an effective decision-making support tool to aid decision makers in prioritizing adaptation options for CSIDs under climate change based on their cumulative threats and burdens to public health. MCDA enables consideration of a range of factors in the decision-making process as well as inclusion of experts and stakeholders and their judgements.
Cross-cutting Issues: Knowledge on climate change-health linkages is generally low in the study context [reference: Manuscript 1& 2: (1) (2), (6)]

7.2.1 Objective 1: Examine Climate Change-Health Knowledge Among the Public and Health Experts in Ghana

The first objective sought to evaluate the awareness, understanding and knowledge levels of climate change and its potential health risks among health experts and the general public. This objective was addressed in Chapter Four (Manuscript One). The manuscript relied on data from both quantitative (surveys) and qualitative (in-depth interviews) sources. Elements from the Climate Change Risk Perception Model: cognitive and the socio-demographic dimensions, were drawn upon in this manuscript to evaluate the extent to which they predict perceptions of climate change as a health risk among the study population. In assessing climate change knowledge, objective assessment was adopted which involved an evaluation based on knowledge of the single most important underlying cause of climate change (factual knowledge). Further, in-depth interviews were used to explore perceptions and understanding of how climate change is linked with or impacting health or would affect and its associated health risks or concerns. Logistic regression was used in the assessment of climate change knowledge, whiles thematic analysis of interview transcripts was employed to identify salient themes relating to the pathways and conceptualization of climate change health links between the study groups.

From these analyses, it emerged that, climate change knowledge was low in the study districts, even though health experts showed higher factual knowledge of the most important underlying cause of climate change compared to the public. Heath experts were also more likely to link health-related risks to climate change compared to the public. Results also indicated that although compositional factors (gender, age, and education) and contextual factors (region of residence) predicted knowledge of climate change, the contextual factors (urbanicity and region of residence) examined did not predict association of climate change to health links or perceiving it as a health risk. In addition, it emerged that whiles the pathways and conceptualizations of climate change-health links between the public were supported by individualized experiences (embodied experiences of local climate), health experts' conceptualization was underpinned by some scientific understandings. However, it was demonstrated that despite this scientific underpinning among the health experts, some demonstrated little knowledge about climate science as they attributed climate change to issues such as ozone depletion. The dominant narratives from both groups were underpinned by pathways involving climate variability such as changes in temperature and rainfall and its resultant health risks. Overall, it was found that discourses used in linking climate change with health diverged in terms of the knowledge used in the conceptualizations. Despite the differences in knowledge used, it emerged that non-scientifically trained individuals also understood the potential and current implication of climate change on health within their contexts. Both health experts and the public were also more likely to mention diseases as climate change-related health concerns as reported in other studies such as Akerlof et al. (2010) and Olaris (2008).

7.2.2 Objective 2: Assess the preparedness and institutional capabilities of health-care systems and professionals towards climate change health risks.

From Manuscript One, it emerged that health professionals perceived climate change as a health risk compared to the public. In addition, health risks related to diseases were anticipated as climate change impacts from both the public and health professionals. With these findings, Manuscript Two (Chapter Five) proceeded to evaluate whether health experts who are tasked with protecting public health are capable and prepared to address the additional health risk burden from climate change that they anticipate. A mixed method approach involving the use of both quantitative data (surveys) and qualitative data (in-depth interviews), analyzed using descriptive, Chi-square and thematic analysis respectively were used to address this objective.

Findings from this study show that, although health professionals perceived climate change as a public health risk as reported in earlier studies such as Carr et al. (2012) and Roser-Renouf et al. (2016), their perceived knowledge on the subject was relatively low as majority indicated not having adequate information on climate change-health linkages. Capacity and preparedness to respond to climate change-related health emergencies and outcomes around climate-sensitive infectious diseases were also weak. This finding corroborates earlier research which reported health professionals perceiving their divisions to be ill-prepared to address the additional potential climate-health burdens and risks and lacked expertise and resources to address the local public health impacts from climate change (Polivka et al., 2012; Roser-Renouf et al., 2016). It also emerged that, the position of the health facility on the health system's hierarchical structure also impacted their capacity and preparedness levels. Health professionals within the higher level of health delivery (District Hospitals-referral point) acknowledged some level of preparedness to deal with climate emergencies compared to those at the lower level of the health hierarchy (Health

Centres). However, both levels declared challenges such as incomplete knowledge, inadequate staffing and logistics in addressing the climate-related health emergencies and outcomes.

From the study, it came to light that there was an urgent need for reforms in the health sector in light of looming climate change impact on the health of local populations. Knowledge and skill building, and provision of logistics and infrastructure emerged as the areas that needed the most attention and pressing restructuring to help strengthen health system and service providers capacity and preparedness and enable building resilience towards climate change-health risks in Ghana.

7.2.3 Objective 3: Prioritize climate sensitive infectious diseases for policy attention in Ghana under climate change inducements based on their cumulative threat and burdens to human populations and health-care systems.

The third objective of this study identified the specific climate-sensitive diseases that would pose the greatest impact and risks to public health in Ghana under climate change inducement based on a prioritization procedure. As demonstrated from the appraisal of health-care systems and professionals carried out (Objective Two - Manuscript Two), they were not prepared or in position to address the additional risk burdens from potential climate-related health risks due to climate change. As a result, knowledge of potential climate-sensitive diseases with the greatest risk to public health under changing climatic conditions is critical in helping with health risks adaptation planning and preparation to help build both public and health systems resilience.

The third objective was addressed in Manuscript Three (Chapter Six), surveys were conducted among individuals with expertise in climate change and health, epidemiology and public health in Ghana. In addition, secondary data consisting of morbidity data of prevalent climate-sensitive infectious diseases in Ghana and data from literature were used. Through multicriteria evaluation analysis, an evaluation model was developed to assess and prioritize selected climate-sensitive infectious diseases of significance to public health in Ghana.

The manuscript demonstrated that, although climate change has been predicted to impact climate-sensitive infectious diseases, their burdens and impacts to human population and health systems would be of differing values. From the prioritization procedure carried out, epidemic prone climate-sensitive infectious diseases were identified to be of significance to public health in

Ghana under a changing climate based on their cumulative risks and threats to public health and human populations. Specifically, diarrhoea, cholera and meningitis were identified as the top three that might pose the greatest risks and threats. Further, it came to the fore that water and food related infectious diseases would also be of concern to public health in Ghana under a changing climate. From the analysis, it was found that in prioritizing climate-sensitive infectious diseases, the epidemiology of the disease (endemicity, mode of transmission and geographic distribution) need to be critically considered. Overall, this manuscript established the capabilities of multicriteria evaluation analysis to help decision makers in prioritizing adaptation options based on threats and risks that climate-sensitive infectious diseases pose or would to public health under climate change inducement by providing a standardized and transparent approach to order them. Multicriteria evaluation analysis enables breaking down of the complex problem into its constituent parts, inclusion of a broad range of considerations and criteria which are factored into the prioritization procedures and provide a structured framework to make transparent decisions.

7.2.4 Cross-Cutting Issue

From addressing Objectives One and Two, it is clear from this research that, climate change knowledge in general and relating to its health linkages is low in the study contexts. In Manuscript One (Chapter 4: Objective One), it emerged that 26% of health experts and 44% of the public lacked knowledge of the underlying cause of climate change. Even though health professionals had higher odds of knowing the fundamental underlying cause of climate change, as well as perceived it as a health risk compared to the public, they also demonstrated some lack of knowledge on the issue. In Manuscript Two (Chapter Five: Objective Two), the study found health professionals reporting relatively low levels of knowledge on climate change-health nexus. Although health professionals perceived climate change as a public health risk (>90%), approximately two-thirds of surveyed health professionals indicated not having adequate information on climate change and health linkages especially relating to infectious diseases which was assessed.

7.3 Contributions of the Study

Although focused on the frontiers of Ghana, this study makes conceptual, methodological and practical contributions to the field of climate change and health. This dissertation specifically makes contribution to the field of climate change and health perception, and current scholarship on health capacity and preparedness assessment towards climate change.

7.3.1 Conceptual Contributions

From a conceptual viewpoint, this study has implications for climate change and health risk perception research. By employing elements from the Climate Change Risk Perception Model (CCRPM) (van der Linden, 2015), this dissertation also elucidated another significant aspect of climate change awareness, knowledge and perception research. For instance, by accounting for the cognitive, and sociodemographic and social-structural factors of climate change risk perception, Chapter Four demonstrated that there were compositional (gender, age, and education) and contextual (region of residence) differences when it comes to knowledge of the underlying cause of climate change. Although indicators from both compositional and contextual factors influenced climate change knowledge, contextual factors examined did not influence perceptions of climate change as a health risk. Hence, this dissertation highlights that when it comes to climate change perception as a health risk, there are varying degrees to which compositional and contextual factors influence this knowledge levels. In addition, this research reinforces the fact that knowledge about cause of climate change (factual knowledge) is a significant predictor of climate change risk perception, in this case as a health risk.

This dissertation by employing the WHO Operational Framework for Building Climate Resilient Health Systems (WHO, 2015) extends the work of earlier scholars (e.g., Carr et al., 2012; Maibach et al., 2008; Roser-Renouf et al., 2016) as it contributes to the wider issue of how health systems climate change capacity and preparedness can be assessed. Drawing on the WHO framework which is yet to be used in extant empirical studies, this dissertation assessed one area of capacity and preparedness that have not been explored: human resource skill building, training and education which considers training courses or workshops on climate change and health topics targeting health personnel conducted or received. As health workforce is one of the main building blocks of health systems, increasing health officials' understanding of the health impacts of climate change is the first step to increasing preparedness to respond to such health impacts. As such, evaluating this component of capacity and preparedness is very important as it would serve as pointers for future skill-building and capacity trainings that are required by enabling identification of areas that needs improvements and current gaps that exist.

This dissertation also demonstrates the relevance of assessing and contrasting climate change and health perceptions and understanding among the public and health professionals. As argued by Maibach et al. (2010), cognitive research over the years indicates that how people frame an issue, that is how they mentally organize and discuss with others the issue's central ideas greatly impacts how they comprehend the nature of the problem, who or what they see as being accountable for the problem, and what they feel should be done to address the problem. Contrasting the views of health officials and the public empirically in this study enables us to understand how the public and the health experts' mental models and discourses on climate change links with health compares or differ to each other and that of the scientific community. This dissertation by assessing how the public and health experts conceptualized and framed climate change health links and associated risks help shed light on the knowledge levels and perception of what constitute climate change to them. In addition, potential misconceptions that exist and underpin such discourses which might be critical for their adaptation decisions are also revealed. This knowledge is very critical for climate change health risk communication.

Hathaway and Maibach (2018)'s systematic review shows a paucity of research on perception of the health implications of climate change, especially within the developing world context and specifically, Africa. Their study found that 18 studies have been done to assess the public's understanding of the health impacts of climate change with only three conducted in Africa (Armah et al., 2015; Haque, Yamamoto, Malik, & Sauerborn, 2012; Mayala et al., 2015). Relating to studies assessing how health professionals perceive the health impacts of climate change, they reported that only one out of sixteen was conducted in Africa and even that was among health science students (Nigatu, Asamoah, & Kloos, 2014). This dissertation in assessing both health professionals and the public's knowledge and perception of climate change health links and implications thus makes a significant contribution to the emerging literature on Africa.

7.3.2 Methodological Contributions

Further contributions of this dissertation to academic knowledge relates to methodology. In terms of research methods, this study combined qualitative and quantitative approaches as well as Multicriteria Decision/Evaluation Analysis (MCDA). This methodological pluralism helped provide a valuable account of a complex issue such as climate change and health linkages. Using MCDA, this study developed a multicriteria evaluation model for climate-sensitive infectious disease prioritization under changing climate. The model developed provides great opportunity for policy and decision makers and researchers in similar contexts to adopt or modify to prioritize climate-sensitive infectious diseases for policy attention under climate change conditions. The effectiveness of MCDA as a decision support method has been highlighted in the climate change literature, as it has been widely recommended for adaptation planning. This dissertation by applying the method in prioritizing climate-sensitive infectious diseases have also shown its usefulness in other aspects relating to climate change, in this case health, and has further indicated the efficacy of MCDA methods as a decision-aid tool. In doing this, the dissertation advances the application areas of the method and the specific decision rule used: Analytic Hierarchy Process. As argued in Chapter Six, MCDA methods are now finding application in epidemiological research.

This dissertation also establishes the value of combining qualitative and quantitative methods in social science research. Current scholarly works on climate change and health, especially, health capacity and readiness assessment have predominantly been by quantitative techniques with isolated qualitative research. By combining qualitative and quantitative approaches in this dissertation, this study highlights nuances relating to Ghana's weak responsiveness and ill-equipped nature towards climate change-health threats. Through the combined approach, the study went beyond just the establishment of numbers and generalization but provided a valuable insight into the current capacity and preparedness levels. By combining the strength of both qualitative and quantitative methods, this study was able to provide a reflection of climate change-health nexus in Ghana in terms of the nitty-gritty that exist, provided deeper insights into the cognitive processes underlying climate change and its health links between the public and health experts. Further, it offers several categories of insights into individuals' perception and engagement with climate change which could not have been captured with the reliance on a single approach. The study consequently generated significant information useful in developing climate change health policy and adaptation measures. This study thus reiterates Patton`s (2002: 573) argument that the vital issue about social science research is not to be 'pro-numbers' or 'anti-number' but rather to be 'pro-meaningfulness.'

7.3.3 Practical Contributions and Policy Recommendations

Finally, the dissertation also makes some important practical contribution to climate change and health issues in Ghana. By assessing climate change health nexus in two districts located in different sectors of the country with diverse climatic predictions under climate change, this dissertation brings to the fore perspectives and views from both sectors which is very important for policy formulation and climate change communication strategies. As it brings to light the knowledge levels, issues and challenges that are peculiar to each area. The empirical aspects of this study, Chapters 4 through 6, have specific policy implications that are relevant for strengthening health institutions in Ghana in view of impending climate change health risks and for climate change health policy formulation and decision-making. First, the findings show that knowledge on climate change and its health linkages are low in the study contexts. Particularly, the findings from Manuscripts 1 and 2 demonstrate this. As seen in Chapter Four, even though health professionals are frontline leaders in helping the public build climate change adaptation to reduce impacts and vulnerability and increase resilience efforts, they also displayed some levels of misconception about climate change. These findings underscore the need for increased education, enlightenment programs on climate change and its associated health problems for the public and health officials.

Additionally, findings from this study (including, incomplete knowledge, inadequate staffing, logistics and infrastructure, and insufficient training) raise a special concern about the need to build health systems and service providers resilience towards climate-related health risks in terms of capacity and preparedness. The findings call for efforts to strengthen human and institutional capacity and adaptation to climate change. Such efforts should include building the capacity of health service providers through knowledge and skill building trainings and workshops which should consider future climate change health risk trends in space and time. The study further stresses the need for resourcing health systems especially at the local levels, as functioning and robust health systems are critical for effective and strategic climate change health adaptation. One significant goal of adaptation is to develop climate-resilient health systems that have the resources, flexibility, skills, and tools required to effectively prepare for a changing climate (WHO, 2015). Overall, actions to adapt healthcare systems in Ghana must be informed by climate science, health surveillance, and local capacity realities which this study provides a comprehensive account of.

The study also calls for improvements in current disease surveillance, forecasting and monitoring systems for climate-sensitive diseases in Ghana, especially, epidemic prone and food and water related diseases. These actions are not required just at the national level but at the local as well to help the healthcare systems at this level gauge against any emergency related outbreaks due to climate change inducements. Overall, this dissertation has generated valuable and insightful information that can aid the preparation of strategies to address the adverse health impacts of climate change in Ghana.

7.4 Study Limitations and Direction for Future Research

As with all research, this study which aimed at examining climate change-health nexus in Ghana exhibits some limitations regardless of the numerous contributions. First, this study is based on a cross-sectional data and hence, analysis is not able to make cause and effect claims but rather limited to associations instead of causal linkages. In addition, this study was conducted in two districts in Ghana and therefore, the findings may not necessarily be generalized to the entire country. Furthermore, the health risk perception of climate change assessed was basically limited to a single question which asked whether respondents perceived climate change as a health risk or not with predicting factors limited to compositional and contextual factors. However, studies have indicated that vulnerability to threats play a role in shaping people’s assessment of the threat (Akerlof et al., 2015). Thus, future studies can expand on this study by assessing the relationship between vulnerability to climate change health threats and climate change health risk perceptions in Ghana.

Also, capacity and preparedness evaluated in this study were limited to healthcare systems and service providers. Future research can also assess preparedness and capacity levels of the public to address the anticipated additional burdens from climate change health risks to their households in terms of adaptation measures they have in place and what their barriers to health adaptations are. Finally, as argued in the first chapter of this dissertation, knowledge and perception has a critical role to play in climate change adaptation and behavioral changes. As a result, future research designed to elaborate on or add depth to the findings of this study could take this direction by assessing whether perceiving climate change as a health risk impact behavioral changes such as climate change health adaptation and climate change mitigation efforts.

7.5 Conclusion

This dissertation concludes by returning to the admonishment that was provided at the very beginning of Chapter 1. That is, "given the potential of climate change to reverse the health gains from economic development, and the health co-benefits that accrue from actions for a sustainable economy, **tackling climate change could be the greatest global health opportunity of this century**" (Watts et al. 2015: 1861; *emphasis added*). Considering the myriad health risks anticipated from climate change and their adverse nature, coupled with current health system capacities and preparedness to respond to them, tackling climate change is indeed the greatest global health opportunity of the 21st century. The reality of ancillary health benefits of climate change mitigation provides a powerful incentive to accelerate policy change (mitigation policies). Accordingly, urgent and substantial climate change mitigation is essential if hard-won health gains are not to be lost but rather sustained and advanced.

The public health sector and the populace have important roles to play in protecting and promoting health vis-à-vis to climate change mitigation and adaptation strategies. Critical roles for the health sector in advancing priority mitigation strategies include communicating those relative potential health risks and advocating for health co-benefits of climate change mitigation (Watts et al., 2015). However, these roles can only be achieved with an understanding of the climate change problem by the public health officials, therefore, the need for knowledge building. Leiserowitz (2007) argued that, until people have a general understanding of climate change, people might perceive lesser risk and would be less willing to follow mitigation and adaptation measures. Therefore, building of knowledge among the public on the climate change problem is very critical as well. With climate change knowledge being a vital aspect of concern towards climate-related mitigation, and adaptation strategies, information on the current perceptions, knowledge levels and understanding of climate change and its potential health risks within countries is inevitable. This information is important for activities geared towards building climate change knowledge and risk communications within countries, as “risk communication will be most successful and efficient when it is directed toward correcting those knowledge gaps and misconceptions that are most critical to the decisions people face” (Read et al., 1994: 971). Overall, the findings in the current research present opportunities for institutions at all levels to begin enhancing and building climate change knowledge base and communicating its health-related risks in various countries (especially low-income countries), as well as advocacy to combat climate change.

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APPENDICES

APPENDIX A: LETTER OF ETHICS APPROVAL- WESTERN UNIVERSITY

Western Research

Research Ethics

Western University Non-Medical Research Ethics Board
NMREB Delegated Initial Approval Notice

Principal Investigator: Dr. Godwin Arku
Department & Institution: Social Science\Geography,Western University

NMREB File Number: 107805
Study Title: Multicriteria Evaluation Approach to Climate Change-Infectious Disease Linkages in Ghana

NMREB Initial Approval Date: April 05, 2016
NMREB Expiry Date: April 05, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Instruments	Community Survey	2016/02/23
Instruments	Experts Questionnaire	2016/02/23
Instruments	Health Practitioners Questionnaire	2016/02/23
Instruments	Health Administration - Interview Guide	2016/02/22
Instruments	Key Informants Interview Guide	2016/02/22
Letter of Information & Consent	LOI - Experts	2016/03/21
Letter of Information & Consent	LOI - Health Administrators	2016/03/21
Letter of Information & Consent	LOI - Health Practitioners	2016/03/21
Letter of Information & Consent	LOI - Key informants	2016/03/21
Letter of Information & Consent	LOI - Focus Group Discussion	2016/03/21
Letter of Information & Consent	LOI - Residents Survey	2016/03/21
Western University Protocol	Received February 29, 2016	

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the above named study, as of the NMREB Initial Approval Date noted above.

NMREB approval for this study remains valid until the NMREB Expiry Date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario.

Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

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Ethics Officer, on behalf of Dr. Riley Hinson, NMREB Chair or delegated board member

Ethics Officer to Contact for Further Information: Erika Basile ___ Nicole Kaniki ___ Grace Kelly ✓ Katelyn Harris___ Vikki Tran ___

Western University, Research, Support Services Bldg., Rm. 5150
London, ON, Canada N6G 1G9 t. 519.661.3036 f. 519.850.2466 www.uwo.ca/research/ethics

APPENDIX B: LETTER OF ETHICS APPROVAL- GHANA HEALTH SERVICE

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

In case of reply the number and date of this Letter should be quoted.

Research & Development Division
Ghana Health Service
P. O. Box MB 190
Accra
Tel: +233-302-681109
Fax + 233-302-685424
Email: ghserc@gmail.com

My Ref. GHS/RDD/ERC/Admin/App/16/151
Your Ref. No.

Lucia Kafui Hussey & Dr. Godwin Arku
Western University
Canada

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of your Study Protocol.

GHS-ERC Number	**GHS-ERC 17/07/16**
Project Title	"Multi criteria Evaluation Approach to Climate Change-Infectious Disease Linkages in Ghana"
Approval Date	9th August, 2016
Expiry Date	8th August, 2017
GHS-ERC Decision	**Approved**

This approval requires the following from the Principal Investigator

- Submission of yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months,
- Reporting of all serious adverse events related to this study to the ERC within three days verbally and seven days in writing.
- Submission of a final report **after completion** of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why
- Informing the ERC and your sponsor (where applicable) before any publication of the research findings.

Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Kindly quote the protocol identification number in all future correspondence in relation to this approved protocol

SIGNED ....
PROFESSOR MOSES AIKINS
(GHS-ERC VICE-CHAIRPERSON)

Cc: The Director, Research & Development Division, Ghana Health Service, Accra

APPENDIX C- 6.1: DISEASE CHARACTERISTICS

Disease	Mode of Transmission	Endemicity Status Endemic (Y) / Non-endemic(N)	Geographical Distribution	Outbreak Potential	Trend	Incidence
Malaria	Vector borne	Y Malaria is hyper-endemic in Ghana *(ICF Macro.2010)*	Nationwide Because it is prevalent in all Regions in Ghana.	Low Risk Of public health significance but outbreaks are not a common phenomenon in Ghana since its endemic	Stable incidence overall *(little to no change in transmission)*	Very high (>500)
Diarrhoeal	Food/ Waterborne	Y Endemic particularly amongst children *(Nyadanu, et al., 2016)*	Nationwide Classified as nationwide because, all Districts in the country are at risk	High Risks Classified as high risk because is epidemic prone *(GHS/MoH, 2015)*	Increasing incidence	Very high (>500)
Typhoid Fever	Waterborne/ Foodborne	Y Typhoid fever is among the most endemic diseases in the tropics with Ghana being no exception *(Afoakwah et al., 2011)*	Nationwide Classified as nationwide because, all Districts in the country are at risk	High risk An outbreak reported before *(Ghanaweb, 2011)*	Increasing incidence	Very high (>500)

Schistosomiasis	Vector borne	Y Highly endemic within communities located along rivers in all ten Regions *(WHO, 2010; GHS, 2017)*	Nationwide *(WHO, 2010)*	Low Risk Of public health significance but outbreaks are not a common phenomenon in Ghana	Diminishing incidence overall	Very high (>500)
Cholera	Waterborne	Y Cholera is becoming endemic in Ghana with cyclical epidemics every 4 to 6 years. However, in recent years outbreaks have become more frequent and protracted *(GHS/MoH, 2016)*	Nationwide Classified as nationwide because all Districts in the country are at risk of an outbreak although with different risk levels *(GHS/MoH, 2016)*	High risk Classified as a high risk because it is an epidemic prone disease according to classifications in Ghana *(GHS/MoH, 2015)*	Unstable incidence *(changes in transmission)*	Very high (>500)
Meningococcal meningitis	Airborne	Y Meningitis is somewhat endemic in the three northern regions of Ghana *(MoH, 2018)*	Nationwide In Ghana, meningitis cases occur throughout the year in all regions. However, yearly meningococcal epidemics have occurred mostly in the northern savannah zone of the country which lies in the meningitis belt *(GHS/MoH, 2016).*	High risk Classified as a high risk because it is an epidemic prone disease with recorded outbreaks in Ghana *(GHS/MoH, 2015)*	Unstable incidence *(changes in transmission)*	Very high (>500)

Human African Trypanosomiases	Vector borne	Y	Partial Classified as partial based on below. HAT has an estimated at-risk population of 4,500,000 in five out of the ten regions *(GHS, 2016)*	Low Risk Of public health significance but outbreaks are not a common phenomenon in Ghana	Unstable incidence *(changes in transmission)*	High (101±500)
Onchocerciasis (River Blindness)	Vector borne	Y Onchocerciasis has an estimated at-risk population of over 2 million in 3,115 communities in 40 endemic districts from nine out of the 10 Regions *(GHS, 2016)*	Partial *(WHO, 2010)*	Low Risk Of public health significance but outbreaks are not a common phenomenon in Ghana	Unstable incidence *(changes in transmission)*	Very high (>500)
Yellow Fever	Vector borne	Y *(GHS/MoH, 2016)*	Nationwide According to the public health risk mapping and capacities assessment in Ghana, the whole country is situated in the YF ecological risk zone *(GHS/MoH, 2016)*	High Risk Classified as a high risk because it is an epidemic prone disease *(GHS/MoH, 2015)*	Unstable incidence *(changes in transmission)*	High (101±500)

***Trend and Incidence characteristics were assigned based on the morbidity data obtained.

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APPENDIX C- 6.2: SELECTED INFECTIOUS DISEASES- MORBIDITY CASES FOR GHANA: 2008-2015

INFECTIOUS CASES	YEAR							
	2008	2009	2010	2011	2012	2013	2014	2015
Total OPD cases (Malaria)	11,816,951	15,412,836	18,580,725	24,127,108	28,518,347	31,044,533	27,686,808	26,676,640
Diarrhoeal Diseases	433,871	586,795	727,226	1,024,802	1,317,377	1,530,311	1,573,569	1,515,189
Typhoid Fever	99,188	140,830	177,190	227,893	263,332	339,410	334,103	337,120
Schistosomiasis (Bilharzia)	17,645	12,916	12,498	14,811	10,877	8,900	9,481	5,467
Suspected Cholera	786	807	387	5,242	6,076	1,905	24,697	29,491
Cholera Cases *			438	9370	9562	18	28975	692
Onchocerciasis	2,225	2,111	1,728	1,263	724	462	609	380
Meningitis	1,559	1,347	1,031	943	874	275	303	426
Yellow Fever	72	187	207	75	130	71	116	58
Trypanosomiasis cases					123	124	134	8

Data Source: Monitoring and Evaluation Department-Policy, Planning, Monitoring and Evaluation Division (PPMED), Ghana Health Service (Field work, 2016)

*Obtained from MoH/GHS (2016). Public Health Risk Mapping and Capacities Assessment in Ghana.

APPENDIX C- 6.3: EXPERTS CHARACTERISTICS

CHARACTERISTICS	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7
Institute	Noguchi Memorial Institute for Medical Research	University of Ghana, School of Public Health	Noguchi Memorial Institute for Medical Research	Noguchi Memorial Institute for Medical Research	Noguchi Memorial Institute for Medical Research	WHO	Noguchi Memorial Institute for Medical Research
Type of Institute	Research/ Academia	Research/ Academia	Research/ Academia	Research/ Academia	Research/ Academia	NGO	Research/ Academia
Specialization	Epidemiology	Public Health/ Environment Research	Health Research/ Epidemiology (Malaria interventions and clinical trials)	Health Research	Medical Research/ Enteric Viruses & Molecular Biology	Public Health	Biomedical Research (Epidemiological Disease Control)
Years of working in field of specialization	16 years	13 years	23 years	11 years	9 years	10 years	9 years
How concerned is your organization about the impacts of climate change on health, especially infectious disease risks to human health? 1. Very concerned 2. Somewhat concerned 3. Not concerned at all 4. No position/outside the organization's mission	Very concerned	Very concerned	Somewhat concerned	Very concerned	Very concerned	Very concerned	Very concerned
What are some of the efforts of this organization/institution to help address some of the infectious disease health risks associated with climate change	Research into impact of interventions and disease surveillance	Evidence based research to inform policy	The institute is undertaking climate change risk and infectious disease with ISSER- another institute at University of Ghana	Disease surveillance and monitoring to respond to changes in disease occurrence and distributions	-	Development of preparedness and response plans to outbreak, training of health workers.	-
Highest level of educational attainment	Ph.D.	Ph.D.	Ph.D.	Ph.D.	Ph.D.	Masters	Masters
Age range	46-50	41-50	56-60	36-40	36-40	46-50	31-35
Gender	Male	Male	Male	Male	Male	Female	Female

APPENDIX C-6.4: CRITERIA AND WEIGHTINGS USED FOR CLIMATE SENSITIVE INFECTIOUS DISEASE PRIORITIZATION IN GHANA

<table>
<tr><th>CRITERIA GROUP/ SUB-CRITERIA</th><th>ATTRIBUTES- MEASUREMENT UNITS</th><th>WEIGHTS</th><th>SOURCE OF ASSESSMENT</th><th>ATTRIBUTE MEASUREMENT (SOURCE)</th></tr>
<tr><td colspan="2">Disease Epidemiology</td><td colspan="3"></td></tr>
<tr><td>A1. Endemicity
(endemic levels of disease in Ghana)</td><td>1. Not endemic in Ghana

2. Endemic in Ghana</td><td>Rank 1 was weighted thrice as 2
Rank | Pairwise score
1 | 3
2 | 9</td><td>Literature review was used to identify the endemicity status of selected diseases in Ghana.</td><td>Authors construct</td></tr>
<tr><td>A2. Mode of Transmission
(How is the pathogen transmitted?)</td><td>1. Vector borne (e.g. via a bite or contact by a vector)

2. Waterborne (e.g. via consumption or contact with contaminated water)

3. Food borne (e.g. via consumption of contaminated food)

4. Air borne (e.g. via inhalation of a pathogen suspended in air or water droplets</td><td>- Experts opinion on whether climate change will impact these groups of infectious diseases in the Ghanaian context was used as a basis for the weighting.

- First a rating model was developed for each expert based on the Likert scale (not likely; likely; extremely likely). Each category was weighted twice as the other with extremely likely weighting the highest.

-The ranks from the ratings from each expert were converted into scores on the pairwise scale and used for comparisons. The resulting individual's weights were then aggregated.</td><td>Experts opinion</td><td>Cox, Sanchez, & Revie (2013)</td></tr>
</table>

		- From the aggregated weights, the following ranks emerged and are converted to the following weights on the pairwise scale **Rank / Disease** — **Pairwise score** 1-Vector borne — 9 2- Air borne — 7 3-Water borne — 5 4- Food borne — 3 -In a case where a disease can, be transmitted through more than one mode like Typhoid (water and food borne), the transmission mode with the greatest weight was applied		
A3. Geographical Distribution *(Geographical coverage of disease in Ghana)*	1. Nationwide 2. Partial coverage	Rank 1 was weighted thrice as 2 **Rank** — **Pairwise score** **1** — 3 **2** — 9	Literature review was used to identify the geographical coverage of diseases in Ghana	Authors construct
B. Disease Burden				
B1. Incidence *(current incidence of human disease in Ghana -Reported yearly incidence of human cases in Ghana*).	1: Very Low (<5) 2: Low (6±30) 3: Moderate (31-100) 4: High (101±500) 5: Very high (>500)	Ranks for the various categories were converted into the following scores on the pairwise comparison scale. Highest rank was weighted more since it constitutes more of a risk and burden.	Secondary data (morbidity data for an 8 years span on selected climate sensitive infectious diseases, except for cholera cases in which 5 years span was used)	Hongoh et al. 2016; 2017

<table>
<tr><td></td><td></td><td><table><tr><th>Rank</th><th>Pairwise score</th></tr><tr><td>1</td><td>2</td></tr><tr><td>2</td><td>3</td></tr><tr><td>3</td><td>5</td></tr><tr><td>4</td><td>7</td></tr><tr><td>5</td><td>9</td></tr></table></td><td>-Because data used covered an 8 years span, the closet number to the median which is 5 was used as a cut off to determine the category that a disease fit.

-Thus, if a disease record numbers fitting within a specific category for 5 years, the weight for that category was applied.
- In a case the disease incidence over the years fit into two categories, the highest rank was chosen.</td><td></td></tr>
<tr><td colspan="5">Epidemiological Dynamic</td></tr>
<tr><td>C1. Trend
(looking at disease incidence in the last 5 years)</td><td>1. No cases or too few cases to establish a trend

2. Diminishing incidence overall

3. Stable incidence overall (little to no change in transmission)</td><td>Ranks for the various categories were converted into the following scores on the pairwise comparison scale. Highest rank was weighted more since it constitutes more of a risk and burden.</td><td>Secondary data (last 5 years of obtained morbidity data on selected climate-sensitive infectious diseases was used).</td><td>Cox, Sanchez, & Revie (2013)</td></tr>
</table>

	4. Unstable incidence *(changes in transmission)* 5. Increasing incidence	**Rank** / **Pairwise score** **1** / 2 **2** / 3 **3** / 5 **4** / 7 **5** / 9		
C2. Outbreak Potential *(epidemic potential of disease if climate change induced and its ability to spread rapidly)*	1. Low risk *(outbreaks are very rare)* 2. High risk *(outbreaks with 5 or more cases reported)*	Rank 1 was weighted twice as 2 **Rank** / **Pairwise score** **1** / 3 **2** / 9 Epidemic prone diseases, and diseases that had recorded an epidemic before in recent years were assumed to have a higher risk	Review of literature on selected diseases within the Ghanaian context	
Health Gain Opportunity-Monitoring, Treatment and Diagnosis				
D1. Treatability *(What treatment is available for the disease? -Ability to treat disease in humans in Ghana (availability and effectiveness of treatment- that would enable ability to deal with exacerbation of cases due to climate change).*	1. Medical treatment is desirable, but no specific treatment is available that reduces disease burden or prognosis. Care is based on symptoms 2. Medical treatment has a limited influence on disease burden or diagnosis. And/or antimicrobial resistance to treatment has been recorded 3. Effective treatments are available that positively influenced the burden of disease or diagnosis	-A rank reversal approach was adopted with the low category on the Likert scale weighting more. -This mode was adopted because it denotes more risk in case of climate change inducement in disease prevalence. -Each category was weighted twice more than the other. **Rank** / **Pairwise score** **1** / 9 **2** / 6 **3** / 3	Expert opinion based on Likert scale	Gérard Krause and the Working Group on Prioritization at the Robert Koch Institute, 2008

<table>
<tr>
<td>D2. Preventability
(Is there a feasible process that could prevent the disease? - Ability to prevent disease in Ghana (e.g. by vaccination or public health education-).</td>
<td>1. Preventive measures are not available or do not exist

2. Disease incidence can be modified by an educational program (public health education or behavioral modification)

3. Some preventive measures are established but there is a need for further research to improve effectiveness

4. Prevention is possible (e.g., vaccination, eradication program exists)</td>
<td>-A rank reversal approach was adopted with the low category on the Likert scale weighting more.

-This mode was adopted because it denotes more risk in case of climate change inducement in disease prevalence.

-Each category was weighted as follows.

<table><tr><th>Rank</th><th>Pairwise score</th></tr><tr><td>1</td><td>9</td></tr><tr><td>2</td><td>7</td></tr><tr><td>3</td><td>5</td></tr><tr><td>4</td><td>3</td></tr></table></td>
<td>Expert opinion- based on Likert scale</td>
<td>Cox, Sanchez, & Revie (2013)</td>
</tr>
<tr>
<td>D3. Surveillance
(Effectiveness of national surveillance- is there ongoing systematic collection and analysis of data that leads to disease prevention or control?)</td>
<td>1. Effective surveillance strategies do not exist within Ghana

2. No formal surveillance exists in Ghana but there are some guidelines for the identification and management of outbreaks.

3. Effective surveillance strategies exist in Ghana</td>
<td>-A rank reversal approach was adopted with the low category on the Likert scale weighting more.

-This mode was adopted because it denotes more risk in case of climate change inducement in disease prevalence.

-Each category was weighted twice more than the other.

<table><tr><th>Rank</th><th>Pairwise score</th></tr><tr><td>1</td><td>9</td></tr><tr><td>2</td><td>6</td></tr><tr><td>3</td><td>3</td></tr></table></td>
<td>Experts assessment based on Likert scale</td>
<td>Cox, Sanchez, & Revie (2013)</td>
</tr>
</table>

<table>
<tr>
<td>D4. Ability to Diagnose
(Ability to diagnose disease in Ghana - availability and sensitivity of diagnostic tests)</td>
<td>1. A diagnostic test exists, but a more sensitive, specific or rapid test is needed.

2. Sensitive diagnostic test exists, although availability and uptake need to improve

3. A sensitive diagnostic test is widely available across the country to allow early detection</td>
<td>A rank reversal approach adopted with the low category on the Likert scale weighting more because that category denotes more risk in case of climate change inducement in disease. Each category was weighted twice more than the other.
<table>
<tr><th>Rank</th><th>Pairwise score</th></tr>
<tr><td>**1**</td><td>9</td></tr>
<tr><td>**2**</td><td>6</td></tr>
<tr><td>**3**</td><td>3</td></tr>
</table>
</td>
<td>Experts assessment based on Likert scale.</td>
<td>Cox, Sanchez, & Revie (2013)</td>
</tr>
<tr>
<td colspan="5">**E. Risk**</td>
</tr>
<tr>
<td>E1. Influence of Climate Change</td>
<td>1. Not enough information is known to make a prediction

2. Unlikely to influence

3. Likely to influence

4. Extremely influence</td>
<td>- Following from Cox et al., (2013) the category 1-*Not enough information is known to make a prediction*- is deemed low risk.

-Weights increase if disease is going to be influenced by climate change.
<table>
<tr><th>Rank</th><th>Pairwise score</th></tr>
<tr><td>**1**</td><td>3</td></tr>
<tr><td>**2**</td><td>5</td></tr>
<tr><td>**3**</td><td>7</td></tr>
<tr><td>**4**</td><td>9</td></tr>
</table>
</td>
<td>Experts assessment based on Likert scale</td>
<td>Cox, Sanchez, & Revie (2013)</td>
</tr>
</table>

APPENDIX D: SURVEY INSTRUMENT -COMMUNITIES

COMMUNITY SURVEY

District ____________________ Community________________________________

Respondent #_________________ Enumerator Code/ Name ___________________

Survey Date _____/______/2016 Survey Number_____________________

Survey Status: ☐ Completed ☐ Postponed Survey Entered ☐

SECTION I: COMMUNITY STATUS/HOUSING & HOUSING FACILITIES

No.	Questions/Instructions	Possible Responses	Code (✓)
1.	Have you lived in this area for the last five years?	No	0☐
		Yes	1☐
		Don't know	98☐
		Refused	99☐
2.	How long have you lived in this area?	0-5 years	1☐
		6-10 years	2☐
		11-15 years	3☐
		20 years or more	4☐
		Don't know	98☐
		Refused	99☐
3.	How many years have you lived in this house? **(RECORD ONE RESPONSE ONLY)**	0-5 years	1☐
		6-10 years	2☐
		11-15 years	3☐
		20 years or more	4☐
		Don't know	98☐
		Refused	99☐
4.	Which of the following housing type's best describes the type of dwelling this household occupies?	Separate/Detached house	1☐
		Semi-detached house	2☐
		Flats/Apartments	3☐
		Compound house	4☐
		Huts	5☐
		Improvised home (Kiosk/Container)	6☐
		Uncompleted building	7☐
		Others *(Specify)*	97☐
5.	What is/are the source(s) of drinking water in dry season? **(Check the applicable category)**	Unimproved drinking water sources: *[Unprotected dug well, unprotected spring, cart with small tank/drum, tanker truck, and surface water (river, dam, lake, pond, stream, canal, irrigation channels), bottled water].*	1☐

		Other improved drinking water sources: *[Public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs and rainwater collection]*.	2☐
		Improved- Piped water on premises: *[Piped household water connection located inside the user's dwelling, plot or yard]*.	3☐
		Refused	99☐
6.	What is/are the source(s) of drinking water in rainy season? **(Check the applicable category)**	Unimproved drinking water sources: *[Unprotected dug well, unprotected spring, cart with small tank/drum, tanker truck, and surface water (river, dam, lake, pond, stream, canal, irrigation channels), bottled water]*.	1☐
		Other improved drinking water sources: *[Public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs and rainwater collection]*.	2☐
		Improved- Piped water on premises: *[Piped household water connection located inside the user's dwelling, plot or yard]*.	3☐
		Refused	99☐
7.	What type of bathing facility does this household use?	Own bathroom for exclusive use of household	1☐
		Shared bathroom with other households	2☐
		Public bath house	3☐
		Open space around house	4☐
		River/Pond/Lake/Dam	5☐
		Others *(Specify)*	97☐
		Refused	99☐
8.	What type of toilet facility does this household use?	Own toilet facility for exclusive use of household (Water Closet, KVIP)	1☐
		Shared toilet facility with other households (Water Closet, KVIP)	2☐
		Pit latrine (exclusive use of household)	3☐
		Pit latrine (shared with other household)	4☐
		Public toilet facility (Water Closet, KVIP)	5☐
		No facility (bush/beach/field)	6☐
		Others *(Specify)*	97☐
		Refused	99☐

9.	How many rooms does household have / how many rooms are in this house?	Write the exact number:………………..	
10.	How many of the rooms are used for sleeping?	Write the exact number:…………………	
11.	What is the average number of persons per room?	Write the exact number	……… ….
		Refused	99☐

SECTION II: ENDEMIC DISEASES AND DISEASE BURDEN

ENDEMIC DISEASES			
No.	**Questions/ Enumerator Instructions**	**Possible Responses**	**Code (✓)**
12.	What diseases are endemic in this community?	1. African Trypanosomiasis (Sleeping sickness)	0☐ /1☐
		2. Malaria	0☐ /1☐
		3. Tuberculosis	0☐ /1☐
		4. Schistosomiasis	0☐ /1☐
		5. Lymphatic Filariasis (Elephantiasis)	0☐ /1☐
		6. Onchocerciasis (River Blindness)	0☐ /1☐
		7. Meningococcal meningitis	0☐ /1☐
		8. Cholera	0☐ /1☐
		9. Measles	0☐ /1☐
		10. Trachoma	0☐ /1☐
		11. Yaws	0☐ /1☐
		12. Guinea worm	0☐ /1☐
		13. Yellow fever	0☐ /1☐
		14. Buruli Ulcer	0☐ /1☐
		15. Soil-transmitted Helminths	0☐ /1☐
		16. Leishmaniasis	0☐ /1☐
		17. HIV/AIDs	0☐ /1☐
		18. Hepatitis *(specify type(s)*	0☐ /1☐
		19. Diarrhoea	0☐ /1☐
		20. Leprosy	0☐ /1☐
		21. Typhoid fever	0☐ /1☐
		22. Rabies	0☐ /1☐
		23. Others *(specify)*	97 ☐
		24. Refused	99 ☐
13.	Which of these diseases **(in response to Q12)** is /are of greatest concern in this community?	Enter Response. …………………………………………………… …………………………………………………… ……………………………………………………	

14.	On a scale of 1-5, how would you rate the severity of the diseases mentioned in **Q13?**					
		Diseases *(Enter all diseases from Q13)*	**Severity**			
			1	2	3	4	5

15.	Have you ever experienced any of these endemic diseases?	No **[GO TO 17]**	0 ☐
		Yes **[GO TO 16]**	1 ☐
16.	Which of the endemic diseases mentioned in **Q12** have you ever experienced within this community? **(Check Only Mentioned Diseases)** **[0= NOT EXPERIENCED, 1=EXPERIENCED]**	1. African Trypanosomiasis (Sleeping sickness)	0☐ /1☐
		2. Malaria	0☐ /1☐
		3. Tuberculosis	0☐ /1☐
		4. Schistosomiasis	0☐ /1☐
		5. Lymphatic Filariasis (Elephantiasis)	0☐ /1☐
		6. Onchocerciasis (River Blindness)	0☐ /1☐
		7. Meningococcal meningitis	0☐ /1☐
		8. Cholera	0☐ /1☐
		9. Measles	0☐ /1☐
		10. Trachoma	0☐ /1☐
		11. Yaws	0☐ /1☐
		12. Guinea worm	0☐ /1☐
		13. Yellow fever	0☐ /1☐
		14. Buruli Ulcer	0☐ /1☐
		15. Soil-transmitted Helminths	0☐ /1☐
		16. Leishmaniasis	0☐ /1☐
		17. HIV/AIDs	0☐ /1☐
		18. Hepatitis *(specify type(s)*	0☐ /1☐
		19. Diarrhoea	0☐ /1☐
		20. Leprosy	0☐ /1☐
		21. Typhoid fever	0☐ /1☐
		22. Rabies	0☐ /1☐
		23. Others *(specify)*	97 ☐
17.	When was the last time you experienced any of these endemic diseases and which one?	Enter disease and time (enter year and month) ……………………………………………	
18.	Have any member of your family experienced any of the endemic infectious diseases?	No **[GO TO 20]**	0 ☐
		Yes **[GO TO 19]**	1 ☐

19.	If **YES**, which kind of disease?	Enter as mentioned. ……………………………………………………………… ……………………………………………………………… ………………………………………………………………		
20.	Which of the seasons did you or your family member experience the disease(s)?/ Which season do the diseases identified in Q12 occur? **[ANSWER RELATES TO ONLY DISEASES THAT THE RESPONDENT OR A FAMILY MEMBER HAVE EVER EXPERIENCED / DISEASES IDENTIFIED IN Q12]** **If disease was experienced in both seasons, check both Wet and Dry**	Diseases	Season (✓ applicable)	
			Wet	*Dry*
		1. African Trypanosomiasis (Sleeping sickness)		
		2. Malaria		
		3. Tuberculosis		
		4. Schistosomiasis		
		5. Lymphatic Filariasis (Elephantiasis)		
		6. Onchocerciasis (River Blindness)		
		7. Meningococcal meningitis		
		8. Cholera		
		9. Measles		
		10. Trachoma		
		11. Yaws		
		12. Guinea worm		
		13. Yellow fever		
		14. Buruli Ulcer		
		15. Soil-transmitted Helminths		
		16. Leishmaniasis		
		17. HIV/AIDs		
		18. Hepatitis *(specify type(s)*		
		19. Diarrhoea		
		20. Leprosy		
		21. Typhoid fever		
		22. Rabies		
		23. Others *(specify)*		
21.	What do you think are the causes of endemic diseases within this community? [**Question relates only to endemic diseases identified in Q12**]	Diseases	Cause (s)	
		1. African Trypanosomiasis (Sleeping sickness)		
		2. Malaria		
		3. Tuberculosis		
		4. Schistosomiasis		
		5. Lymphatic Filariasis (Elephantiasis)		
		6. Onchocerciasis (River Blindness)		
		7. Meningococcal meningitis		
		8. Cholera		
		9. Measles		
		10. Trachoma		
		11. Yaws		

		12. Guinea worm	
		13. Yellow fever	
		14. Buruli Ulcer	
		15. Soil-transmitted Helminths	
		16. Leishmaniasis	
		17. HIV/AIDs	
		18. Hepatitis *(specify type(s)*	
		19. Diarrhoea	
		20. Leprosy	
		21. Typhoid fever	
		22. Rabies	
		23. Others *(specify)*	
22.	What problems do you and your household face or experience as a result of endemic diseases or in cases of outbreaks?	Write problem(s) mentioned 1…………………………………………….. 2. ………………………………………… 3. ……………………………………………	
23.	Do you think the area you live in makes you prone to endemic infectious diseases?	No **[GO TO 25]**	0☐
		Yes **[GO TO 24]**	1☐
24.	If **YES** to **Q23**, why is that the case?	*Write the reason(s) given.* 1…………………………………………… 2……………………………………………..	
25.	Do you think the kind of work you engage in or your employment makes you prone to endemic infectious diseases within this community?	No **[GO TO 27]**	0☐
		Yes **[GO TO 26]**	1☐
26.	If **YES** to **Q25**, why is that the case?	*Write the reason(s) given.* 1…………………………………………… 2……………………………………………	
27.	Do you think the gender roles you perform (e.g. fetching water from the streams for girls/women or farming/hunting by men/boys) makes you prone or exposed to endemic diseases within this community?	No **[GO TO 29]**	0☐
		Yes **[GO TO 28]**	1☐
28.	If **YES** to **Q27**, why is that the case?	*Write the reason(s) given.* 1…………………………………………….. 2…………………………………………	
29.	Have you noticed any changes in cases of endemic infectious diseases recorded over the years?	No **[GO TO 31]**	0☐
		Yes **[GO TO 30]**	1☐

30.	If **YES** to **Q29**, what changes have you noticed? **(Check only the diseases identified in Q12)**	Extreme Increase (4)	Moderate increase (3)	Slight increase (2)	Reduced (1)
	1. African Trypanosomiasis (Sleeping sickness)				
	2. Malaria				

	3. Tuberculosis				
	4. Schistosomiasis				
	5. Lymphatic Filariasis (Elephantiasis)				
	6. Onchocerciasis (River Blindness)				
	7. Meningococcal meningitis				
	8. Cholera				
	9. Measles				
	10. Trachoma				
	11. Yaws				
	12. Guinea worm				
	13. Yellow fever				
	14. Buruli Ulcer				
	15. Soil-transmitted Helminths				
	16. Leishmaniasis				
	17. HIV/AIDs				
	18. Hepatitis *(specify type(s)*				
	19. Diarrhoea				
	20. Leprosy				
	21. Typhoid fever				
	22. Rabies				
	23. Others *(specify)*				

31.	Which endemic diseases have recorded outbreaks over the years? **[Check only identified diseases in Q12]**	**Within the past 1-5 years**				**Within the past 6 -10 years**				**Between 11 and 20 years**			
		Never (0)	Only once (1)	Twice (2)	Thrice or more (3)	Never (0)	Only once (1)	Twice (2)	More than thrice (3)	Never (0)	Only once (1)	Twice (2)	More than thrice (3)
	1. African Trypanosomiasis (Sleeping sickness)												
	2. Malaria												
	3. Tuberculosis												
	4. Schistosomiasis												
	5. Lymphatic Filariasis (Elephantiasis)												
	6. Onchocerciasis (River Blindness)												
	7. Meningococcal meningitis												
	8. Cholera												
	9. Measles												
	10. Trachoma												
	11. Yaws												
	12. Guinea worm												
	13. Yellow fever												
	14. Buruli Ulcer												

	15. Soil-transmitted Helminths												
	16. Leishmaniasis												
	17. HIV/AIDs												
	18. Hepatitis *(specify type(s)*												
	19. Diarrhoea												
	20. Leprosy												
	21. Typhoid fever												
	22. Rabies												
	23. Others *(specify)*												

32.	For the recorded outbreaks identified in **Q31,** when do they normally occur?	After raining season (1)	During raining season (2)	During the dry season (3)	After Dry Season (4)
	1. African Trypanosomiasis				
	2. Malaria				
	3. Tuberculosis				
	4. Schistosomiasis				
	5. Lymphatic Filariasis (Elephantiasis)				
	6. Onchocerciasis (River Blindness)				
	7. Meningococcal meningitis				
	8. Cholera				
	9. Measles				
	10. Trachoma				
	11. Yaws				
	12. Guinea worm				
	13. Yellow fever				
	14. Buruli Ulcer				
	15. Soil-transmitted Helminths				
	16. Leishmaniasis				
	17. HIV/AIDs				
	18. Hepatitis *(specify type(s)*				
	19. Diarrhoea				
	20. Leprosy				
	21. Typhoid fever				
	22. Rabies				
	23. Others *(specify)*				

33.	Have you noticed any new disease(s) within this community that did not exist previously?	No **[GO TO 35]**	0☐
		Yes **[GO TO 34]**	1☐
		Don't know	98☐
		Refused	99☐
34.	If **YES**, can you tell me the type of disease(s)?	Write the type(s) of disease as mentioned 1………………………………………………… 2…………………………………………………	
35.	How would you rank problems related to endemic diseases relative to other problems within this community?	Very low	1 ☐
		Low	2 ☐
		At par (same)	3 ☐
		High	4 ☐
		Top priority	5 ☐
		Don't know	98☐
		Refused	99☐

SECTION III: IDEAS/ KNOWLEDGE ABOUT CLIMATE CHANGE

No.	Questions/Instructions	Possible Responses	Code (✓)
36.	Have you heard about global climate change or global warming?	No **[GO to 38]**	0☐
		Yes **[GO TO 37]**	1☐
37.	Based on what you have heard about climate change / global warming, in your opinion, what is climate change?	Enter as explained …………………………………………… …………………………………………… ……………………………………………	
		Don't know	98☐
		Refused	99☐
38.	Have you noticed any changes in temperature over the past years?	No **[GO TO 41]**	0 ☐
		Yes **[GO TO 39]**	1 ☐
		Don't know	98 ☐
		Refused	99 ☐
39.	**[IF YES]** What changes have you observed? **[0 = NO, 1=YES]**	Getting hotter	0☐ /1☐
		Getting colder	0☐ /1☐
		Longer spells of hot temperature	0☐ /1☐
		Longer spells of cold temperature	0☐ /1☐
		Shorter spells of cold temperature	0☐ /1☐
		Shorter spells of hot temperature	0☐ /1☐
		Rapid changes in temperature	0☐ /1☐
		Others *(specify)*	97☐

		Never (0)	1-3x (1)	4-5x (2)	>5x (3)	Don't know (98)	Refused (99)
40.	How long ago do you remember these changes in temperature happening?						
	a. Within the past 10 years						
	b. Between 11 and 30 years						
	c. More than 30 years						

41.	Have you noticed any changes in rainfall over the past years?	No **[GO TO 44]**					0 ☐
		Yes **[GO TO 42]**					1 ☐
		Don't know					98 ☐
		Refused					99 ☐
42.	**[IF YES]** What changes have you observed? **[0 = NO, 1=YES]**	Early start of rainy season					0☐ /1☐
		Delay in start of rainy season					0☐ /1☐
		Shorter rainy season					0☐ /1☐
		Extended rainy season					0☐ /1☐
		Less amount of rainfall					0☐ /1☐
		Increase in amount of rainfall					0☐ /1☐
		Rapid changes in rainfall pattern					0☐ /1☐
		Others *(specify)*					97 ☐
43.	How long ago do you remember these changes in rainfall happening?	Never (0)	1-3x (1)	4-5x (2)	>5x (3)	Don't know (98)	Refused (99)
	a. Within the past 10 years						
	b. Between 11 and 30 years						
	c. More than 30 years						
44.	Have you noticed changes in the **STARTING TIME** of rainfall from the past?	No **[GO TO 46]**					0 ☐
		Yes **[GO TO 45]**					1 ☐
		Don't know					98 ☐
		Refused					99 ☐
45.	How long ago did you start noticing changes in the **STARTING TIME** of rainfall?	Never (0)	1-3x (1)	4-5x (2)	>5x (3)	Don't know (98)	Refused (99)
	a. Within the past 10 years						
	b. Between 11 and 30 years						
	c. More than 30 years						
46.	Have you noticed any changes in the **ENDING TIME** of rainfall from the past?	No **[GO TO 48]**					0 ☐
		Yes **[GO TO 47]**					1 ☐
		Don't know					98 ☐
		Refused					99 ☐
47.	What kind of changes in the **ENDING TIME** of rainfall have you noticed?	No change					1 ☐
		Ends early					2 ☐
		Ends late					3 ☐
		Ends early and abruptly					4 ☐
		Ends late and abruptly					5 ☐
		Others *(Specify)*					97 ☐
		Refused					99 ☐
48.	How would you describe the rate at which the environmental conditions (temperature and rainfall) is changing?	No change					0 ☐
		Slowly					1 ☐
		Rapidly					2 ☐
		Very rapidly					3 ☐
		Don't know					98 ☐
		Refused					99 ☐

49.	**[ONLY IF ANSWER TO 48 IS NOT 0]** What do you think is the most important underlying cause of environmental change (climate change)? ***Please select one***	Deforestation	1 ☐
		Overpopulation	2 ☐
		Greenhouse gas emissions	3 ☐
		Resource extraction	4 ☐
		God's will	5 ☐
		Violated cultural values	6 ☐
		Others *(specify)*	97 ☐
		Don't know	98 ☐
		Refused	99 ☐

SECTION V: PERCEIVED IMPACTS AND HEALTH RISKS TO CLIMATE CHANGE

PERCEIVED GENERAL IMPACTS OF CLIMATE CHANGE			
No.	**Questions/Instructions**	**Possible Responses**	**Code (✓)**
50.	Would you say climate change causes the following types of environmental impacts? **[0 = NO, 1=YES]**	1. Heat waves (prolonged episodes of hot weather)	0☐ /1☐
		2. Increased rainfall	0☐ /1☐
		3. Drought condition or water shortage	0☐ /1☐
		4. Forest fire	0☐ /1☐
		5. Coastal erosion	0☐ /1☐
		6. Flooding	0☐ /1☐
		7. Average temperature increase	0☐ /1☐
		8. Increased cases in Infectious diseases (e.g. malaria, cholera, onchocerciasis)	0☐ /1☐
		9. Sea-level rise	0☐ /1☐
		10. Reduced food production	0☐ /1☐
		11. Loss of wildlife	0☐ /1☐
PERCEIVED HEALTH IMPACTS OF CLIMATE CHANGE			
51.	Do you think there is a link between climate change and health?	No **[GO TO 53]**	0☐
		Yes **[GO TO 52]**	1☐
52.	What specific health risks related to climate change have you heard?	Enter as mentioned 1……………………………………………… 2…………………………………………… 3………………………………………………	
53.	Would you say that climate change will cause or causes the following types of health impacts within this community/ poses a risk to populations in this community in any of the following ways?	1. Air pollution	0☐ /1☐
		2. Changes in vector ecology (e.g. malaria, dengue)	0☐ /1☐
		3. Extreme heat (e.g. heat related deaths, illness)	0☐ /1☐

	[0 = NO, 1=YES]	4. Water and food supply (e.g. malnutrition, diarrheal diseases)	0☐ /1☐
		5. Water quality issues (e.g. cholera)	0☐ /1☐
		6. Increasing allergens (e.g. respiratory allergies)	0☐ /1☐
		7. Severe weather (e.g. injuries/ deaths from flooding, storms, bush fires)	0☐ /1☐
54.	Do you think climate change is having an impact or will have an impact on endemic diseases with this community?	No **[GO TO 57]**	0☐
		Yes **[GO TO 55]**	1☐
55.	**[If YES]**, which disease(s)? Question relates to diseases that climate change is likely to affect. **[CHECK ONLY MENTIONED DISEASES]**	*Check as mentioned or identified*	
		1.African Trypanosomiasis (Sleeping sickness)	1☐
		2.Malaria	2☐
		3.Tuberculosis	3☐
		4.Schistosomiasis	4☐
		5.Lymphatic Filariasis (Elephantiasis)	5☐
		6. Onchocerciasis (River Blindness)	6☐
		7.Meningococcal meningitis	7☐
		8.Cholera	8☐
		9.Measles	9☐
		10.Trachoma	10☐
		11.Yaws	11☐
		12.Guinea worm	12☐
		13.Yellow fever	10☐
		14.Buruli Ulcer	11☐
		15.Soil-transmitted Helminths	12☐
		16.Leishmaniasis	13☐
		17.HIV/AIDs	14☐
		18.Hepatitis *(specify type(s)*	15☐
		19.Diarrhoea	16☐
		20.Leprosy	17☐
		21.Typhoid fever	18☐
		22.Rabies	19☐
		23.Others *(specify)*	97☐

56.	What makes you think that climate change is affecting or will affect diseases identified in Q55?	Enter impact(s) for only diseases mentioned	
	1. African Trypanosomiasis (Sleeping sickness)		
	2. Malaria		
	3. Tuberculosis		
	4. Schistosomiasis		
	5. Lymphatic Filariasis (Elephantiasis)		
	6. Onchocerciasis (River Blindness)		
	7. Pneumococcal/Meningococcal meningitis		
	8. Cholera		
	9. Measles		
	10. Trachoma		
	11. Yaws		
	12. Guinea worm		
	13. Yellow fever		
	14. Buruli Ulcer		
	15. Soil-transmitted Helminths		
	16. Leishmaniasis		
	17. HIV/AIDs		
	18. Hepatitis *(specify type(s)*		
	19. Diarrhoea		
	20. Leprosy		
	21. Typhoid fever		
	22. Rabies		
	23. Others *(specify)*		
57.	Do you think climate change or extreme weather is the reason for the changes in prevalence of endemic diseases identified in **Q30**?	Extremely likely	5☐
		Very likely	4 ☐
		Somewhat likely	3 ☐
		Less likely	2☐
		Extremely unlikely	1 ☐
58.	Have you considered the impact of climate change on infectious diseases in your work?	Not at all considered	0 ☐
		Considered	1 ☐
		Considered and conducted related researches	2 ☐
		Refused	99 ☐
59.	Have you received any sensitization with regards to climate change and / its impacts on health within this community?	No **[GO TO Q61]**	0☐
		Yes **[GO TO Q60]**	1☐
		Don't know	98☐
		Refused	99☐
60.	If **YES** to **Q59,** what kind/type did you receive?	Enter as mentioned 1…………………………………………… 2…………………………………………… 3……………………………………………. 4…………………………………………….	

SECTION VII: COPING STRATEGIES, ADAPTATION & ADAPTIVE CAPACITY TO ENDEMIC DISEASES

COPING STRATEGIES AND ADAPTIVE CAPACITY TO ENDEMIC DISEASES			
61.	**Now I would like to ask you about what you do to manage or cope during outbreaks of endemic diseases.** Do you have any coping strategies?	No **[GO TO 63]**	0☐
		Yes **[GO TO 62]**	1☐
		Don't know	98☐
		Refused	99☐
62.	What specific things or actions did you take or did to manage or prevent yourself and family from the most recent outbreak of disease within this community?	Write the disease and the action(s) used or taken	
		1……………………………………… 2……………………………………… 3………………………………………	
		☐Nothing **[GO TO 63]**	
63.	If nothing, why did you not do anything? **(Ask this question only if respondent choose nothing in Q62)**	Enter as mentioned 1……………………………………… 2……………………………………… 3………………………………………	
64.	Did you receive any assistance from the health institution in cases of outbreaks of disease?	No **[GO TO 66]**	0☐
		Yes **[GO TO 65]**	1☐
65.	What kind of assistance did you receive?	Write the assistance(s) received as mentioned 1……………………………………… 2……………………………………… 3………………………………………	
66.	Do you or have you ever received information on disease outbreaks or potential outbreaks?	No **[GO TO 68]**	0☐
		Yes **[GO TO 67]**	1☐
		Don't know	98☐
		Refused	99☐
67.	From whom do you receive or get such information? **[Check all mentioned]**	Friends and family	1☐
		Community leader	2☐
		Social networks	3☐
		Media	4☐
		Local government	5☐
		Central government	6☐
		Private organization	7☐
		NGOs	8☐
		Others *(Specify)*	97☐
		Don't know	98☐
		Refused	99☐
68.	What challenges do you face or have faced in the past in terms of coping with disease outbreaks?	Enter as mentioned 1……………………………………… 2……………………………………… 3……………………………………… 4………………………………………	

69.	What are the action(s) that the community take in the event of outbreak of endemic diseases to prevent recording of new cases?	Enter as mentioned 1…………………………………… 2…………………………………… 3…………………………………… 4……………………………………	
70.	Do you have any intervention or program from the health facility or government to reduce or prevent endemic diseases within this community?	No **[GO TO 72]**	0 ☐
		Yes **[GO TO 71]**	1 ☐
71.	**If YES**, can you mention them or tell me what they are?	Enter as mentioned 1…………………………………… 2……………………………………	
72.	Did the health institutions contact the community to integrate local knowledge in implementing these interventions?	No	0 ☐
		Yes	1 ☐
73.	Do you believe climate change could affect your way of life or lifestyle if you do not prepare?	No **[GO TO 74]**	0 ☐
		Yes **[GO TO 75]**	1 ☐
74.	Do you believe that climate change can endanger your life?	No	0 ☐
		Yes	1 ☐
75.	Are there serious obstacles and barriers to protecting yourself and household from negative consequences of climate change such as severe outbreaks of endemic diseases?	No **[GO TO 77]**	0 ☐
		Yes **[GO TO 76]**	1 ☐
76.	**[ONLY YES ON 75]** What are these serious obstacles and barriers to protecting yourself from negative consequences of climate change such as severe outbreaks of endemic diseases? **[0= NO, 1=YES]**	Don't know what steps to take as I don't have the necessary information	0☐ /1☐
		Lack the necessary skills	0☐ /1☐
		Don't have personal motivation or the energy	0☐ /1☐
		Don't have the money or resource	0☐ /1☐
		Don't believe in climate change	0☐ /1☐
		Believe that the government will protect me	0☐ /1☐
		I am not at risk	0☐ /1☐
		Lack the help from others	0☐ /1☐
		Others *(Specify)*	0☐ /1☐
77.	Do you think you have the necessary information to prepare for any impacts of climate change on health? e.g. frequent and severe outbreaks of endemic diseases within this community?	No	0 ☐
		Yes	1 ☐
78.	Do you think you have the ability and power to protect yourself and family from any impacts of climate change on health such as frequent and severe outbreaks of endemic diseases within this community?	No	0 ☐
		Yes	1 ☐

79.	How would you rate your ability to cope with future outbreaks of endemic diseases with severe cases compared to those of the previous years you have witnessed?	Very poor	1 ☐
		Poor	2 ☐
		Satisfactory	3 ☐
		Good	4 ☐
		Very good	5 ☐
		Don't know	98 ☐
		Refused	99 ☐
80.	How do you plan or what plans do you have to deal with any future outbreaks of endemic diseases in cases of climate change impacts?	Enter the plan(s) as mentioned? 1…………………………………… 2…………………………………… 3……………………………………	

SECTION V: COMMUNITY PERCEPTION OF HEALTH INSTITUTIONS WITH REGARDS TO ENDEMIC DISEASES

		Disagree			Agree		Refused
		Strongly Disagree (1)	Somewhat Disagree (2)	Neither agree or disagree (3)	Somewhat Agree (4)	Strongly Agree (5)	(99)
81.	I am satisfied with the procedures and interventions used by the health institutions in this community/district in addressing endemic diseases within this community?						
82.	These interventions or procedures have resulted in decreased cases in endemic diseases or outbreaks recorded in this community?						
83.	These interventions or procedures are not working and there are still increased cases in endemic diseases or outbreaks recorded in this community?						
84.	I have confidence in the health institutions to address and monitor any future outbreaks of endemic infectious diseases due to climate change impacts?						
85.	I have reservations or concerns with regards to the health institutions ability to address and monitor any future outbreaks of endemic infectious diseases due to climate change impacts?						

SECTION VI: HEALTHCARE AND HEALTH SERVICES

ACCESS TO HEALTH CARE			
86.	**Now I would like to ask you about your access to health care.** Is there any health facility in this community?	No	0☐
		Yes	1☐
		Don't know	98☐
		Refused	99☐
87.	How far is it from where you live to the nearest health facility?	Record as mentioned	
		Don't know	98☐
		Refused	99☐
88.	How easy is it for you to reach this health facility?	Not easy	0☐
		Fairly easy	1☐
		Easy	2☐
		Very easy	3☐
		Don't know	98☐
		Refused	99☐
89.	What is your mode of access to the health facility?	Taxi/ Trotro	1☐
		Motor cycle	2☐
		Bicycle	3☐
		Walk	4☐
		River	5 ☐
		Others (Specify)	97 ☐
		Refused	99 ☐

PERCEPTIONS OF SERVICES OFFERED

90.	How satisfied are you with the following services offered by your health institution?	**Not satisfied**	**Fairly satisfied**	**Satisfied**	**Very satisfied**	**Most satisfied**	**Don't know**	**Refused**
	1. Service provision							
	2. Staff attitudes							
	3. Communication skills of staffs							
	4. Physical state of facilities							
	5. Availability of drugs and equipment							
	6. Accuracy and timeliness of diagnostic test							
	7. Waiting time							

91.	Based on **Q90,** overall how satisfied are you with the services?	Not satisfied	0☐
		Fairly satisfied	1☐
		Satisfied	2☐
		Very satisfied	3☐
		Most satisfied	4☐
		Don't know	98☐
		Refused	99☐

92.	If not satisfied with the services, what are the alternative(s) that you use? **(Check all mentioned)**	Traditional health care services	0☐
		Local pharmacy	1☐
		Home care service	2☐
		Other *(Specify)*	97☐
		Don't know	98☐
		Refused	99☐
93.	Why do you prefer this alternative mode in **Q92?**	Enter reason(s) 1………………………………………………………… 2. …………………………………………………………	
94.	How do you rate the cost of health care services in the community health facility?	Not affordable	0☐
		Fairly affordable	1☐
		Affordable	2☐
		Very affordable	3☐
		Most affordable	4☐
		Free service (NHIS)	5☐
		Don't know	98☐
		Refused	99☐
95.	What is the major barrier that prevents you from seeking health services?	Nothing	0☐
		Unavailability of services needed	1☐
		Accessibility to health facility	2☐
		Acceptability of services provided	3☐
		Not able to afford health care cost	4☐
		Others *(Specify)*	97☐
		Don't know	98☐
		Refused	99☐
96.	In your household, who makes the decision concerning seeking health care when someone is sick?	Everyone makes own decision	1☐
		Mother	2☐
		Father	3☐
		Both mother and father	4☐
		Male relative	5☐
		Female relative	6☐
		Others *(Specify)*	98☐
		Refused	99☐

SECTION VII: SOCIO-DEMOGRAPHIC PROFILE

97.	Gender	Male	1☐
		Female	2☐
98.	How old are you?	18-25	1☐
		26-30	2☐
		31-35	3☐
		36-40	4☐
		41-45	5☐
		46-50	6☐
		51-55	7☐
		56-60	8☐
		61-65	9☐
		65+	10☐
		Refused	99☐
99.	What is your marital status?	Single	1 ☐
		Married	2☐
		Divorced	3☐
		Separated	4☐
		Widowed	5☐
		Refused	99☐
100.	What is your position in the household?	Non-head	0☐
		Head	1☐
		Refused	2☐
101.	**[Ask question only if Non-head is chosen in Q100]** What is your relation to the household head?	Wife	1☐
		Husband	2☐
		Parent	3☐
		Child	4☐
		Other *(Specify)*	5☐
		Refused	99☐
102.	Which of the following best describes the household structure? **[Do not read out the options, just ask question and code response]**	*Household structure*	
		Female centered *(No husband, many include relatives, children)*	1☐
		Male entered *(no wife, may include relatives, children)*	2☐
		Nuclear *(husband/wife/female partner with or without children)*	3 ☐
		Extended *(husband, wife/and children and relatives)*	4☐
		Child-headed	5☐
		Polygamous household	6☐
		Ederly headed	7☐
		Refused	99☐

103.	What is the total number of people living in your household?	1-3	1☐
		4-5	2☐
		6 or more	3☐
		Refused	99☐
104.	What is your ethnicity?	Akan	1☐
		Ga	2☐
		Ga-Dangme	3☐
		Ewe	4☐
		Guan	5☐
		Gurma	6☐
		Mole-Dagbani	7☐
		Grusi	8☐
		Mande	9☐
		Other *(Specify)*	
		Refused	99☐
105.	What is your religion?	Christian	1☐
		Muslim	2☐
		Traditional religion	3☐
		Atheist	4☐
		Other *(Specify)*	5☐
		Refused	99☐
106.	What is your occupation / main economic activity?	Unemployed	0☐
		Fisherman/ fishmonger	1☐
		Farmer	2☐
		Laborer	3☐
		Seller, Vendor	4☐
		Public Servant (Gov't staff)	5☐
		Civil servant (NGO staff)	6☐
		Private company worker	7☐
		Others (Specify)	97☐
		Refused	99☐
107.	Residential locality of resident?	Urban	1☐
		Rural	2☐
108.	Region of resident?	Northern	1☐
		Greater Accra	2☐

109.	Would you mind if I ask you about your household's average income per month?	Record as mentioned	
		Don't know	98☐
		Refused	99☐
110.	What is your highest level of education attained?	No schooling	0☐
		Primary	1☐
		Junior high	2☐
		Senior high	3☐
		Voc./Technical/Commercial	4☐
		Post-Secondary Diploma etc	5☐
		Bachelor's degree	6☐
		Post graduate	7☐

Any remarks…………………………………………………………………………………………....

……………………………………………………………………………………………………

Thank you very much for your time.

APPENDIX E: SURVEY INSTRUMENT -HEALTH INSTITUTIONS

HEALTH PRACTITIONERS QUESTIONNAIRE

District ____________________	Community ________________________________
Respondent #________________	Enumerator Code/ Name_______________________
Survey Date _____/______/2016	Survey Status ☐ Completed ☐ Postpone
Survey Entered ☐	

SECTION I: IDEAS/ KNOWLEDGE ABOUT CLIMATE CHANGE

No.	Questions/Instructions	Possible Responses	Code (✓)
1.	Have you heard about global climate change or global warming?	No **[GO to 3]**	0☐
		Yes **[GO TO 2]**	1☐
2.	In your opinion, what is climate change?	Enter as explained …………………………………………………… …………………………………………………… …………………………………………………… ………	
		Don't know	98☐
		Refused	99☐
3.	Have you noticed any changes in **temperature** over the past years?	No **[GO TO 6]**	0 ☐
		Yes **[GO TO 4]**	1 ☐
		Don't know	98 ☐
		Refused	99 ☐
4.	**[IF YES]** What changes have you observed?	Getting hotter	0☐ /1☐
		Getting colder	0☐ /1☐
		Longer spells of hot temperature	0☐ /1☐
	[0 = NO, 1=YES]	Longer spells of cold temperature	0☐ /1☐
		Shorter spells of cold temperature	0☐ /1☐
		Shorter spells of hot temperature	0☐ /1☐
		Rapid changes in temperature	0☐ /1☐
		Others *(specify)*	97 ☐

No.	Questions/Instructions	Never (0)	1-3x (1)	4-5x (2)	>5x (3)	Don't know (98)	Refused (99)
5.	How long do you remember these changes in temperature happening?						
	d. Within the past 10 years						
	e. Between 11 and 30 years						
	f. More than 30 years						

No.	Questions/Instructions	Possible Responses	Code (✓)
6.	Have you noticed any changes in **rainfal**l over the past years?	No **[GO TO 9]**	0 ☐
		Yes **[GO TO 7]**	1 ☐
		Don't know	98 ☐
		Refused	99 ☐

7.	**[IF YES]** What changes have you observed? **[0 = NO, 1=YES]**	Early start of rainy season					0☐/1☐
		Delay in start of rainy season					0☐/1☐
		Shorter rainy season					0☐/1☐
		Extended rainy season					0☐/1☐
		Less amount of rainfall					0☐/1☐
		Increase in amount of rainfall					0☐/1☐
		Rapid changes in rainfall pattern					0☐/1☐
		Others *(specify)*					97 ☐
8.	How long do you remember these changes in rainfall happening?	Never (0)	1-3x (1)	4-5x (2)	>5x (3)	Don't know (98)	Refused (99)
	d. Within the past 10 years						
	e. Between 11 and 30 years						
	f. More than 30 years						
9.	Have you noticed changes in the **STARTING TIME** of rainfall from the past?	No **[GO TO 11]**					0 ☐
		Yes **[GO TO 10]**					1 ☐
		Don't know					98 ☐
		Refused					99 ☐
10.	How long ago did you start noticing changes in the **STARTING TIME** of rainfall?	Never (0)	1-3x (1)	4-5x (2)	>5x (3)	Don't know (98)	Refused (99)
	Within the past 10 years						
	Between 11 and 30 years						
	More than 30 years						
11.	Have you noticed any changes in the **ENDING TIME** of rainfall from the past?	No **[GO TO 13]**					0 ☐
		Yes **[GO TO 12]**					1 ☐
		Don't know					98 ☐
		Refused					99 ☐
12.	What kind of changes in the **ENDING TIME** of rainfall have you noticed?	No change					1 ☐
		Ends early					2 ☐
		Ends late					3 ☐
		Ends early and abruptly					4 ☐
		Ends late and abruptly					5 ☐
		Others *(Specify)*					97 ☐
		Refused					99 ☐
13.	How would you describe the rate at which the environmental conditions (temperature and rainfall) is changing?	No change					0 ☐
		Slowly					1 ☐
		Rapidly					2 ☐
		Very rapidly					3 ☐
		Don't know					98 ☐
		Refused					99 ☐

14.	**[ONLY IF ANSWER TO Q13 IS NOT 0]** What do you think is the most important underlying cause of environmental change (climate change)? **[Please select one]**	Deforestation	1 ☐
		Overpopulation	2 ☐
		Greenhouse gas emissions	3 ☐
		Resource extraction	4 ☐
		God's will	5 ☐
		Violated cultural values	6 ☐
		Others (*specify)*	97 ☐
		Don't know	98 ☐
		Refused	99 ☐

SECTION II: PERCIEVED IMPACTS OF CLIMATE CHANGE

PERCEIVED GENERAL IMPACTS OF CLIMATE CHANGE			
No.	**Questions/Instructions**	**Possible Responses**	**Code (✓)**
15.	Would you say climate change causes the following types of environmental impacts? **[0 = NO, 1=YES]**	1. Heat waves (prolonged episodes of hot weather)	0☐ /1☐
		2. Increased rainfall	0☐ /1☐
		3. Drought condition or water shortage	0☐ /1☐
		4. Forest fire	0☐ /1☐
		5. Coastal erosion	0☐ /1☐
		6. Flooding	0☐ /1☐
		7. Temperature increase	0☐ /1☐
		8. Increased/Reduced cases in Infectious diseases (e.g. malaria, cholera, onchocerciasis)	0☐ /1☐
		9. Sea-level rise	0☐ /1☐
		10. Reduced food production	0☐ /1☐
		11. Loss of wildlife	0☐ /1☐
PERCEIVED HEALTH IMPACTS OF CLIMATE CHANGE			
16.	Do you think there is a link between climate change and health?	No	0☐
		Yes	1☐
		Don't know	98 ☐
		Refused	99 ☐
17.	Would you say that climate change will cause or causes the following types of health impacts? **[0 = NO, 1=YES]**	**1.** Air pollution	0☐ /1☐
		2. Changes in vector ecology (e.g. malaria)	0☐ /1☐
		3. Extreme heat (e.g. heat related deaths, illness)	0☐ /1☐
		4. Water and food supply (e.g. malnutrition, diarrheal diseases)	0☐ /1☐
		5. Water quality issues (e.g. cholera)	0☐ /1☐

		6. Increasing allergens (e.g. respiratory allergies)					0☐ /1☐
		7. Severe weather (e.g. injuries/ deaths from flooding, storms, bush fires)					0☐ /1☐
18.	Do you think climate change have impacts on human diseases or can cause changes in their prevalence or outbreaks?	No					0☐
		Yes					1☐
		Don't know					98 ☐
		Refused					99 ☐
19.	What diseases do you think are sensitive to climate change /extreme weather? **[0 = NO, 1=YES]**	Respiratory diseases (e.g. asthma, pneumonia)					0☐ /1☐
		Cardiovascular diseases (e.g. hypertension, heart disease)					0☐ /1☐
		Urinary system diseases (e.g. kidney stones)					0☐ /1☐
		Digestive system diseases (e.g. gastritis, hepatises)					0☐ /1☐
		Infectious diseases					0☐ /1☐
		Other *(specify)*					97☐
		Don't know					98☐
		Refused					99☐
20.	Do you think global warming will aggravate the transmission of these diseases?	Extremely likely (5)	Very likely (4)	Somewhat likely (3)	Less likel y (2)	Extremely unlikely (1)	
	a. Vector-borne diseases (e.g. malaria, dengue fever, elephantiasis)						
	b. Rodent borne diseases (e.g. hemorrhagic fever)						
	c. Water-borne diseases and foodborne diseases (e.g. dysentery, schistosomiasis, cholera)						
21.	Have you considered the impact of climate change on infectious diseases in your work?	Not at all considered				0 ☐	
		Considered but not conducted related research				1 ☐	
		Considered and conducted related researches				2 ☐	
		Refused				99 ☐	

SECTION III: ENDEMIC DISEASES AND RELATIONS WITH CLIMATE VARIABLES

ENDEMIC DISEASES			
No.	**Questions/Instructions**	**Possible Responses**	**Code (✓)**
22.	Which of the following diseases do you encounter in your line of work? **[0 = NO, 1=YES]**	1. African Trypanosomiasis (Sleeping sickness)	0☐ /1☐
		2. Malaria	0☐ /1☐
		3. Tuberculosis	0☐ /1☐
		4. Schistosomiasis	0☐ /1☐
		5. Lymphatic Filariasis (Elephantiasis)	0☐ /1☐
		6. Onchocerciasis (River Blindness)	0☐ /1☐
		7. Pneumococcal/Meningococcal 8. Meningitis	0☐ /1☐
		9. Cholera	0☐ /1☐
		10. Measles	0☐ /1☐
		11. Trachoma	0☐ /1☐
		12. Yaws	0☐ /1☐
		13. Guinea worm	0☐ /1☐
		14. Yellow fever	0☐ /1☐
		15. Buruli Ulcer	0☐ /1☐
		16. Soil-transmitted Helminths	0☐ /1☐
		17. Leishmaniasis	0☐ /1☐
		18. HIV/AIDs	0☐ /1☐
		19. Hepatitis *(specify type(s)*	0☐ /1☐
		20. Diarrhoea	0☐ /1☐
		21. Leprosy	0☐ /1☐
		22. Typhoid fever	0☐ /1☐
		23. Rabies	0☐ /1☐
		24. Others *(specify)*	97 ☐
		25. Refused	99 ☐
23.	Which of the following diseases is more common or endemic in this district? **[0 = NO, 1=YES]**	1. African Trypanosomiasis (Sleeping sickness)	0☐ /1☐
		2. Malaria	0☐ /1☐
		3. Tuberculosis	0☐ /1☐
		4. Schistosomiasis	0☐ /1☐
		5. Lymphatic Filariasis (Elephantiasis)	0☐ /1☐
		6. Onchocerciasis (River Blindness)	0☐ /1☐
		7. Pneumococcal/Meningococcal meningitis	0☐ /1☐
		8. Cholera	0☐ /1☐
		9. Measles	0☐ /1☐
		10. Trachoma	0☐ /1☐
		11. Yaws	0☐ /1☐

		12. Guinea worm	0☐ /1☐
		13. Yellow fever	0☐ /1☐
		14. Buruli Ulcer	0☐ /1☐
		15. Soil-transmitted Helminths	0☐ /1☐
		16. Leishmaniasis	0☐ /1☐
		17. HIV/AIDs	0☐ /1☐
		18. Hepatitis *(specify type(s)*	0☐ /1☐
		19. Diarrhoea	0☐ /1☐
		20. Leprosy	0☐ /1☐
		21. Typhoid fever	0☐ /1☐
		22. Rabies	0☐ /1☐
		23. Others *(specify)*	97 ☐
24.	With respect to the endemic diseases in **Q23,** can you rank them based on the burden of disease within this district? **Where** **1 = lowest burden,** **5 = average burden and** **10 = highest burden** **[CHECK ONLY DISEASES MENTIONED IN Q23,]**	*Diseases*	*Rank*
		1. African Trypanosomiasis (Sleeping sickness)	[1] [5] [10]
		2. Malaria	[1] [5] [10]
		3. Tuberculosis	[1] [5] [10]
		4. Schistosomiasis	[1] [5] [10]
		5. Lymphatic Filariasis (Elephantiasis)	[1] [5] [10]
		6. Onchocerciasis (River Blindness)	[1] [5] [10]
		7. Pneumococcal/Meningococcal meningitis	[1] [5] [10]
		8. Cholera	[1] [5] [10]
		9. Measles	[1] [5] [10]
		10. Trachoma	[1] [5] [10]
		11. Yaws	[1] [5] [10]
		12. Guinea worm	[1] [5] [10]
		13. Yellow fever	[1] [5] [10]
		14. Buruli Ulcer	[1] [5] [10]
		15. Soil-transmitted Helminths	[1] [5] [10]
		16. Leishmaniasis	[1] [5] [10]
		17. HIV/AIDs	[1] [5] [10]
		18. Hepatitis *(specify type(s)*	[1] [5] [10]
		19. Diarrhoea	[1] [5] [10]
		20. Leprosy	[1] [5] [10]
		21. Typhoid fever	[1] [5] [10]
		22. Rabies	[1] [5] [10]
		23. Others *(specify)*	

25.	Which endemic diseases **(In Q23)** have recorded outbreaks over the years?	**Within the past 1-5 years**				**Within the past 6 -10 years**				**Between 11 and 20 years**			
		Never (0)	Only once (1)	Twice (2)	Thrice or more (3)	Never (0)	Only once (1)	Twice (2)	More than thrice (3)	Never (0)	Only once (1)	Twice (2)	More than thrice (3)
	1. African Trypanosomiasis (Sleeping sickness)												
	2. Malaria												
	3. Tuberculosis												
	4. Schistosomiasis												
	5. Lymphatic Filariasis (Elephantiasis)												
	6. Onchocerciasis (River Blindness)												
	7. Meningococcal meningitis												
	8. Cholera												
	9. Measles												
	10. Trachoma												
	11. Yaws												
	12. Guinea worm												
	13. Yellow fever												
	14. Buruli Ulcer												
	15. Soil-transmitted Helminths												
	16. Leishmaniasis												
	17. HIV/AIDs												
	18. Hepatitis *(specify type(s)*												
	19. Diarrhoea												
	20. Leprosy												
	21. Typhoid fever												
	22. Rabies												
	23. Others *(specify)*												

26.	For the recorded outbreaks identified in **Q25,** when do they normally occur? **[Check only diseases identified in Q25]**	Tick (✓) only those applicable			
		After raining season	During raining season	During the dry season	After Dry Season
	1. African Trypanosomiasis (Sleeping sickness)				
	2. Malaria				
	3. Tuberculosis				
	4. Schistosomiasis				
	5. Lymphatic Filariasis (Elephantiasis)				
	6. Onchocerciasis (River Blindness)				
	7. Pneumococcal/Meningococcal meningitis				
	8. Cholera				
	9. Measles				
	10. Trachoma				
	11. Yaws				
	12. Guinea worm				
	13. Yellow fever				
	14. Buruli Ulcer				
	15. Soil-transmitted Helminths				
	16. Leishmaniasis				
	17. HIV/AIDs				
	18. Hepatitis *(specify type(s)*				
	19. Diarrhoea				
	20. Leprosy				
	21. Typhoid fever				
	22. Rabies				
	23. Others *(specify)*				

27.	Has there been changes in prevalence of endemic diseases over the past 5 years within this district?	No **[GO TO 30]**	0☐
		Yes **[GO TO 28]**	1☐

28.	**If YES** to **Q27,** what changes in prevalence and frequency have you noticed? **(Answer relates to only the diseases identified in Q23)**	Extreme Increase (4)	Moderate increase (3)	Slight increase (2)	Reduced (1)
	25. African Trypanosomiasis (Sleeping sickness)				
	26. Malaria				
	27. Tuberculosis				
	28. Schistosomiasis				
	29. Lymphatic Filariasis (Elephantiasis)				
	30. Onchocerciasis (River Blindness)				
	31. Pneumococcal/Meningococcal meningitis				
	32. Cholera				
	33. Measles				
	34. Trachoma				
	35. Yaws				

	36. Guinea worm				
	37. Yellow fever				
	38. Buruli Ulcer				
	39. Soil-transmitted Helminths				
	40. Leishmaniasis				
	41. HIV/AIDs				
	42. Hepatitis *(specify type(s)*				
	43. Diarrhoea				
	44. Leprosy				
	45. Typhoid fever				
	46. Rabies				
	47. Others *(specify)*				

29.	Do you think climate change or extreme weather is the reason for the changes in prevalence of endemic diseases identified in **Q28**?	Extremely likely	4☐
		Very likely	3 ☐
		Somewhat likely	2 ☐
		Less likely	1 ☐
		Don't know	98 ☐
30.	Do you think climate change poses a risk to the health of populations within this district based on the endemic diseases within this community? **(Check only the diseases identified in Q23 that you think climate change will pose a risk to)** **[0 = NO, 1=YES]**	1. African Trypanosomiasis (Sleeping sickness)	0☐ /1☐
		2. Malaria	0☐ /1☐
		3. Tuberculosis	0☐ /1☐
		4. Schistosomiasis	0☐ /1☐
		5. Lymphatic Filariasis (Elephantiasis)	0☐ /1☐
		6. Onchocerciasis (River Blindness)	0☐ /1☐
		7. Meningococcal meningitis	0☐ /1☐
		8. Cholera	0☐ /1☐
		9. Measles	0☐ /1☐
		10. Trachoma	0☐ /1☐
		11. Yaws	0☐ /1☐
		12. Guinea worm	0☐ /1☐
		13. Yellow fever	0☐ /1☐
		14. Bruruli Ulcer	0☐ /1☐
		15. Soil-transmitted Helminths	0☐ /1☐
		16. Leishmaniasis	0☐ /1☐
		17. HIV/AIDs	0☐ /1☐
		18. Hepatitis *(specify type(s)*	0☐ /1☐
		19. Diarrhoea	0☐ /1☐
		20. Leprosy	0☐ /1☐
		21. Typhoid fever	0☐ /1☐
		22. Rabies	0☐ /1☐
		23. Others *(specify)*	0☐ /1☐

31.	Which population do you think is/are at the most risk from climate change/extreme weather based on the following diseases?	Infants and children	Young Adults	Middle-Aged	The elderly

	1. African Trypanosomiasis (Sleeping sickness)				
	2. Malaria				
	3. Tuberculosis				
	4. Schistosomiasis				
	5. Lymphatic Filariasis (Elephantiasis)				
	6. Onchocerciasis (River Blindness)				
	7. Meningococcal meningitis				
	8. Cholera				
	9. Measles				
	10. Trachoma				
	11. Yaws				
	12. Guinea worm				
	13. Yellow fever				
	14. Bruruli Ulcer				
	15. Soil-transmitted Helminths				
	16. Leishmaniasis				
	17. HIV/AIDs				
	18. Hepatitis *(specify type(s)*				
	19. Diarrhoea				
	20. Leprosy				
	21. Typhoid fever				
	22. Rabies				
	23. Others *(specify)*				

SECTION IV: MITIGATION AND ADAPTATION TO CLIMATE CHANGE

No.	Questions/Instructions	Possible Responses	Code (✓)
32.	Do you believe climate change could have effects on the health sector if the heath sector doesn't prepare?	No **[GO TO 34]**	0 ☐
		Yes **[GO TO 33]**	1 ☐
33.	f **YES**, what are some of these effects?	Enter Response …………………………………………… ……………………………………………	
34.	Do you think that you have the information necessary to prepare for the impacts of climate change on infectious diseases and health in general?	No	0 ☐
		Yes	1 ☐
35.	Have you received any training/workshop with regards to climate change and health issues (e.g. impacts of climate change on infectious diseases) in your line of duty?	No **[GO TO 37]**	0 ☐
		Yes **[GO TO 36]**	1 ☐
36.	Can you provide a brief description of the type of training/workshop that you received?	**Provide training/workshop description here.** ………………………………………………………………… …………………………………………………………………	
37.	Are there any obstacles or barriers that might hinder your ability to provide service in your line of duty with regards to issues on climate change impacts on health and specifically infectious diseases?	No **[GO TO 39]**	0 ☐
		Yes **[GO TO 38]**	1 ☐

38.	What are these obstacles or barriers that will impede your ability to provide services?	Enter Response 1……………………………………………… 2……………………………………………… 3………………………………………………	
39.	Does the hospital currently have any policies and plans in place to help deal with any climate induced diseases especially infectious diseases in the event of increase in prevalence? Such a plan might include how to deal with emergence of new infectious diseases, or those at the point of eradication.	No **[GO TO 41]**	0 ☐
		Yes **[GO TO 40]**	1 ☐
40.	Can you list the plans, measures or policies that are in place?	Enter Response ………………………………………………………………………….. …………………………………………………………………………… ……………………………………………………………………………	
41.	With regards to endemic diseases within this district, how efficient is this hospital in treating cases that are reported. Do you have the necessary medicines and equipment's for treatments?	No **[GO TO 42]**	0 ☐
		Yes **[GO TO 43]**	1 ☐
42.	How do you manage or cope with the cases that are reported?	Enter Response …………………………………………… ……………………………………………	
43.	How does the hospital deal with emergency cases related to disease outbreaks?	Enter Response …………………………………………… …………………………………………… ……………………………………………	
44.	Does the hospital have any emergency response measures to deal with cases during disease outbreaks?	No **[GO TO 46]**	0 ☐
		Yes **[GO TO 45]**	1 ☐
		Don't know	98 ☐
45.	**If YES,** can you tell me what they are or an example of such measures?	Enter Response …………………………………………… …………………………………………… ……………………………………………	
46.	Are there many hospital staffs to assist people when they visit with endemic diseases during outbreaks?	No	0 ☐
		Yes	1 ☐
47.	What is/are the major challenge(s) of this hospital with regards to treating endemic diseases during cases of outbreaks?	Enter Response …………………………………………… …………………………………………… ……………………………………………	
48.	Do the health institution currently have any measures/intervention in place within communities or the districts to help curtail prevalence of endemic infectious diseases?	No **[GO TO 50]**	0 ☐
		Yes **[GO TO 49]**	1 ☐
49.	Can you tell me examples of them?	Enter Response …………………………………………… …………………………………………… ……………………………………………	

50.	Do you think anything can be done to reduce the impacts of climate change on human health specifically infectious diseases?	No **[GO TO 52]**	0 ☐
		Yes **[GO TO 51]**	1 ☐
51.	What do you think should or can be done?	Enter Response …………………………………………… …………………………………………… …………………………………………..	
52.	What do you think should be the role of the health sector in order to deal with impacts of climate change on human health and infectious diseases?	Enter Response …………………………………………… …………………………………………… ……………………………………………	

SECTION V: RESPONSE MEASURES TO CLIMATE CHANGE

No.	Questions/Instructions	Possible Responses			
53.	How important do you think these response measures are in terms of dealing with the threat of infectious diseases due to climate change?	Unimportant (1)	Important (2)	Very important (3)	Extremely Important (4)
	1. Improve the quality of disease surveillance data				
	2. Strengthen the surveillance of infectious diseases, especially vector-borne, waterborne and foodborne disease				
	3. Vector surveillance / control (e.g. mosquitoes and other insects)				
	4. Meteorological variable observation				
	5. Vector breeding site surveillance				
	6. Vulnerable groups surveillance and protection				
	7. Clinical monitoring of patients				
54.	How important are these aspects of scientific research in terms of dealing with the health impacts of climate change?	Unimportant (1)	Important (2)	Very important (3)	Extremely Important (4)
	1. Enhancing surveillance and projection capacities				
	2. Assessing the risk of spreading infectious diseases due to climate change				
	3. Identifying high risks climatic zones				
	4. Improving emergency response mechanisms for disease outbreaks				
	5. Increasing investment in scientific research associated with addressing climate change				

55.	How important are these disease control and prevention measures to adapt to climate change as well as develop capacity?	Unimportant (1)	Important (2)	Very important (3)	Extremely Important (4)
	1. Infrastructure development /refinement (e.g. improve disease surveillance platform, online disease notification)				
	2. Staff in-house training				
	3. Cross department information sharing (veterinary surveillance and public health sector)				
	4. Community health education				
56.	Policies, legislation and regulations formulation to address climate change?				
57.	Decision-making coordination among government departments with regards to climate change and health impacts				
58.	How important are these strategies and measures towards infectious disease prevention?	Unimportant (1)	Important (2)	Very important (3)	Extremely Important (4)
	1. Improve living conditions (e.g. housing)				
	2. Improve sanitation				
	3. Individual protection (e.g. vaccination)				
	4. Food safety measures				
	5. Control the environment of vector breeding sites				
	6. Improve drinking water				
59.	How important are these strategies and measures towards adaptation against the health impacts (infectious diseases) of climate change in the future?	Unimportant (1)	Important (2)	Very important (3)	Extremely Important (4)
	1. Prevention of infectious diseases				
	2. Establish a national infectious disease monitoring and response systems for information sharing				
	3. Timely and effectively coordinating health action in an emergency event				
	4. Provide high quality data and information on infectious disease cases reported for effective monitoring of cases, especially in non-endemic areas				
	5. Promote adaptation actions through in-house training and legislation				
	6. Promote research in the area of climate change and health				
	7. Medical intervention				

SECTION VI: DEMOGRAPHIC PROFILE

60.	How old are you?	18-25	1 ☐
		26-30	2☐
		31-35	3☐
		36-40	4☐
		46-50	5☐
		51-55	6☐
		56-60	7☐
		61+	8☐
		Refused	99☐
61.	Your Gender/ Sex?	Male	1☐
		Female	2☐
62.	Your Educational level?	Secondary	1☐
		Training College/ Diploma	2☐
		Bachelor	3☐
		Masters	4☐
		Ph.D.	5☐
		Others *(Specify)*	6☐
		Refused	99☐
63.	What is your ethnicity?	Akan	1☐
		Ga	2☐
		Ga-Dangme	3☐
		Ewe	4☐
		Guan	5☐
		Gurma	6☐
		Mole-Dagbani	7☐
		Grusi	8☐
		Mande	9☐
		Other *(Specify)*	
		Refused	99☐
64.	What is your religion?	Christian	1☐
		Muslim	2☐
		Traditional religion	3☐
		Atheist	4☐
		Other *(Specify)*	5☐
		Refused	99☐
65.	What is your marital status?	Single	1 ☐
		Married	2☐
		Divorced	3☐
		Separated	4☐
		Widowed	5☐
		Refused	99☐

66.	What is your role or position in this hospital?	Nurse	1☐
		Medical Officer	2☐
		Ward assistant	3☐
		Laboratory staff	4☐
		Community health officer	5☐
		Dispensary technicians	6☐
		Pharmacists	7☐
		Midwife	8☐
		X-ray technician	9☐
		Others *(Specify)*	98☐
		Refused	99☐
67.	What is your professional level within the position in **Q63?**	Junior	1☐
		Intermediate	2☐
		Senior	3☐
		Refused	99☐
68.	What is your speciality?	Public health	1☐
		Infectious disease control	2☐
		Emergency response and management	3☐
		Medical laboratory	4☐
		Maternal health	5☐
		Others *(Specify)*	6☐
		Refused	99☐
69.	How long have you been working in this position within this hospital?	Less than 1year	1☐
		1-5 years	2☐
		5-10 years	3☐
		10-20 years	4☐
		More than 20 years	5☐
		Refused	99☐
70.	How long have you been working in the health sector in general?	Less than 1year	1☐
		1-5 years	2☐
		5-10 years	3☐
		10-20 years	4☐
		More than 20 years	5☐
		Refused	99☐
71.	How long have you been living within this community/district?	Less than 1year	1☐
		1-5 years	2☐
		6-10 years	3☐
		10-20 years	4☐
		More than 20 years	5☐
		Refused	99☐
72.	Residential locality of health worker/ practitioner?	Urban	1☐
		Rural	2☐

73.	Region of resident?	Northern	1☐
		Greater Accra	2☐

Any remarks……………………………………………………………………………………………

……………………………………………………………………………………………………

Thank you very much for your time.

APPENDIX F: SURVEY INSTRUMENT -EXPERTS

EXPERT QUESTIONNAIRE

Institution ____

District______________________________Region___________________________

Survey Date _______/________/2016

Survey Status ☐Completed ☐ Postponed Survey Entered ☐

SECTION I: GENERAL QUESTIONS

No.	Questions/Instructions	Possible Responses		Code (✓)
1.	What type is your institute	Research/Academia		
		Public Health sector		
		Private health sector		
		Non-Governmental Organization *(specify)*		
		Other *(specify)*		
2.	What is the specialized area of this institute/ what is your specialization?	Write down your specialization here.		
3.	How many years have you been working in this field?	Enter response		
4.	How concerned is your organization about the impacts of climate change on heath, especially infectious disease risks to human health?	Very concerned **[GO TO Q5]**		
		Somewhat concerned **[GO TO Q5]**		
		Not concerned at all		
		No position/outside the organization's mission		
5.	What are some of the efforts of this organization /institution to help address some of the infectious disease health risks associated with climate change	Enter some of the ongoing actions to help address the risk ……………………………………………………………… ……………………………………………………………… ………………………………………………………………		
6.	What is your highest level of educational attainment	Secondary	1☐	
		Training College/ Diploma	2☐	
		Bachelor	3☐	
		Masters	4☐	
		Ph.D.	5☐	
		Others *(Specify)*	97☐	
		Refused	99☐	
7.	How old are you?	18-25	1 ☐	
		26-30	2☐	
		31-35	3☐	
		36-40	4☐	
		41-45	5☐	
		46-50	6☐	
		51-55	7☐	
		56-60	8☐	
		61+	9☐	
		Refused	99☐	
8.	Your Gender/ Sex?	Male		
		Female		

SECTION II: INFECTIOUS DISEASE CHARACTERISTICS

ABILITY TO MONITOR TREAT AND CONTROL DISEASE IN GHANA

9. ***Treatability***
What treatment is available for the disease?
[check only which is applicable to a particular disease]

10. ***Preventability***
Is there a feasible process that could prevent the disease?
[check only which is applicable to a particular disease]

	9. Treatability: Medical treatment is not or rarely necessary (1)	9. Treatability: Medical treatment is desirable, but no specific treatment is available that reduces disease burden or prognosis. Care is based on symptoms (2)	9. Treatability: Medical treatment has a limited influence on disease burden or diagnosis. And/or antimicrobial resistance to treatment has been recorded (3)	9. Treatability: Effective treatments are available that positively influenced the burden of disease or diagnosis (4)	10. Preventability: Preventive measures are not available or do not exist (1)	10. Preventability: Disease incidence can be modified by an educational program (public health education or behavioural modification) (2)	10. Preventability: Some preventive measures are established but there is a need for further research to improve effectiveness (3)	10. Preventability: Prevention is possible (e.g., vaccination, eradication program exists) (4)
African Trypanosomiases (Sleeping sickness)								
Malaria								
Tuberculosis								
Schistosomiasis (Bilharzia)								
Lymphatic Filariasis (Elephantiasis)								
Onchocerciasis (River Blindness)								
Meningitis								
Cholera								
Measles								
Trachoma								
Yaws								
Guinea worm								
Yellow fever								
Buruli Ulcer								
Soil-Transmitted Helminths								
Leishmaniasis								
HIV/AIDs								
Hepatitis A								
Diarrhoeal								
Leprosy								
Rabies								
Typhoid fever								
Others *(Specify)*								

11.	**_Effectiveness of surveillance_** Is there on-going systematic collection and analysis of data that leads to disease prevention or control? *[check only which is applicable to a particular disease]*					12.	**_Ability to diagnose disease in Ghana_** Is there a method to diagnose the disease? (e.g., examination or laboratory analysis, examination of patient history). *[check only which is applicable to a particular disease]*		
		Effective surveillance strategies do not exist within Ghana	No formal surveillance exists in Ghana but there are some guidelines for the identification and management of outbreaks.	Effective surveillance strategies exist in Ghana			A diagnostic test exists, but a more sensitive, specific or rapid test is needed.	A sensitive diagnostic test exists, although availability and uptake need to improve	A sensitive diagnostic test is widely available across the country to allow early detection
	African Trypanosomiases (Sleeping sickness)								
	Malaria								
	Tuberculosis								
	Schistosomiasis (Bilharzia)								
	Lymphatic Filariasis (Elephantiasis)								
	Onchocerciasis (River Blindness)								
	Meningitis								
	Cholera								
	Measles								
	Trachoma								
	Yaws								
	Guinea worm								
	Yellow fever								
	Buruli Ulcer								
	Soil-Transmitted Helminths								
	Leishmaniasis								
	HIV/AIDs								
	Hepatitis A								
	Diarrhoeal								
	Leprosy								
	Rabies								
	Typhoid fever								
	Others *(Specify)*								

SECTION III: INFLUENCE OF CLIMATE CHANGE

13. ***<u>Future infectious disease risks in a changing climate</u>***

Which infectious diseases do you think climate change will most affect in Ghana?

	Not enough information is known to make a prediction	Unlikely to influence	Likely to influence	Extremely influence
African Trypanosomiases (Sleeping sickness)				
Malaria				
Tuberculosis				
Schistosomiasis (Bilharzia)				
Lymphatic Filariasis (Elephantiasis)				
Onchocerciasis (River Blindness)				
meningitis				
Cholera				
Measles				
Trachoma				
Yaws				
Guinea worm				
Yellow fever				
Buruli Ulcer				
Soil-Transmitted Helminths				
Leishmaniasis				
HIV/AIDs				
Hepatitis A				
Diarrhoeal				
Leprosy				
Rabies				
Typhoid fever				
Others *(Specify)*				

14. Which group of infectious diseases has the highest likelihood of being influenced by climate change within the Ghanaian context?

	Not likely	Likely	Extremely likely
Vector-borne			
Water-borne			
Food-borne			
Air-borne			
Rodent -borne			

SECTION IV: RESPONSE MEASURES TO CLIMATE CHANGE

15.	Questions/Instructions	Possible Responses			
	How important do you think these response measures are in terms of dealing with the threat of infectious diseases due to climate change?	**Unimportant (1)**	**Important (2)**	**Very important (3)**	**Extremely Important (4)**
	8. Improve the quality of disease surveillance data				
	9. Strengthen the surveillance of infectious diseases, especially vector-borne, waterborne and foodborne disease				
	10. Vector surveillance / control (e.g. mosquitoes and other insects)				
	11. Meteorological variable observation				
	12. Vector breeding site surveillance				
	13. Vulnerable groups surveillance and protection				
	14. Clinical monitoring of patients				
17.	How important are these disease control and prevention measures to adapt to climate change as well as develop capacity?	**Unimportant (1)**	**Important (2)**	**Very important (3)**	**Extremely Important (4)**
	1. Infrastructure development /refinement (e.g. improve disease surveillance platform, online disease notification)				
	2. Staff in-house training				
	3. Cross department information sharing (veterinary surveillance and public health sector)				
	4. Community health education				

16.	Questions/Instructions	Possible Responses			
	How important are these aspects of scientific research in terms of dealing with the health impacts of climate change?	**Unimportant (1)**	**Important (2)**	**Very Important (3)**	**Extremely Important (4)**
	1. Enhancing surveillance and projection capacities				
	2. Assessing the risk of spreading infectious diseases due to climate change				
	3. Identifying high risks climatic zones				
	4. Improving emergency response mechanisms for disease outbreaks				
	5. Increasing investment in scientific research associated with addressing climate change				

No.		Unimportant (1)	Important (2)	Very important (3)	Extremely Important (4)	No.		Unimportant (1)	Important (2)	Very important (3)	Extremely Important (4)
18.	Policies, legislation and regulations formulation to address climate change?					**19.**	Decision-making coordination among government departments with regards to climate change and health impacts				
20.	How important are the following measures in terms of Infectious disease prevention?	**Unimportant (1)**	**Important (2)**	**Very important (3)**	**Extremely Important (4)**	**21.**	How important are these strategies and measures towards adaptation against the health impacts (infectious diseases) of climate change in the future?	**Unimportant (1)**	**Important (2)**	**Very importa nt (3)**	**Extremely Important (4)**
	1. Improve living conditions (e.g. housing)						1. Prevention of infectious diseases				
	2. Improve sanitation						2. Establish a national infectious disease monitoring and response systems for information sharing				
	3. Individual protection (e.g. vaccination)						3. Timely and effectively coordinating health action in an emergency event				
	4. Food safety measures						4. Provide high quality data and information on infectious diseases cases reported for effective monitoring of cases, especially in non-endemic areas				
	5. Control the environment of vector breeding sites						6. Promote adaptation actions through in-house training and legislation				
	7. Improve drinking water sources						8. Promote research in the area of climate change and health				
							9. Medical intervention				

SECTION V: IMPACTS

Environmental Impact																	
22.	What are the environmental impacts of disease in Ghana? Consider the impact of the disease and its control measures on soil, air, water and biodiversity.	**Soil**				**Air**				**Water**				**Biodiversity**			
		N/A	*Low*	*Medium*	*High*	*N/A*	*Low*	*Medium*	*High*	*N/A*	*Low*	*Medium*	*High*	*N/A*	*Low*	*Medium*	*High*
	African Trypanosomiases (Sleeping sickness)																
	Malaria																
	Tuberculosis																
	Schistosomiasis (Bilharzia)																
	Lymphatic Filariasis (Elephantiasis)																
	Onchocerciasis (River Blindness)																
	meningitis																
	Cholera																
	Measles																
	Trachoma																
	Yaws																
	Guinea worm																
	Yellow fever																
	Buruli Ulcer																
	Soil-Transmitted Helminths																
	Leishmaniasis																
	HIV/AIDs																
	Hepatitis A																
	Diarrhoeal																
	Leprosy																
	Rabies																
	Typhoid fever																
	Others *(Specify)*																

SECTION VI: PRIORITIZATION OF FACTORS

In this section, you are comparing a set of criteria based on their importance in considering climate sensitive infectious diseases to tackle for prevention and control in case of climate change impacts or inducements within Ghana.

Comparison of criteria for climate sensitive infectious disease prioritization

For each pair of value comparison below:

a) Tick the white box of each of the grey-highlighted section to indicate the factor that is more important to you.
b) Tick one box of the white section to the right to indicate how much more important that value compared to the other.
c) In case you consider both factors as equally important (equal importance), please tick both factors and the equal importance box.
d) Please note that values 2, 4, 6 and 8 are intermediate values between 1, 3, 5, 7 and 9.

➢ For **example**, a statement of preferences indicating that **criterion A is strongly more important than B**, implies that **A is five times more important than B**.

23. Disease epidemiology Which of the criteria do you consider important with regards to climate sensitive infectious disease epidemiology, when prioritizing diseases in the case of climate change influence?			*How much more important?* *[choose only one category]*								
			Equal importance 1	Weak importance 2	Moderate importance 3	Moderate plus importance 4	Strong importance 5	Strong plus importance 6	Very strong importance 7	Very, very importance 8	Extreme importance 9
☐ Endemicity	vs.	☐ Mode of transmission									
☐ Endemicity	vs.	☐ Geographic distribution									
☐ Mode of transmission	vs.	☐ Geographic distribution									

24. Disease Burden Which of the criteria do you consider important with regards to climate sensitive infectious disease burden, when prioritizing diseases in the case of climate change influence?			*How much more important?*								
			Equal importance 1	Weak importance 2	Moderate importance 3	Moderate plus importance 4	Strong importance 5	Strong plus importance 6	Very strong importance 7	Very, very importance 8	Extreme importance 9
☐ Incidence	vs.	☐ Severity									
☐ Incidence	vs.	☐ Mortality/Human case fatality									
☐ Severity	vs.	☐ Mortality/Human case fatality									

25. Epidemiological dynamic Which of the criteria do you consider important with regards to climate sensitive infectious diseases, when prioritizing diseases for policy attention in case of climate change influence?			*How much more important?*								
			Equal 1	Weak importance 2	Moderate importance 3	Moderate plus importance 4	Strong importance 5	Strong plus importance 6	Very strong importance 7	Very, very importance 8	Extreme importance 9
☐ Trend	vs.	☐ Outbreak potential									

26. Ability to monitor, treat and diagnose Which of these criteria of each line do you consider important?			*How much more important?*								
			Equal 1	Weak importance 2	Moderate importance 3	Moderate plus importance 4	Strong importance 5	Strong plus importance 6	Very strong importance 7	Very, very importance 8	Extreme importance 9
☐ Treatability	vs.	☐ Preventability									
☐ Treatability	vs.	☐ Surveillance									
☐ Treatability	vs.	☐ Able to Diagnose									
☐ Preventability	vs.	☐ Surveillance									
☐ Preventability	vs.	☐ Able to Diagnose									
☐ Surveillance	vs.	☐ Able to Diagnose									

27. Impacts Which of these criteria do you consider important?			*How much more important?*								
			Equal 1	Weak importance 2	Moderate importance 3	Moderate plus importance 4	Strong importance 5	Strong plus importance 6	Very strong importance 7	Very, very importance 8	Extreme importance 9
☐ Economic	vs.	☐ Environmental									
☐ Economic	vs.	☐ Social									
☐ Environmental	vs.	☐ Social									

28. How important is criteria A compared to B in deciding which climate sensitive diseases to tackle in case of climate change inducements. Using the nine-point scale below, enter your importance in the white cell for each comparison.

Equal 1	Weak importance 2	Moderate importance 3	Moderate plus importance 4	Strong importance 5	Strong plus importance 6	Very strong importance 7	Very, very importance 8	Extreme importance 9

For **example**, a statement of importance indicating that criteria **A (e.g. endemicity) is moderate plus important than B (e.g. geographic distribution),** implies that criteria **A is four times more important than criteria B** in deciding which climate sensitive diseases to tackle in case of climate change inducements.

	MoT	**GD**	**T**	**OP**	**I**	**S**	**HCF**	**TR**	**P**	**SUV**	**AD**	**E**	**SI**	**EV**
Endemicity														
Mode of transmission (**MoT)**														
Geographic distribution (**GD)**														
Trend (**T)**														
Outbreak Potential (**OP)**														
Incidence **(I)**														
Severity **(S)**														
Human case fatality **(HCF)**														
Treatability **(TR)**														
Preventability **(P)**														
Surveillance **(SUV)**														
Ability to diagnose **(AD)**														
Economic impacts **(E)**														
Social impacts **(SI)**														
Environmental impacts **(EV)**														

SECTION VII: EVALUATION OF CLIMATE SENSITIVE INFECTIOUS DISEASES

In this section, you are evaluating climate sensitive infectious diseases based on a set of criteria.

Evaluation of climate sensitive infectious diseases

For each pair of value comparison below:

a) Decide on your preference with regards to which climate sensitive infectious diseases pose **a greater risk to the human population and the health sector in Ghana** and indicate how much more risk it poses compared to the other diseases it's been compared with based on the criteria they are being assessed on.
b) Enter your preference based on the 9-point scale given in the non-shaded portion of the evaluation matrix to indicate how much more important that disease pose a risk compared to the other.
c) In case of the two diseases been compared pose the same amount of risk, choose the equal importance category from the scale and enter the corresponding value of 1 in the matrix.

For **example**, a statement of preferences indicating that disease **A is moderate plus important than B,** implies that disease **A pose four times more risk than disease B** on the criteria they are being assessed on (e.g. mortality or fatality rate).

All assessments should be done based on the scale below:

Equal Importance 1	Weak Importance 2	Moderate Importance 3	Moderate Plus Importance 4	Strong Importance 5	Strong Plus Importance 6	Very Strong Importance 7	Very, Very Importance 8	Extreme Importance 9

Explanation of Scale

1 Equal importance: Two diseases contribute equally on the criteria

3 Moderate importance: Experience and judgment slightly favor one disease over another

5 Strong importance: Experience and judgment strongly favor one disease over another

7 Very strong importance: A disease is favored very strongly over another; its dominance demonstrated in practice

9 Extreme importance: The evidence favoring one disease over another is of the highest possible order of affirmation

Please note that values 2, 4, 6 and 8 are intermediate values between 1, 3, 5, 7 and 9.

29. How much more important (risk) is disease group X than disease group Y in terms of potential effects of climate change in Ghana? [*Please use the nine-point scale]*.

	Water-borne diseases	Food-borne diseases	Rodent-borne diseases
Vector-borne diseases			
Water-borne diseases			
Food-borne diseases			
Rodent-borne diseases			

30. Endemicity *(looking at endemic levels of disease in Ghana)***:**
How much more important (risk) is disease X than disease Y in terms of how endemic they are in Ghana?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases (Sleeping sickness)															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) **(O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

31. Mode of transmission: How much more important (risk) is disease X than disease Y in terms of influence of climate change (climate variables) on their mode of transmission?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases (Sleeping sickness)															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) **(O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

32. Geographic distribution *(looking at geographical coverage of disease in Ghana)***:**
How much more important (risk) is disease X than disease Y in terms of geographic distribution within Ghana?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases (Sleeping sickness)															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

33. Incidence *(looking at average new cases per year):*
How much more important (risk) is disease X than disease Y in terms of incidence in Ghana?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

34. Severity *(looking at loss of work time, disability associated with disease)***:**
How much more important (risk) is disease X than disease Y in terms of severity?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

35. Mortality/Fatality rate (*looking at the average number of deaths associated with the disease as a percentage of recorded diseases per year)***:** How much more important (risk) is disease X than disease Y in terms of cases of mortality/fatality associated?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

36. Trend *(looking at incidence of disease in Ghana for the past five years, whether cases are diminishing, increasing etc.)***:** How much more important (risk) is disease X than disease Y in terms of disease trend?

	M	S	LF	O	MM	C	Y	GW	YF	BU	STH	L	D	H.A	T
African Trypanosomiases															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O**)															
Meningitis **(MM)**															
Cholera (**C**)															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

37. Outbreak Potential/Epidemic (*looking at an outbreak potential of disease if induced by climate change and its ability to spread rapidly)***:** How much more important (risk) is disease X than disease Y in terms of its outbreak potential in Ghana based on previous cases recorded?

	M	S	LF	O	MM	C	Y	GW	YF	BU	STH	L	D	H.A	T
African Trypanosomiases															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O**)															
Meningitis **(MM)**															
Cholera (**C**)															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

38. **Treatability** *(looking at available treatment options and how effective they are to deal with any exacerbation of cases due to climate change impacts):* How much more important (risk) is disease X than disease Y in terms of how treatable the disease is and the available treatment options?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

39. **Preventability** *(looking at prevention methods available and how they will help in dealing with exacerbation of cases due to potential climate change inducement)***:** How much more important (risk) is disease X than disease Y in terms of feasible prevention methods available?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

40. **Surveillance** *(taking into account on-going surveillance for diseases in Ghana. Does the disease have a current surveillance in place, and its effectiveness in monitoring disease for any potential climate change impacts):* How much more important (risk) is disease X than disease Y in terms of surveillance systems?

	M	S	LF	O	MM	C	Y	GW	YF	BU	STH	L	D	H.A	T
African Trypanosomiases															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O**)															
Meningitis **(MM)**															
Cholera (**C**)															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

41. **Ability to diagnose** *(takes into account how easily it is to diagnose disease in Ghana and if there are available methods/facilities for doing that i.e. can virtually every health centre diagnose the disease):* How much more important (risk) is disease X than disease Y in terms of ability to diagnose disease?

	M	S	LF	O	MM	C	Y	GW	YF	BU	STH	L	D	H.A	T
African Trypanosomiases															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O**)															
Meningitis **(MM)**															
Cholera (**C**)															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

INFLUENCE OF CLIMATE CHANGE

*This criterion is taking into account the impact of climate variables (temperature, rainfall) on disease pathogens, emergence and potential impact of changes in these variables due to climate change***.** *Example will climate change inhibit disease pathogen development or provide the necessary conditions for development.*

Current projections of climate change in Ghana indicate that the mean annual temperature is projected to increase by 1.0 to 3.0˚C by the 2060s, and 1.5 to 5.2˚C by the 2090s. Projections of mean annual rainfall average over the country indicates a wide range of changes in precipitation for Ghana. Seasonally, the projections tend towards decreases in January, February, March and April, May, June rainfall, and increases in July, August, September and October, November, December rainfall (McSweeney, New, & Lizcano, 2010).

Four scenarios are created for evaluating which diseases will come under the greater impact in cases of changes in these variables in Ghana.

42. **Scenario 1: In a case of increase in annual temperatures based on the above projections,** how much more important (risk) is disease X than disease Y in terms of influence of climate change on disease pathogens and emergence?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M**)															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) (**LF)**															
Onchocerciasis (River Blindness) **(O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

43. Scenario 2: In a case of increase in annual rainfall based on the above projections, how much more important (risk) is disease X than disease Y in terms of influence of climate change on disease pathogens and emergence?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

44. Scenario 3: In a case of decrease in annual temperatures based on the above projections, how much more important (risk) is disease X than disease Y in terms of influence of climate change on disease pathogens and emergence?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

45. **Scenario 4: In a case of decrease in annual rainfall based on the above projections,** how much more important (risk) is disease X than disease Y in terms of influence of climate change on disease pathogens and emergence?

	M	S	LF	O	MM	C	Y	GW	YF	BU	STH	L	D	H.A	T
African Trypanosomiases															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) (**LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

IMPACTS

This criterion is looking at some of the current impacts that diseases pose and how they will be issues of concern if impacted by climate change to both human populations and the health sector.

46. **Environmental impacts (***concerned with impacts that are posed to water, soils and biodiversity in terms of methods of control and prevention. Example is impact of insecticides for controlling pathogens etc***.:** How much more important (risk) is disease X than disease Y in terms of current environmental impacts?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

47. **Economic impacts** (*concerned with current costs of control, treatments and prevention and which disease(s) pose the greater economic burdens):* How much more important (risk) is disease X than disease Y in terms of current economic impacts?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) **(LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

48. **Social impacts (***concerned with societal impacts such as risk perception of population, impact on social gatherings and activities etc.)* How much more important (risk) is disease X than disease Y in terms of current social impacts?

	M	**S**	**LF**	**O**	**MM**	**C**	**Y**	**GW**	**YF**	**BU**	**STH**	**L**	**D**	**H.A**	**T**
African Trypanosomiases															
Malaria (**M)**															
Schistosomiasis (Bilharzia) **(S)**															
Lymphatic Filariasis (Elephantiasis) (**LF)**															
Onchocerciasis (River Blindness) (**O)**															
Meningitis **(MM)**															
Cholera (**C)**															
Yaws **(Y)**															
Guinea worm **(GW)**															
Yellow fever **(YF)**															
Bruruli Ulcer **(BU)**															
Soil-Transmitted Helminths **(STH)**															
Leishmaniasis **(L)**															
Diarrhoeal **(D)**															
Hepatitis A **(H.A)**															
Typhoid fever **(T)**															

Any remarks………………………………………………………………………………………............
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Thank you for your time in completing this questionnaire.

APPENDIX G: IN-DEPTH INTERVIEW GUIDE FOR COMMUNITIES

IN-DEPTH INTERVIEW GUIDE FOR COMMUNITIES

BROAD THEMES	CENTRAL QUESTION	PROBES
Endemicity of Infectious Diseases / Disease Burden		
	1. What specific health issues do people complain about in this community?	• Do you think this specific health problem (e.g. cholera) have any connection with the quality of the environment or changes in the environment?
	2. Can you tell me what kinds of diseases people suffer from in this area?	
	3. Which of these diseases are of great concern in this community?	• On a scale of 1-5, how will you rate the severity of these diseases? • Compared to 5 or 10 years ago, was their severity the same as now? • What changes in severity have you noticed?
	4. Have you ever experienced any of the endemic diseases within this community?	• Can you tell me which kinds?
	5. What kinds of impacts do people experience from endemic diseases within this community?	• Can you tell me some of your experiences?
	6. What in your opinion are the causes of endemic diseases within this community?	• Have you received any education as a community with regards to the causes of these diseases and how you can cope with them or prevent them?
	7. What are some of the preventive measures in place within this community with regards to endemic diseases?	• Who is responsible for these measures?
	8. Which group of people are vulnerable to endemic diseases within this community?	• Example, which group of people get schistosomiasis, malaria a lot within this community/area?

		• What underlying factors do you think influences vulnerabilities of populations within this community to endemic diseases? • Do you think the main occupation of the people within this community could be a factor?
	9. Which of these diseases mentioned that are endemic within this community/area have recorded outbreaks over the last year or the past five years?	• How often do you experience outbreaks of endemic diseases within this community? • When was the last time this community experienced outbreaks of diseases? • Have there been any developmental projects that have resulted in outbreaks of any disease in this community? —dams, irrigation projects etc.
	10. Which season of the year do you normally record outbreaks of these diseases?	• Rainy season or Dry season? • Probe for the type of disease that had the outbreak and the season
	11. Have you noticed any changes in cases of endemic diseases recorded over the years?	• Can you tell me some of the changes you have seen? -increasing, decreasing, stable etc. • How long did you start noticing these changes? • What do you think account for the changes that you have noticed?
	12. Have you also noticed any new disease(s) within this community which did not use to be?	• If yes, can you tell me when this community started to see signs of this disease(s)? • What do you think might be the cause of this new disease?
Adaptation / Coping Strategies		
	13. In cases of outbreaks of diseases within this community, how have or did the people adapt to the outbreaks, coped with or helped to prevent the spread of the diseases?	• Can you give me any examples? • What are the specific coping activities that are used? ---ask of examples of specific diseases and what was done in that case. • Does everyone engage in these coping activities – men and women alike?

	14. What are the things you do or the roles you play as a community in cases of outbreak to help curtail the spread and also cause a reduction in new cases?	• Example, do you ban social/communal activities? • Can you give me examples with regards to specific diseases?
	15. What are some of the challenges that you face as a community that makes it difficult to cope during outbreaks of diseases?	• Based on the challenges in the past do you have any plans as a community for the future to help address these challenges?
	16. Do you as a community have any adaptation measures in place to prevent or help deal with the endemic diseases within this community?	• In case this community records outbreaks of diseases that are more severe or frequent compared to those recorded in the past, would you say that you are in the position to cope with them?
	17. What responsibilities or roles did the hospitals or health centers within this community played in cases of outbreaks?	• Was the community satisfied which these roles and responsibilities?
	18. What do you think can be done to improve the response measures to outbreaks of endemic diseases within this community?	
Climate Change and Health		
	19. Have you ever heard about climate change/global warming?	• Can you tell me what is your understanding or meaning of climate change? • What do you call climate change in your local dialect?
	20. Have you noticed any changes in rainfall over the years?	• If yes, what are some of these changes? —increased intensity, delay in start of season, early start of season, less rainfall, short rainy season, long rainy season. • Since when did you start noticing the changes reported? —past year, past five years etc. • The changes noticed, can you say it has been the same for the past 5 or 10 years or there has been differences?
	21. Have you noticed any changes in temperature over the years?	• If yes, what changes have you observed? —hottest months, coldest months, hotter days etc. • Since when did you start noticing the changes reported? —past year, past five years etc.

		• The changes noticed can you say it has been the same for the past 5 or 10 years or there has been differences?
	22. In your opinion have climate change caused any impacts in this community?	• If yes, what are some of these changes? Probe for infectious diseases if not mentioned.
	23. Do you think climate change have any impact on health?	• What are some of these impacts? • Probe for infectious diseases if not mentioned
	24. Have you received any sensitization with regards to climate change and / its impacts on health within this community?	• Can you give me examples of them? • Have you received any training on how to adapt (actions or options available) to climate change in the area of health (infectious diseases)?
Access to Health Care and Health Facilities		
	25. Do you have any health centers or hospitals to cater for health issues within this community?	• Are they private owned or government? • Is the health facility located within this community? • If not, how far is it from your community? • What is the mode of access to this health facility?
	26. Are there enough hospital staffs to assist people when they visit hospitals for endemic diseases?	• How long do you have to wait to be attended to when you visit? • What are some of the things that people within this community complain of with regards to their visit to the health facilities?
	27. Is the community hospital or district hospital able to treat cases of endemic diseases and able to help everyone during cases of outbreaks?	
	28. Do you think people in your community are able to afford health-cost for hospital treatments for endemic diseases?	• If not, what are some of the factors that account for non-affordability?
	29. What is/are some of the major barriers that prevent people within this community from assessing the health facility?	• Financial, transportation, cultural beliefs of causes of disease, perception about health workers—staff attitudes, waiting time etc.
	30. In a case that you don't visit the health facilities, how do you treat yourself when you suffer from any of the disease's endemic within this community?	• Is this mode of treatment effective? • Do you have any local ways of preventing and treating these diseases?

APPENDIX H: IN-DEPTH INTERVIEW GUIDE FOR HEALTH INSTITUTIONS

IN-DEPTH INTERVIEW GUIDE FOR HEATH PRACTITIONERS

BROAD THEMES	CENTRAL QUESTION	PROBES
Endemic Diseases/ Disease Burdens		
	1. What diseases are the most reported to this health facility?	
	2. What infectious diseases are most common in this district/community?	
	3. On a scale of 1-5, how would you rate the severity of the various endemic infectious diseases within this community/district?	• Which of the endemic infectious diseases in your opinion have the highest diseases burdens and as a result are issues of concern within this district/community?
	4. When was the last time you recorded outbreaks in endemic diseases within this district/community?	• Which of the endemic diseases have been recording frequent outbreaks? • What are the underlying factors causing or influencing these outbreaks recorded? • Which season do you normally record outbreaks or increased cases?
	5. Do you think changes in seasons account for or have any impact on diseases outbreaks or cases recorded?	• If yes, can you tell me some of the reasons why this is the case?
	6. Have you noticed any changes in endemic diseases recorded over the years?	• Can you tell me the changes you have noticed: -increased cases, frequent outbreaks, decreased cases, stable etc.?
	7. Have you recorded any new disease within this district that didn't use to exist?	• If yes, can you tell me the kind(s) of diseases and when you started noticing or receiving cases in this facility?
	8. Is this health facility able to treat all endemic diseases that are reported or have the necessary equipment's for treatment (e.g. diagnostic kits, laboratory)	• What are some of the challenges that you face? —Financial, diagnostic kits, laboratory, staff etc. • Which of the diseases pose a greater challenge to this health facility? Why is that the case?

Climate Change and Health		
	9. Have you heard about climate change or global warming before?	• Can you tell me what your understanding is or meaning of climate change?
	10. What risks in your opinion are associated with climate change?	
	11. Do you think climate change have any impact on human health?	• What are some of these impacts? • Probe for infectious diseases if not mentioned.
	12. Which of the mentioned endemic infectious diseases within this district/community in your opinion is/are sensitive to climate change?	• Why is that the case? • What are some of the effects of climate change on these diseases?
	13. Do you think that the changes in endemic diseases that you mentioned earlier could be a sign of climate change?	
Adaptation and Adaptive Capacity		
	14. How do you monitor disease occurrence in cases of outbreaks to prevent spread and recording of new cases?	
	15. With regards to previous outbreaks, on a scale of 1-5, how would you rate this health facility's ability to monitor, treat and curtail the problem?	• What were some of the challenges that this facility experienced during those outbreaks?
	16. What are some of the short-term actions (interventions) that your institution is taking to deal with current endemic diseases within this district, such as reducing incidence or occurrence?	
	17. Would you say that these interventions have been effective in achieving their goal?	• Have there been reduction in cases since their implementation?
	18. Are there any long-term actions in place within this institution to deal with changes in rates of recorded diseases or frequent outbreaks due to impacts from climate change?	• If yes, what are some of these adaptation measures? e.g., interventions, capacity building measures.
	19. Does this health facility have any measures or plans in place (e.g. emergency response) to deal with outbreaks of infectious diseases with inducement from climate change or impacts of climate change on health?	

	20. Have the workers in this institution been provided with any training /workshop with regards to climate change and health linkages (e.g. climate change impacts on climate sensitive diseases) to enhance their capacity towards dealing with impacts from climate change on human health?	• If yes, can you tell me some of these workshops or trainings that were organized?
	21. Does your department have plans over the next 5 years for research on and response to climate-sensitive infectious diseases?	
	22. In case of frequent and severe outbreaks of infectious diseases such as schistosomiasis, cholera, onchocerciasis, malaria etc. resulting in higher incidence of reported cases due to impacts from climate change, would you say that your outfit is prepared or in the position to deal with this issue?	• If yes, what are the plans or measures you have in place that makes your health facility prepared and ready? • What do you think will be the major challenges that this institution might face in such a scenario, or you anticipate to face?
	23. Does the public health sector have any policies in place that you know of concerning mainstreaming climate change impacts into the health sector?	• If yes, what are these policies? • What are they supposed to achieve?
Monitoring		
	24. Does your health institution have any disease surveillance systems in place to watch and track the distribution and trends in incidence of endemic diseases within this community/district?	• What kinds of surveillance system do you have? - e.g. community-based surveillance volunteers at the District level. • Would you say that they are very effective?
	25. Do you have an extensive database of incidence of endemic diseases especially infectious diseases that can be used as a monitoring tool for potential surveillance activities related to climate change and infectious diseases linkages?	• Is this database comprehensive enough to be used for pattern and trend analysis? Such as checking for range expansion of cases of diseases based on place of residence of patients? • Ask about district health information management system (DHIMS)
	26. Are there district or local planning and coordination institutions within the health sector to monitor and control climate-sensitive infectious diseases such as malaria, schistosomiasis cholera, and onchocerciasis?	

	27. Are district or local health services able to provide essential health services during an outbreak?	
	28. How effective is their capacity to provide routine and diagnostic support in case of an epidemic?	
	29. How effective are current surveillance and control programs for vector-, water-, and food-borne diseases?	
	30. What reforms or actions in your opinion are needed in the health sector to equip them to be able to deal with climate change impacts on human health?	

CURRICUM VITAE

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EDUCATION

2014-2018 Ph.D. Geography (Global Health Systems in Africa)
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2016 Queen Elizabeth II Diamond Jubilee Scholarship (Collaborative Program and Training), African Institute-Western University

2016 Association of American Geographers (AAG) Dissertation Award

2016 Faculty of Social Science Graduate Research Award, Western University

2015 Third Place Award for Student Poster Competition
(Science in the Developing World: Enhancing Research Capacity Workshop, Balsillie School of International Affairs, University of Waterloo)

2012-2018 Western Graduate Research Scholarship (WGRS), Western University
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RELATED WORK EXPERIENCE

Fall 2018	Instructor, Geography of Sub-Saharan Africa (GEOG. 2030-Africa South of the Sahara) Limited Duties Instructional Appointment, Geography Department, Western University.
2012 – 2018	Teaching Assistant, Department of Geography, Western University Winter (2018) Introduction to the Human Environment Fall (2017) Foundations of Geography Winter (2017) Introduction to the Human Environment Fall (2016) Africa South of the Sahara Winter (2016) Geography of Tourism Fall (2015) Geography of Tourism Winter (2015) Africa South of the Sahara Fall (2014) Decision-making with GIS Winter (2014) Africa South of the Sahara Fall (2013) Africa South of the Sahara Winter 2013 Fundamentals of Geography Fall (2012) Fundamentals of Geography
Fall 2013	Invited Lecturer, (GEOG. 2030A-Africa South of the Sahara) Department of Geography, Western University

PUBLICATIONS

Refereed Publications

Sowatey, E., Nyantakyi-Frimpong, H., Mkandawire, P., Arku, G., *Hussey, L.*, & Amasaba, A. (2018). Spaces of resilience, ingenuity, and entrepreneurship in informal work in Ghana. International Planning Studies, 1-13.

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Hussey, K. L, and Arku, G. (under review). Are We Ready for It? Health Systems Preparedness and Capacity Towards Climate Change-Induced Health Risks: Perspectives of Health Professionals in Ghana. *Climate and Development.*

Hussey, K. L, and Arku, G. (under review). Prioritizing Climate-Sensitive Infectious Diseases Under Changing Climate: A Multicriteria Evaluation Analysis Approach. *Global Environmental Change.*

Non-refereed Publication

Hussey, Lucia Kafui, "Analytic Network Process (ANP) for Housing Quality Evaluation: A Case Study in Ghana" (2014). *Electronic Thesis and Dissertation Repository*. Paper 2407. http://ir.lib.uwo.ca/etd/2407