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**CLIMATE CHANGE IMPACTS ON URBAN WASH SERVICES IN
GHANA**

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ABSTRACT

The global water and sanitation sector is faced with numerous problems. Evident from Sub-Saharan Africa is the lack of access to potable water and improved sanitation which has made water coverage and sanitation a worry for most governments in low and middle-income countries. Climate change will exacerbate these problems especially in the urban poor communities. There is therefore the need to investigate how to make urban WASH services climate proof. In line with achieving this aim, part of this work assessed the existing WASH vulnerabilities, assessed the potential impacts of developed hydrological scenarios on the existing vulnerabilities and developed recommendations for various stakeholders using the Rapid Climate Adaptation Assessment (RCAA) methodology. The other part of this work assessed the adaptive capacity of the urban WASH sector by applying the Adaptive capacity wheel (ACW) methodology. In the application of these two methodologies, qualitative empirical data were collected from semi-structured interviews, direct observations and focus group discussions. The empirical data collected helped to understand the stakeholders' climate change awareness, the linkages in the local vulnerabilities, and ways to enhance the adaptive capacity of the WASH sector. This research argues that the vulnerabilities of the WASH services are similar within and across the ecological zones in Ghana. These vulnerabilities resulted from intermittent water supply, poorly managed solid waste and lack of spatial planning which are problems in urban poor WASH management. Though these vulnerabilities were arrived by simple hydrological scenario, they show the need for adaptation measures to be incorporated into urban poor WASH planning. To integrate adaptation measures to achieve resilience, this work further argues that the adaptive capacity of the sector can be enhanced by improving the learning capacity and motivation of stakeholders as well as empowering larger-scale institutions to provide structures and guidance at the lower- and individual level.

This work is dedicated to my late grandfather

Hon. I.K. Adjei-Mensah

May his gentle soul rest in perfect peace

The legacy lives on

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I am grateful to my supervisors for their support. They have been very supportive from the first day to the last. They ensured I was provided with the tools necessary for my development. It has not been smooth but they encouraged me to “keep my foot on the pedal”.

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LIST OF ABBREVIATIONS

| | |
|---------|--|
| ACCRA | Africa Climate Change Resilience Alliance |
| ACW | Adaptive Capacity Wheel |
| AFD | French Development Agency |
| APF | Adaptation Policy Framework |
| CSO | Civil Society Organizations |
| CRiSTAL | Community based Risk Screening Tool-Adaptation and Livelihoods |
| DFID | Department for International Development |
| EHD | Environmental Health Department |
| EPA | Ghana Environmental Protection Agency |
| FOAT | Functional and Organizational Assessment Tool |
| GAMA | Greater Accra Metropolitan Area |
| GIZ | German Development Agency |
| GWCL | Ghana Water Company Limited |
| HDPE | High Density Polyethylene |
| IPCC | Intergovernmental Panel Climate Change |
| IRC | International Rescue Committee |
| IWMI | International Water Management Institute |
| KFW | Development Bank |
| KNUST | Kwame Nkrumah University of Science and Technology |
| LAC | Local Adaptive Capacity |
| MDG | The Millennium Development Goal |
| NASA | Nasa Aeronautics and Space Administration |
| NCCAS | National Climate Change Adaptation Strategy |

| | |
|--------|--|
| NCCAS | National Climate Change Adaptation Strategy |
| NCCP | National Climate Change Policy |
| NGO | Non-Governmental Organization |
| ODF | Open Defecation Free |
| OSOP | One Sheet Of Paper Analysis |
| PAR | Pressure And Release |
| PCA | Principal Component Analysis |
| PPP | Private Public Partnership |
| PVC | Polyvinyl Chloride |
| RCAA | Rapid Climate Adaptation Assessment |
| SDG | Sustainable Development Goals |
| SDG | Sustainable Development Goals |
| UDS | University of Development Studies |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environmental Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNICEF | United Nations International Children’s Emergency Fund |
| USAID | United States Agency for International Development |
| VIP | Ventilated Improved Pit latrines |
| WASH | Water Sanitation and Hygiene |
| WATSAN | Water and Sanitation |
| WHO | World Health Organization |
| WSUP | Water and Sanitation for the Urban Poor |

1 INTRODUCTION

This chapter gives the background to the research by explaining the rationale of the thesis. It is followed by the aim and objectives, the explanation of the ecological zones and what they mean for this research. This chapter ends with the science of climate change which highlights the causes of climate change as well as the relevant debates under this topic.

1.1 Rationale for the research topic

Current data from the World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF) Joint Monitoring Programme (JMP) suggest that 844 million people lack access to basic drinking water service and 2.3 billion people also lack access to basic sanitation service (WHO/UNICEF JMP, 2017). The World Health Organization (WHO) states that Sub-Saharan Africa is home to half of these people living without access to improved water sources (WHO, 2014). The Millennium Development Goal (MDG) of halving the number of people in the world without access to proper drinking water and improved sanitation by 2015 could not be realized in Sub-Saharan Africa hence lots of efforts must be channelled into achieving the Sustainable Development Goals (SDG). Though water and sanitation coverage has improved, there are still deficits in achieving "universal and equitable access to safe water and sanitation for all" by 2030 (WHO, 2014) and this needs addressing.

Ghana is a developing country in Sub-Saharan Africa that is striving to expand access to water and sanitation services. In 2015, the WHO and UNICEF reported that 50.1 % had access to basic drinking water whilst 14.3 % had access to basic sanitation services in Ghana (WHO/UNICEF, 2015). This shows that Ghana has to commit a lot of effort in achieving the SDG target of providing universal and equitable access to safe water and sanitation for all by 2030. However such efforts are being undertaken during a period of climate change that is a particular complicating factor in this process. Observed data from 1960 to 2003 depicts an increase in the mean annual temperature by 1.0°C and it is

predicted to rise by a further 1°C to 3°C by 2060 (McSweeney et al., 2010). Annual rainfall is also projected to decrease in all regions in Ghana and the percentage decrease tends to increase from north to south. This will severely impact the water sector (Bates, 2009). There are two components of the water sector; resources and services (Howard et al., 2010) and both will be affected by climate change. The United Nations Environmental Programme (2010) predicts that Ghana will be water stressed by the year 2050. This will bring about a situation where the water available will be insufficient to meet the demand because the available water will decrease. Existing water services' management practices are not robust enough to deal with the impacts (Bates, 2009), so Heath et al. (2012), argues that better water management practices are needed to deal with these impacts.

Ghana, in dealing with issues related to climate change, identified ten sectors that were vulnerable to climate change (EPA, 2008). The National Climate Change Policy (NCCP) further identified ten programme areas that address both adaptation and mitigation issues. One area relevant to this discussion is the minimization of the impacts of climate change on access to water and sanitation. Though the resources part of the water sector has seen more research in terms of climate proofing, little attention has been given to the services that also play a part in ensuring sustainability of the WASH sector. Works such as (Kankam-Yeboah et al., 2010; Owusu et al., 2016), focused on water resource resilience, acknowledge the need to adopt and implement IWRM as well as control the population growth. What then must be done to the technology and the management aspect of the water sector? There is the need to advance research to know the ways in vulnerability relates with impacts; the types of responses that are already used to minimize risk and build resilience and workable measures that can be put in place to climate proof water and sanitation services in Ghana. Making water and sanitation services resilient to climate change will “avoid water quality deterioration, unavailability of water and sanitation systems which contaminates the environment as it would lead to major public health consequence” (Oates et al., 2014).

This work seeks to assess the vulnerability of water and sanitation services in Ghana and recommend adaptations to make them climate proof. This vulnerability will be looked at in urban poor communities within and across ecological zones, as the National Climate Change Adaptation Strategy (NCCAS) reiterates the fact that Ghana’s vulnerability to climate change is “spatially and socially differentiated” and this makes each ecological zone have unique “physical and socio-economic characteristics that define their sensitivity and resilience to climate change impacts” (MEST, 2012). The urban population forms more than half of the Ghana’s population (Ghana Statistical Service, 2012) and rural-urban migration is projected to increase due to effects of climate change on Agriculture (Tacoli, 2009; Van der Geest, 2011). The urban poor is vulnerable to climate change because of inability to deal with impacts on its livelihood and health (Dasgupta and Baschieri, 2010; Hulme et al., 2001). This needs to be addressed so as to avoid what Owusu and Oteng-Ababio (2015) describes as a bipolar urban society with the rich on one hand and the poor on the other.

Table 1-1 National Climate Change Policy (NCCP) programme areas

| |
|--|
| 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 |
| 10. Minimize greenhouse gas emissions |

1.2 Ecological zones in Ghana

Ghana has three broad climatic zones (Stanturf et al., 2011) which are subdivided into six ecological zones; Sudan savannah, Guinea savannah, deciduous rainforest, Rainforest, Coastal savannah and Transitional zone as shown in Figure 1-1 below. These ecological zones have been delineated based on the amount of rainfall they receive a year and the type of vegetation found in these zones (Minia, 2008).



Figure 1-1 Map showing ecological zones in Ghana (Kemausuor et al., 2013)

As shown in Table 1-2, Rainforest records the highest annual rainfall of 2200 mm/yr while the Coastal savannah receives the lowest rainfall of 800 mm/yr. In terms of land area, the Guinea savannah covers 63% of Ghana's total land area while Sudan savannah covers the smallest land area of 1%. The Sudan and Guinea savannahs have a single growing season as compared to the double

growing seasons of the remaining four climatic zones. All these ecological zones are affected by rainfall variability (Owusu and Waylen, 2013).

Table 1-2 Characteristics of Ecological zones in Ghana (Source: AQUASTAT, 2005)

| Ecological zone | Area (km²) | Mean annual rainfall (mm) | Major rainy season | Minor rainy season |
|------------------------|------------------------------|----------------------------------|---------------------------|---------------------------|
| Rain Forest | 9500 | 2200 | March-July | Sept.-Nov. |
| Deciduous Forest | 66000 | 1500 | March-July | Sept.-Nov. |
| Transitional Zone | 8400 | 1300 | March-July | Sept.-Oct. |
| Coastal Savannah | 4500 | 800 | March-July | Sept.-Oct. |
| Guinea Savannah | 147900 | 1000 | May-Sept. | |
| Sudan Savannah | 2200 | 1000 | May-Sept. | |

1.3 The science of climate change

Climate change is defined by the Intergovernmental Panel Climate Change (IPCC) as transformations in the climate's state that can be determined by variations in the mean climatic conditions and/or the changes in its properties. These changes continue for a lengthy period, usually decades or more (IPCC, 2007). Climate change is also described by the UK MET office as an extensive change in the planet's weather sequence or mean temperatures for a lengthy period (UK Met. office, 2015). These two definitions differ slightly from that given by the United Nations Framework Convention on Climate Change (UNFCCC), where climate change is understood to be a "change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC, 1992).

1.3.1 Causes of climate change

Elements that have an influence on climate are known as climate forcings or forcing mechanisms (Smith, 2013). These forcings may be either internal or external. Internal forcing mechanisms are activities such as the thermohaline circulation that occur in nature within the climate system. External forcing mechanisms are basically natural processes such as variations in solar output

and volcano eruptions or anthropogenic processes such as intensified release of greenhouse gases (Brown et al., 2014). The increase in temperature of the earth, which is caused by trapped solar radiation in the atmosphere, is known as the greenhouse effect (Oreskes, 2005).

The reaction of the climate system in response to the mode of the initial forcing mechanism may be fast, slow or a combination of both. While certain components of the climate system react more quickly to climate forcings, others such as oceans and ice caps respond more slowly (Smith, 2013). Though the response of the climate system may sometimes be swift, its complete reaction to the forcing mechanism may not be fully established for centuries (Brown et al., 2014). Because it takes a long time to establish the complete reactions of the forcings, there is often in the climate science

1.3.2 Global warming and the greenhouse effect

One of the arguments in the climate change scholarship has been whether human activities are increasing the greenhouse effect. Nonetheless, various evidences point to the fact that the current global warming cannot be attributed to changes in solar energy (Oreskes, 2005). For instance, the average solar energy has either stayed constant or slightly increased since 1750 (Stocker et al., 2013). Again, assuming there has been drastic increase in average solar energy, warmer temperatures would have been observed in all layers of the atmosphere. Rather, research has shown that warming is only observed at the surface and bottom layer of the atmosphere, whereas the upper layer is being cooled. This is due to the fact that the heat is being trapped by greenhouse gases in the lower layer of the atmosphere (Oreskes, 2005). Moreover, the depiction of climate patterns that include solar irradiance variations cannot replicate the temperature trend observed by scientists over the past centuries without observing an increase in greenhouse gases (Lean, 2010).

Persistent gases with little or no response to chemical or physical variations in temperature continue to exist within the atmosphere and these gases block the earth's heat radiations from escaping the earth. As stated earlier, human activities continue to increase the greenhouse effect, thereby altering the

natural greenhouse. The IPCC emphasizes in its Fifth Assessment Report (AR5) the significance effect of human activities on global warming. The report concluded that over the past 50 years, there is more than 95% chance that global warming and increase in greenhouse gases have been greatly caused by human activities (Stocker et al., 2013). The greenhouse gases include the methane, carbon dioxide, Nitrous oxide, chlorofluorocarbons and water vapour (Karl et al., 2009). Schmidt et al.(2010) used data 1980 atmosphere data from NASA as baseline to estimate that water vapour accounted for half of earth's greenhouse effect, with clouds contributing 25%, carbon dioxide 20%, and the minor greenhouse gases and aerosols accounting for the remaining 5%.

1.3.3 Debates around climate change

Both sides of the debates on global climate change are of the view that the earth's temperature has increased and also the atmospheric concentration of greenhouse gases such as carbon dioxide and methane have significantly increased (Randall, 2011). However, whilst one side argues that human activities have significantly increased the atmospheric concentration of greenhouse gases and thus have a direct impact on climate changes such as global warming and rising of the sea level, the other side argues that the greenhouse gases generated from human activities are too low to have a significant effect on climate change. The latter is of the view that research that attributed global climate change to human activities was based on questionable climate models and measurements and thus not conclusive. Instead, they maintain that global climate change is caused mainly by natural processes such as fluctuations in solar radiation and ocean currents. This has been the major argument for the withdrawal of the United States from the signing of the Paris Agreement (UNFCCC, 2015). Despite this two-sided scientific debate, the scientific consensus by the IPCC is that climate change is anthropogenic. This thesis therefore assumes the position that climate change is anthropogenic and is already happening. The Paris agreement deals with mitigation of greenhouse gases emissions, adaptation and finance starting in the year 2020. The Paris Agreement coupled with the need to achieve Sustainable Development Goals

(SDGs) give cause for climate change issues to be considered in various sectors, especially in a sensitive sector like the water and sanitation water. This research therefore seeks to contribute to that discussion.

1.4 Aim and objectives

The research investigates how to climate proof urban water and sanitation services to achieve resilience. To achieve this main objective, the following specific objectives were investigated:

- To develop probable hydrological scenarios from climate predictions in Ghana and assess and compare across ecological zones their impacts on urban WASH services.
- To develop recommendations for the various stakeholders directly involved in achieving resilience of urban WASH services.
- To investigate how stakeholder politics, economics and power affect the ability of stakeholders to implement adaptation policies in Ghana.

The major academic contribution of this work will be to apply the RCAA methodology within and across different ecological zones and compare the impacts of climate change on urban WASH services. In doing so the work will further develop the RCAA methodology and apply the developed RCAA in Ghana in order to develop recommendations on how best to climate proof the WASH service. This work further assessed the adaptive capacity of the WASH sector in Ghana to understand what the challenges and opportunities are for the sector and how to ensure that the sector achieves resilience.

1.5 Thesis structure

To ensure that the thesis communicates the right information in a structured and a coherent way, the thesis has been structured into 8 chapters as explained below.

- Chapter One 'Introduction' – This is the chapter that introduces the research.

- Chapter Two 'literature review' – Presents a review of key literature on the three main concepts of climate change adaptations. This section discusses appropriate definitions and conceptual frameworks of vulnerability, resilience and adaptive capacity. It focuses on exploring the linkages between these epistemologies and how they have been applied in climate change adaptation literature.
- Chapter Three - This chapter looks at the two main methodologies used to assess the vulnerability of the WASH services, potential impacts of climate change and the adaptive capacity of the WASH sector. It describes the research approaches and the types of data collected. The limitations of the various methodologies were also discussed in this section.
- Chapter Four - Presents for each selected urban city within the ecological zone, the vulnerabilities of the WASH services. The assessment also looks at who is vulnerable, what is vulnerable and how they are vulnerable. It presents the WASH vulnerability assessment from the fieldworks in Kumasi, Accra and Tamale.
- Chapter Five - This chapter presents the developed hydrological scenarios from climate change projections. It further looks at the potential impacts of climate change on the existing vulnerability discussed in the chapter four
- Chapter Six - Presents an assessment of the adaptive capacity of the WASH sector in Ghana. It explains the various adaptive capacity dimensions and explores which characteristics of this sector enhances or hinders its adaptive capacity.
- Chapter Seven – This chapter develops and tests the hypothesis of similar WASH vulnerabilities from the case study. It further looks at where this research sits in terms of theoretical contribution to the adaptive capacity literature.
- Chapter Eight - This chapter develops the conclusions from the research to clarify how the various objectives were achieved. The chapter also

explains the knowledge contribution of the research, the implications, its limitations and what it means for future research.

2 LITERATURE REVIEW

The purpose of this chapter is to review key literature on the three main concepts of climate change adaptations. This section discusses appropriate definitions and conceptual frameworks of vulnerability, resilience and adaptive capacity. The chapter starts by introducing the major body of discussion followed by the review of vulnerability, resilience and adaptive capacity literature. This chapter also discusses various frameworks and highlights examples of their applications as well as strengths and weaknesses.

2.1 Introduction

Adaptation and mitigation have gained a lot of attention in the climate change literature in most developing countries (Füssel, 2007) as a way of dealing with climate change. Mitigation is defined as “an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases” (IPCC, 2001). Though mitigation seems to be the best means of avoiding risks related to climate change, it is too late to rely solely on mitigation (McGranahan et al., 2007) because data shows that climate change is already occurring (IPCC,2001), and hence adaptation is increasingly prioritized. Human societies have always had to adapt in order to survive. Adaptation has been studied not only in sociology and history but also in evolutionary biology (Ridley, 1996; Diamond, 2005). A system’s behaviour changes to react to external events by the altering of its intrinsic characteristic. Most adaptation definitions are distinguished on the basis of the end product or the process of adaptation (Kelly and Adger, 2000). McCarthy et al. (2001) defines adaptations as “actions targeted at the vulnerable system in response to actual or expected climate stimuli with the objective of moderating harm from climate change or exploiting opportunities”. The IPCC provides a general view by defining adaptation as an “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2001) The aim of adaptation is to prevent risk and reduce vulnerability and helps cope with extreme events and to take advantage of the opportunities that comes with the potential impacts of climate change. In order

to make decisions regarding adaptations, vulnerability assessment is prioritized (O'Brien et al., 2007). Vulnerability assessment paints a clear picture of the problems and opportunities of the system being assessed. This literature review will therefore look at vulnerability and other closely related scholarships that help understand the climate change adaptation discourse.

2.2 Vulnerability

The purpose of this section is not to review conceptual frameworks applied in the vulnerability literature. It begins with an overview and it is followed by a review of the various types of vulnerability. The section concludes with a discussion of the major debates in this literature.

2.2.1 Overview

Vulnerability is a term that is widely used across various disciplines. Cutter (2006) reviewed the early debates around the definition of vulnerability from the early eighties to mid-nineties. The early debates were centred on Timmerman (1981) definition of vulnerability as “the degree to which a system acts adversely to the occurrence of a hazardous event” Vulnerability can be classified as internal or external, current or future, dynamic or static, a starting-point or an end-point, as a hazard, as an attribute of concern or within a particular knowledge domain. Yet the multi-disciplinary origin of the term “vulnerability” in climate change literature has given rise to three approaches in classifying vulnerability. Various ways of describing and defining vulnerability led to these various approaches. To streamline the classification of vulnerability, vulnerability approaches have been looked at as biophysical, social or integrated approach. Most researchers like (Adger, 1999; Brooks, 2003; Cutter, 1996; Füssel and Klein, 2006; Ribot, 2014) have distinguished between social vulnerability and biophysical vulnerability but the exact meaning of these classifications is still “polarized”(Colette, 2016), Adger (2006) attributes the polarized meaning of social and biophysical approaches to the multi-discipline origin of vulnerability and argues that it is a strength rather than a weakness of the vulnerability scholarship. There are other researchers like (Soares et al., 2012 and Nguyen et al., 2016) who looked at an integrated (combination of

biophysical and social) approach in contextualizing vulnerability. The following sections will look at the three main approaches in details.

2.2.2 Biophysical approach

Biophysical vulnerability is closely related to the concept of risk such that most literature refers to this approach as the risk-hazard approach. Brooks, (2003)) reviewed various definitions of risk which included the IPCC (2001) definition of risk as “a function of probability and magnitude of different impacts”. Risk is the possibility of a hazard happening and it is considered by the type or nature of the hazard. The type of hazard could be meteorological, hydrological, geological or transportation and the magnitude could be low through medium to high. The level of vulnerability is therefore determined by the degree of risk, magnitude, duration and exposure to the hazardous event (Colette, 2016).

Biophysical denotes both the physical component and the biological component of the system that reduces or increases the impacts (Brooks, 2003). The amount of damage a system suffers when in contact with a hazard is known as the biophysical vulnerability. This approach with its base in natural hazards looks at how the hazard is distributed, who lives within the catchment of the hazard, who is inadequately prepared for the hazardous event and what the severity of the hazardous event is (Muler and Bonetti, 2014). The consideration is on “who is vulnerable rather than why. It gives much attention to people likely to be affected without explaining why they are vulnerable. In such researches, the physical and biological components of the system are quantified to show how many are likely to be affected. It also focuses on indicators rather than justification and solutions rather than causes” (Ribot, 2014). This approach prioritizes the likelihood of an event occurring, the possible outcomes and the expected damage. For example, Turner et al. (2003) observed that intensified climatic conditions cause monetary loss, property loss/damage or human mortality.

The risk-hazard concept shown in Figure 2-1 was developed by Turner et al. (2003). This framework considers the impact of a system after the system becomes sensitive to an exposed “exogenous hazard”. Under this framework,

as explained in previous paragraphs, vulnerability is made up of exposure, sensitivity and the impacts. For example, a community closer to the sea and on a low-lying ground becomes vulnerable to flood due to sea level rise. This is similar to observations made by Addo (2015) when he assessed the vulnerability of Ghana’s coast to sea level rise. He concluded that over 157,738 people were likely to be displaced by the year 2100. This work however did not look at the internal characteristics of the community that makes them vulnerable but rather assumes that the hazard (sea level rise) is the major cause of these losses.

Another application of the Risk-Hazard framework is the rapid participatory tool developed by Campos et al. (2015) to identify vulnerable communities and to select and support risk mitigation programmes. In applying the methodology, they considered the extent of hazardous events related to faecal contamination of the environment, the level of local community exposure to this hazard, and vulnerability factors that exacerbate the impacts of infection. They concluded that the tool can assist sanitation planning by translating the theory of disease transmission into a practical framework. This work just like most application of this framework tries to separate the effect of climate change from existing social conditions.

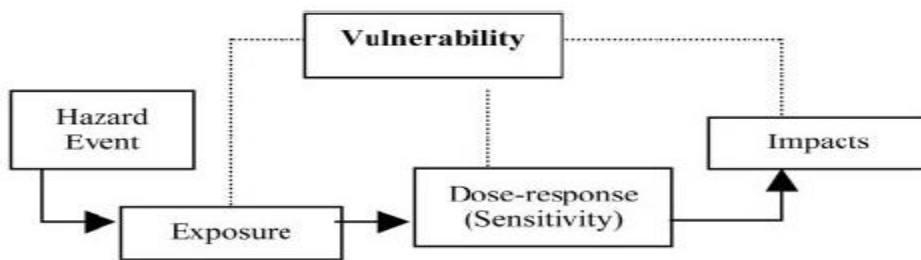


Figure 2-1 Biophysical (risk-hazard) framework (Turner et al., 2003)

The impact analysis as shown in Figure 2-2 as developed by Ribot (2014) and it looks at the numerous outcomes of a single climate event. This approach traces a linear causal event back to the environmental hazard itself. This approach

looks at what drought or flood causes. It could include loss of livelihood, hunger and famine. This approach was just modelled out of the risk-hazard approach explained above. Just like all frameworks under the biophysical approach, it neglects economic, political, social and cultural factors in the estimations of vulnerability (Cardona, 2003) and it is more illustrative but not explanatory (Füssel, 2007). This approach according to Watts & Bohle (1993) fails to consider the role of social structures and institutions which also influences vulnerability. Therefore, most researchers have looked at an alternative approach which considers why people are vulnerable.

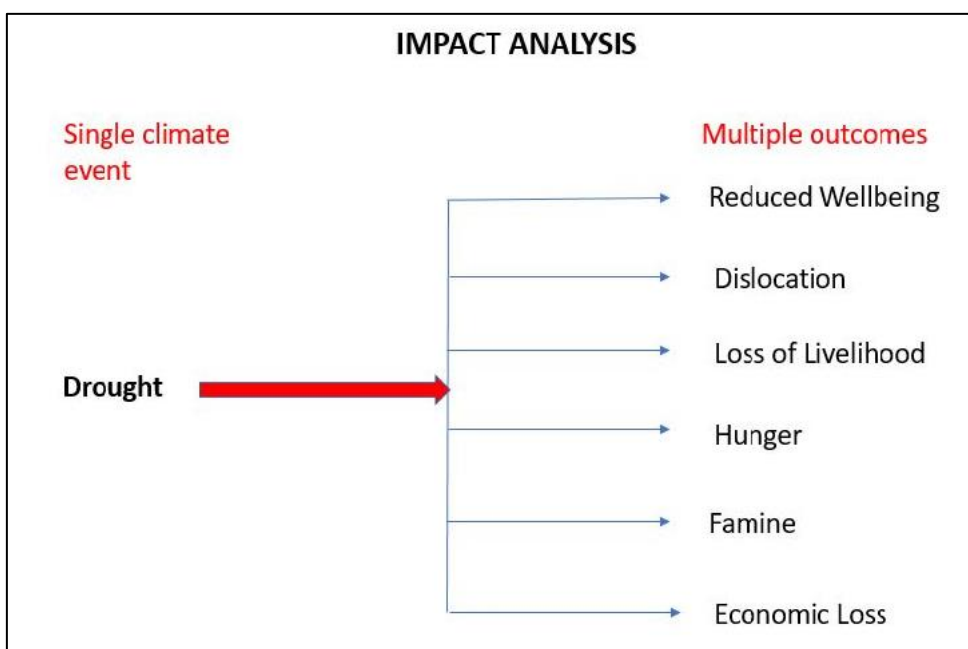


Figure 2-2 Biophysical (impact analysis) framework (sourced from Ribot, 2014)

2.2.3 Social approach

Social vulnerability approach looks at vulnerability from a social construct point by considering culture, economy and history of an individual or a group of people and looking at how these factors hinder their ability to cope with or respond to disasters (Adger, 1999; Brooks, 2003; Cutter, 1996; Mahapatra et al., 2015). This approach considers vulnerability as an inherent property of the system rather than an external hazard. It considers vulnerability as a threat

within a society by highlighting the “properties of a social system (the assets, protections, institutions, and relationships) that mediate the outcome of the hazard event and influence the capacity to adapt in the face of climate events (Adger, 1999; Ribot, 2014). Usually a lower socio- economic status means one is more vulnerable (Cutter et al., 2003)

To understand the complex social interactions that affect the vulnerability of a system, social vulnerability indices have been developed. These indices have been developed either by an inductive or a deductive method. The inductive method is based on statistical relationships (Adger et al., 2004) while the deductive method is based on theoretical understanding of relationships. These indicators do not always serve the purpose of comparability since some indexes may be invalid and data might be hard to come by in certain countries.

The Pressure And Release (PAR) framework was developed by Turner et al. (2003) as shown in Figure 2-3. This framework explains that root causes translate into dynamic pressure which results in unsafe conditions. Root causes could be politically or economically motivated. Dynamic pressures exacerbate these root causes within the community, like shift in livelihood activities. This forms the base vulnerability which causes a disaster when faced with a hazard. This framework conceptualizes disaster as a merger between physical exposure and socio-economic difficulties in a system therefore disaster comprises of a hazard and a process generating vulnerability which is an intrinsic property of the system. The PAR framework is very useful but it does not factor the human and environmental part of the system into its vulnerability assessment. Also, the sequence of how the hazard occurred is not detailed under this framework.

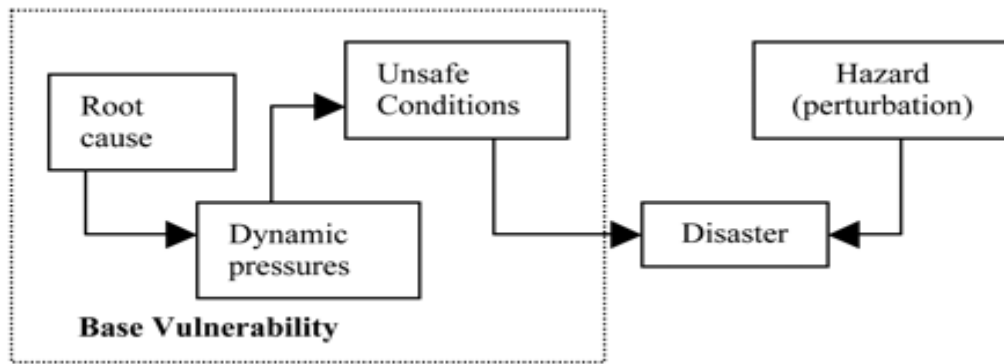


Figure 2-3 Social (Pressure and Release) framework (Turner et al., 2003).

Figure 2-4 also known as the vulnerability analysis looks at the numerous factors that result in a single outcome. This framework explains that the society has its own intrinsic characteristics that makes it vulnerable hence tends to see natural phenomena as just playing a role but not as having ‘caused’ the risk or damage in the face of an event (Brooks, 2003). The vulnerability analysis framework “empirically traces the causes of vulnerability from specific instances of crisis by explaining why a given individual, household, group, nation or region was at risk of a particular set of damages” (Ribot, 2014). A widely used tool developed from this framework is the DFID Sustainable Livelihood Framework. The DFID sustainable livelihood framework helps stakeholders assess sustainable livelihood strategies by understanding the assets available to them within the context of the prevailing institutions, policies and processes. DFID deems a livelihood to be sustainable “when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base” (DFID, 2000).

The vulnerability analysis framework traces crisis instances to understand why the system is vulnerable. It is more concerned with asking questions pertaining to how rather than who. It seeks to explain rather than just justify vulnerability. Criticizing the social vulnerability approach, Hewitt (1997) argues that the social approach has the tendency to neglect people’s perception of a disaster. Also, Bankoff (2003) argues that the underlining principles of the social approach

were shaped by a certain culture and may not work in a different culture. It does not provide enough details on the sequence that led to the hazard (Pimm, 1984). It is also inadequate when it comes to issues of sustainability (Turner et al., 2003).

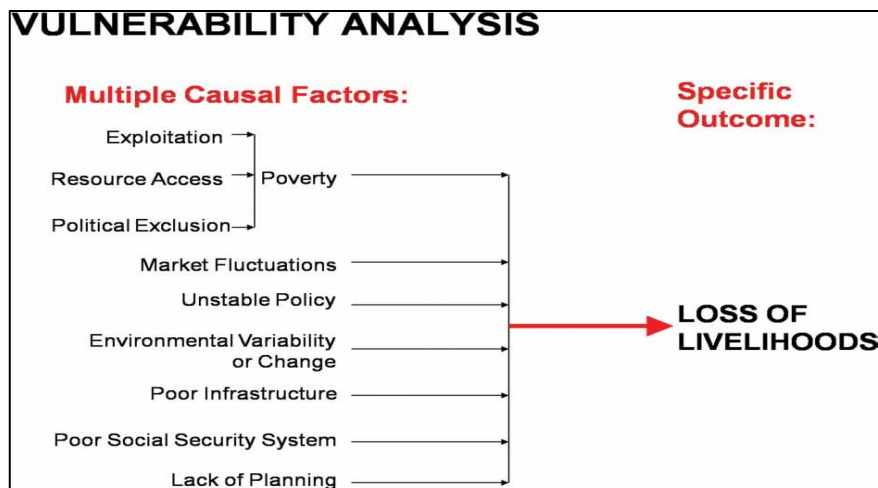


Figure 2-4 Social (vulnerability analysis) framework (Ribot, 2014)

2.2.4 Integrated approach

This approach instead of looking at what happens after a disaster, according to Colette (2016) is more concerned with the processes that lead to a disaster. The integrated approach, considers vulnerability as both biophysical and social but within a geographical context (Cutter, 2006). The geographical context can be who is vulnerable or where these vulnerable people or places are located. This considers the type of hazard and its effect on both physical and biological components of the system under consideration. The integrated approach considers the most vulnerable as people most exposed to hazards, those who possess a limited coping capacity and those who are unable to recover (Bohle et al., 1994). The poor can reside in a resilient biophysical environment and be vulnerable, and the wealthy can be in a fragile physical environment and not be vulnerable (Liverman, 1994). This approach encourages the development of other factors that affects the vulnerability of a system. In line with this, United Nations (2004) proposed the inclusion of economic, physical, social, and

environmental factors in the assessment of a vulnerable system. Fekete (2009) also suggested the inclusion of economic, ecological, social, political and technological aspects in the vulnerability assessment literature.

A framework for assessing the integrated vulnerability called hazards-of-place is shown in Figure 2-5. This approach was developed by Cutter (1996) and modified as seen in this work by Cutter et al (2003). This approach is characterized as having both external and internal (capacity) dimensions however, it runs into boundary problems because the line drawn between the two dimensions depends on what is being analysed (Colette, 2016). Frigerio and De Amicis (2016) explored the spatial patterns of Social Vulnerability Index across Italy, using cluster analysis based on the Hazards-of-Place model approach. They first outlined the main variables that indicate aspects of vulnerability of Italy to natural hazards and then applied a Principal Component Analysis (PCA) to identify the underlying components that make a territory socially vulnerable to natural hazards. As a critique to this work and all Hazards-of-Place model approach, Gaillard (2010) argues that this approach instead of integrating social and biophysical context ends up emphasizing the biophysical factors of risk, attributing pain and suffering to natural phenomena. In this sense, it has been criticized as always focusing on either the social or biophysical aspect without properly being able to address the two equally in researches. A typical example is when Holand et al. (2011) applied both socio-economic and built environment indicators to assess the social vulnerability to natural hazards of municipalities in Norway. They argued that the two indicators must not be applied in the same research as the real picture is painted clearer when only one of the indicators is applied.

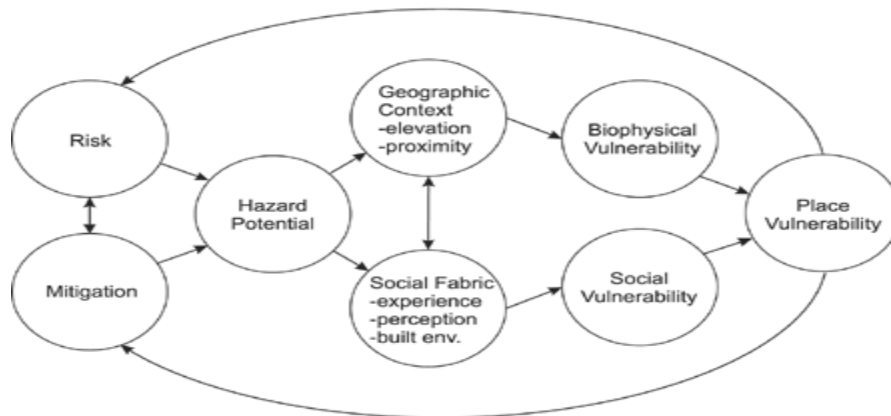


Figure 2-5 Integrated (Hazards-of-Place) framework of vulnerability (Cutter et al., 2003)

2.2.5 Discussion of vulnerability

Two major differences between the social and biophysical approaches are highlighted in this section. The first is that biophysical approach traces a linear causal relation back to the climate hazard itself whiles social approach traces a cause to multiple social and political-economic factors (Ribot, 2014). The second difference is that biophysical approach originated from the realist school whiles the social approach originated from the constructivist school. The realist school shaped the idea that biophysical approach is dependent on the sensitivity of the system. The constructivist school underpins the concept that vulnerability is a property of the system rather than an outside force. Vulnerability whether approached as biophysical, social or integrated has been applied in various ways but it is unclear whether vulnerability is characterized as an outcome or as a context where risk is managed and adapted to (O'Brien et al., 2007). The next paragraphs will discuss a few applications of this scholarship.

On a worldwide application of vulnerability research, Brooks et al. (2005) presented a set of vulnerability indicators which was derived using empirical analysis of data aggregated at the national level and indicated that the most vulnerable nations are those situated in sub-Saharan Africa and those that are just coming out of conflict. Dwyer et al. (2004) integrated social issues into hazard-of-place model development to rank the risk to communities by

developing a quantitative method for measuring the vulnerability of an individual within a household as a means of identifying those at risk to natural hazards. In India, Mahapatra et al. (2015) used socioeconomic and physical variables to develop an integrated coastal vulnerability index for the South Gujarat coast. They used five physical variables – “coastal slope, coastal landforms/features, shoreline change rate, mean spring tidal range, and significant wave height, and four social variables -population density of adjacent coastal villages, land use/land cover, proximity to road network and settlement”, to determine the sections of the coast deemed vulnerable. This work however focused more on the physical conditions rather than the social conditions.

Vulnerability assessment is not new to Ghana as this paragraph outlines some of the researches that have taken place in Ghana. Dumenu and Obeng (2016) developed indicators to assess the social vulnerability of rural communities in four of the six ecological zones in Ghana and advocates for local area-specific policies to reduce vulnerability and make adaptations work. Also, (Westerhoff and Smit (2009) assessed vulnerability by using semi- structured interviews and focus group discussions in a case study in Mimkyemfre in Ghana and observed that the community was both biophysically and socially vulnerable. They therefore advocated for the need to understand the economic, social and institutional challenges before planning adaptations. Finally Hesselberg and Yaro (2006) did an in-depth study to describe the food insecurity situation in three villages in northern Ghana. A social approach was used emphasising the vulnerability of the peasants’ adaptation to a marginal and remote area and argued that multiple income sources are necessary to reduce food insecurity for all but a small part of the peasant households. In adaptation literature, vulnerability is discussed in relation to resilience and adaptive capacity. The next section will review resilience literature and then adaptive capacity literature followed by a discussion of the relationships between these three widely researched scholarships.

2.3 Resilience

The purpose of this section is not to review conceptual frameworks and their applications in the resilience literature but to understand where resilience fits in terms of the broader climate change adaptation literature discourse.

2.3.1 Overview

The concept of resilience in climate change literature originated from the psychology literature where it was defined as the “toughness, persistence and constructive perception of events which help withstand their negative consequences and recover with optimism and buoyancy” (Manyena, 2006). Resilience found its way into the ecology literature after it was conceived by Holling (1973) as a measure of a “system’s integrity and it implies assimilating change and disturbance by preserving organizational functioning without major divergence”. This concept has its roots in the psychology definition of resilience as it conceptualizes the system to have the ability to fluctuate within the domain of attraction without being pushed over the boundaries. According to Weick & Quinn (1999), resilience is not only about functioning continuously, but it is also about exploiting the change that is absorbed. The change must be exploited to create a superior performance than there was previously by turning challenges into opportunities (Lengnick-Hall & Beck, 2003).

Manyena (2006) argues that the concept associated with resilience was adopted into the disaster literature without understanding clearly the various dimensions and definitions. However, Cutter et al. (2008) brings more understanding and clarity into the literature by defining resilience as “the ability of a social system to respond and recover from disasters and includes those inherent conditions that allow the system to absorb impacts and cope with an event, as well as post-event, adaptive processes that facilitate the ability of the social system to re-organize, change, and learn in response to a threat”. This definition shows in conceptual terms that vulnerability is closely related to resilience. Vulnerability is sometimes understood as being opposite to resilience (Engle, 2011), and other times as a risk factor whilst understanding resilience to be the to respond to the risk factor (Manyena, 2006). The thought that

vulnerability and resilience are opposite emanates from viewing resilience as an outcome. Barnett & O'Neill (2010) defined resilience as an outcome to mean the ability to either cope or bounce back. Those who view resilience as a capacity to respond define it as continual learning process that takes responsibility for making better decisions to improve the capacity to handle hazards (Cutter et al., 2008). Resilience whether treated as an outcome or a process provides hope during disaster.

Though resilience helps maintain hope and strength during difficulty (Johnson and Wiechelt, 2004), it is not always positive. Resilience may be negative and perverse (Gallopín, 2006). This happens when a system becomes vulnerable in the future due the past resilience measures. In Melbourne as part of adapting to climate change, a desalination plant and pipelines were constructed to increase resilience. However, years after the projects, low income communities become more vulnerable as they could not afford the high tariffs and hence did not get access to the water. Also during the construction phase of the project, large amounts of energy were used which also increased the emission of greenhouse gases (Barnett & O'Neill, 2010). To prevent negative resilience, Cutter et al. (2008) argues that resilience should be conceptualized as a dynamic process. In line with this, the United Kingdom's Department for International Development (2011) acknowledges the negativity of resilience by defining resilience to include transformation that does not compromise the long term prospects of a system.

Various resilience tools have been designed to assess and enhance resilience at different scales. These tools have assessed the resilience of communities, cities and countries. For example, the Communities Advancing Resilience Toolkit (CART) is a community intervention tool which was designed to enhance resilience by bringing together community stakeholders to take action to address community issues (Pfefferbaum et al., 2013). The Arup's City Resilience Framework and Index (CRFI) is a framework that measures city resilience by defining and measuring indicators such as robustness, redundancy and resources (Arup, 2015). The Tracking Adaptation and

Measuring Development (TAMD) framework measures climate risk management processes at national levels (Brooks and Fisher, 2011). It is however important to look at resilience across different scales because the scales are “inherently interlinked” (ODI, 2016). Looking at resilience across only one scale risk the chance of overlooking the resilience interaction between the scale under study and other related scales (Engle et al., 2014). For example the resilience of a community is influenced by the resilience of individuals as well as the resilience of the city at large and requires a proper understanding of all the interactions. Resilience interactions within and across different scales are important in understanding the roles and duties of all actors which is necessary for adaptive capacity enhancement. This is useful in enhancing adaptive capacity. Adaptive capacity and its overlaps with the resilience literature are discussed in the next section.

2.4 Adaptive capacity

This section looks at the adaptive capacity literature by understanding its position in both the resilience and the vulnerability literatures. The section also discusses major debates around this literature.

2.4.1 Overview

Good ideas and technical expertise are needed to write sound adaptation policies but to adapt to climate change, there is the need for the system to be ready to adapt. The readiness of a system to adapt to climate change is its adaptive capacity (Adger et al., 2004). Adaptive capacity goes beyond readiness to adapt to include the capacity of a person or community to respond and change to the likely impact of changing “shocks and stresses” (Lim et al., 2005). It is also “the ability of a system to adjust, modify or change its characteristics to moderate potential damage, take advantage of opportunities or cope with the consequences of a changing climate” (IPCC, 2007). Adaptive capacity focuses on the ability of stakeholders to respond to shape and create changes in that system (Chapin et al., 2006). The adaptive capacity of stakeholders is however enshrined in the power given to the stakeholders. The capacity to adapt is shaped by socio-political context and this needs to be

recognized to enhance development (Ensor & Harvey, 2015). Also, adaptive capacity depends on the degree of civil order, political openness, and sound economic management (IPCC, 2001).

Adaptive capacity is a dynamic process in ensuring adaptations work to its set goals. Adaptive capacity can be conceptualized with respect to the occurrence of hazard or disaster. Adaptive capacity may exist even before a disaster occurs and after it has occurred. This pre-event and post-event concept of looking at adaptive capacity has made it find its way into both the vulnerability literature and resilience literature discussed earlier. What makes adaptive capacity unique is that it is a universally positive system property. This means that a system cannot have too much of it and it is never described in negative terms. The next section will look at how it is situated in the vulnerability and resilience discussions.

2.4.2 Adaptive capacity in vulnerability literature: Coping capacity

Before a system becomes vulnerable, it sometimes possesses a form of adaptive capacity. Though this capacity may not be enough to prevent the system from being vulnerable, it reduces the impact of the disaster. This adaptive capacity is referred to in some literature as coping capacity (Cutter et al., 2008; Engle, 2011). Coping capacity forms part of the continuous adaptive capacity process and the two terms have been explained by some researchers. Ability to respond to an occurrence of harm and to avoid its potential impacts is how Kelly and Adger (2000) defined coping capacity and defined adaptive capacity as the “ability to transform structure, functioning or organization to survive under hazards' threatening existence”. Yohe and Tol (2002) defined coping capacity as a set of actions available to respond to the perceived climate change risks whiles adaptive capacity is the ability to change the set of available inputs that determine the level of coping capacity. These two definitions clearly state the occurrence of harm. Coping capacity exist before the harm and this decreases the impacts in the vulnerable state of the system. Adaptive capacity however goes beyond the occurrence of the harm. It is also

clear that the coping capacity is a subset of adaptive capacity. These definitions further suggest that coping capacity is the adaptive capacity that existed right until the impact is felt. After the impacts are felt, coping capacity ceases to exist. The IPCC (2007) highlights this argument by defining coping capacity as the “variation in climatic stimuli that a system can absorb without producing significant impacts”.

A framework that looks at how adaptive capacity fits into the vulnerability literature is that shown in Figure 2-6 below. Under this framework, Engle, (2011) proposes that as adaptive capacity of a system increases, there is correlating decrease in the exposure and sensitivity. Adaptive capacity is therefore inversely proportional to the vulnerability of a system and to decrease vulnerability, the adaptive capacity of a system should be increased. This framework presents adaptive capacity as a form of buffer. It reduces the sensitivity of a community to an exposure. Brooks et al. (2005) concludes from secondary data aggregated at the national level as well as focus group discussions of stakeholders that adaptive capacity is one element of vulnerability and it is associated mostly with governance, literacy, civil and political rights.

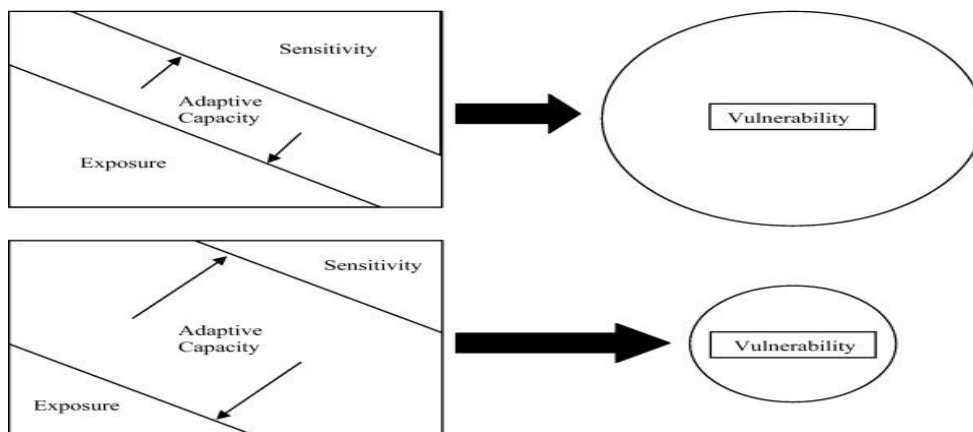


Figure 2-6 Framework of how adaptive capacity affects system's vulnerability. (Engle, 2011))

2.4.3 Adaptive capacity in resilience literature: Adaptability

Adaptive capacity in resilience literature, sometimes referred to as 'adaptability', is the actor's ability to influence and manage resilience (Walker et al., 2004). It is the ability of a system to adjust to change, moderate the effects, and cope with a disturbance (Brooks et al., 2005). The change comes about after harm has occurred in the system. Adaptability describes the post-event state of adaptive capacity and is an improvement on the coping capacity that existed before the system became vulnerable (Berman et al., 2012).

When compared to the global change perspective, hazards researchers normally place adaptive capacity within resilience (Paton and Johnston, 2001). Since resilience ensures continuity and recovery after stress by developing flexible capacities (Redman and Kinzig, 2003), strengthening resilience can be compared to enhancing an individual or a group's on-going adaptive capacity (Perez et al., 2015). High adaptive capacity makes an individual, community, or social-ecological more likely to be able to maintain a desired state, or negotiate a beneficial transformation when the current state is undesirable (Folke, 2006)

Engle (2011) developed a framework as shown in Figure 2-7 below to look at how adaptive capacity affects resilience. He argues that a system achieves a more desirable state when the adaptive capacity of that system is increased. He therefore postulates that a system with more adaptive capacity is likely to achieve a more desirable state as compared to a system with less adaptive capacity. Pelling et al.(2008) used lessons from social learning and institutional aspects of multi-level environmental governance to understand the relationships between individuals and collective action within organizations that can improve or work against adaptive capacity. Also Gupta et al. (2010) identified learning capacity, variety, room for autonomous action, leadership, availability of resources and fair governance as criteria to assess the inborn characteristics of institutions. These criteria can stimulate the adaptive capacity of society to climate change. This methodology forms a bigger discussion of this research and will be explored in detail later in this work.

Practically, a lot of organizations have sought to enhance resilience by improving adaptive capacity. Relevant to developing country context is the work of the Rockefeller Foundation. The foundation in 2009 sought to develop the capacity of fifty Asian cities. This initiative called Asian Cities Climate Change Resilience Network (ACCCRN) involved cities in India, Bangladesh, Vietnam, Thailand, Philippines and Indonesia. Through this initiative, institutions were trained to identify and access different funding sources (Archer et al., 2017) and also to form genuine and sustained partnerships with key external stakeholders (Gawler et al., 2014). This strengthened the institutions to enable them support shared learning dialogues, assess vulnerability, pilot engagement projects and support resilience plans and strategies (Sharma et al., 2013). This eventually improved the energy infrastructure, water and drainage systems, basic sanitation and transport systems.

Success story of ACCRN as reported by The Rockefeller Foundation (2015) includes for example, in India, three quarters of the Surat city flooded after the emergency release of the Ukai dam in the year 2006 and it affected about three million people. Significantly in 2013, a flood of similar intensity happened but due to the ACCRN project which had developed the capacity of the city to be resilient, the severity of the flooding was averted. The capacity was built through the building of a new coordination mechanism which involved thirteen departments across different scales of governance. Also a new reservoir management protocol was introduced. Another example is the lesson learnt from Vietnam, when the typhoon Nari hit the city of Da Nang in October 2013, all 244 of the houses that had been upgraded through a credit and technical design scheme funded by the Rockefeller Foundation through the ACCRN project, survived with no major damages (The Rockefeller Foundation, 2015). The project intervention protected the poor households from great cost that would have put most house owners in debt before they could rebuild their damaged house.

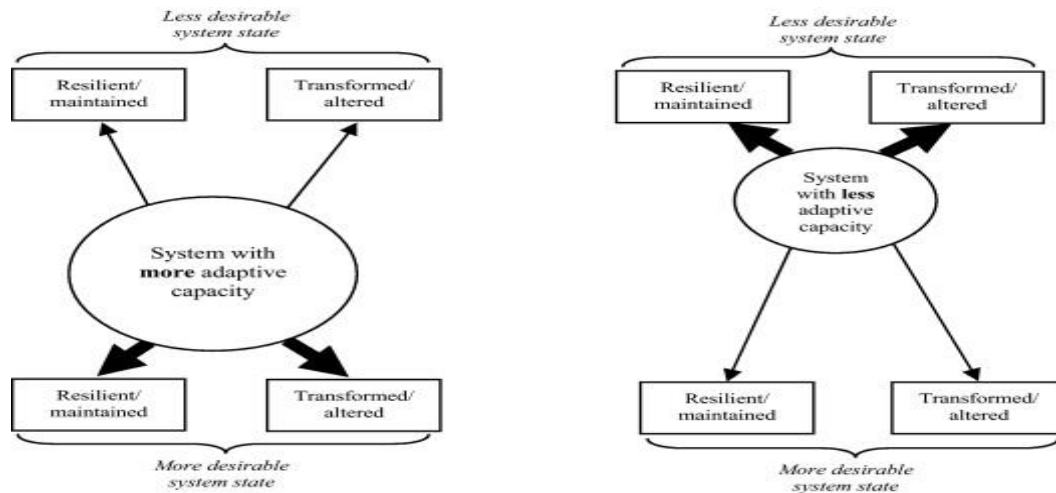


Figure 2-7 Framework of how adaptive capacity affects a system's resilience.
(Engle, 2011)

2.4.4 Discussion of adaptive capacity

According to Cutter et al. (2008), the linkages between adaptive capacity, resilience and vulnerability are still not “well-articulated”. They highlighted with Figure 2-8 below how various researchers conceptualize the links. Researchers (like Adger, 2006; Birkmann, 2006; Folke, 2006) argue that resilience is an integral part of adaptive capacity. Also works (like Burton et al., 2002; O’Brien et al., 2004; Smit et al., 1999) explain that adaptive capacity is a main component of vulnerability. In line with the two contexts above, researchers (like Gallopín, 2006; Turner et al., 2003) look at them as closely related concepts engulfed within the vulnerability concept. Some researchers in hazard science conceptualize resilience to be part of vulnerability (like (Bruneau et al., 2003)) whiles adaptive capacity on the other hand is within resilience (like Tierney and Bruneau, 2007).

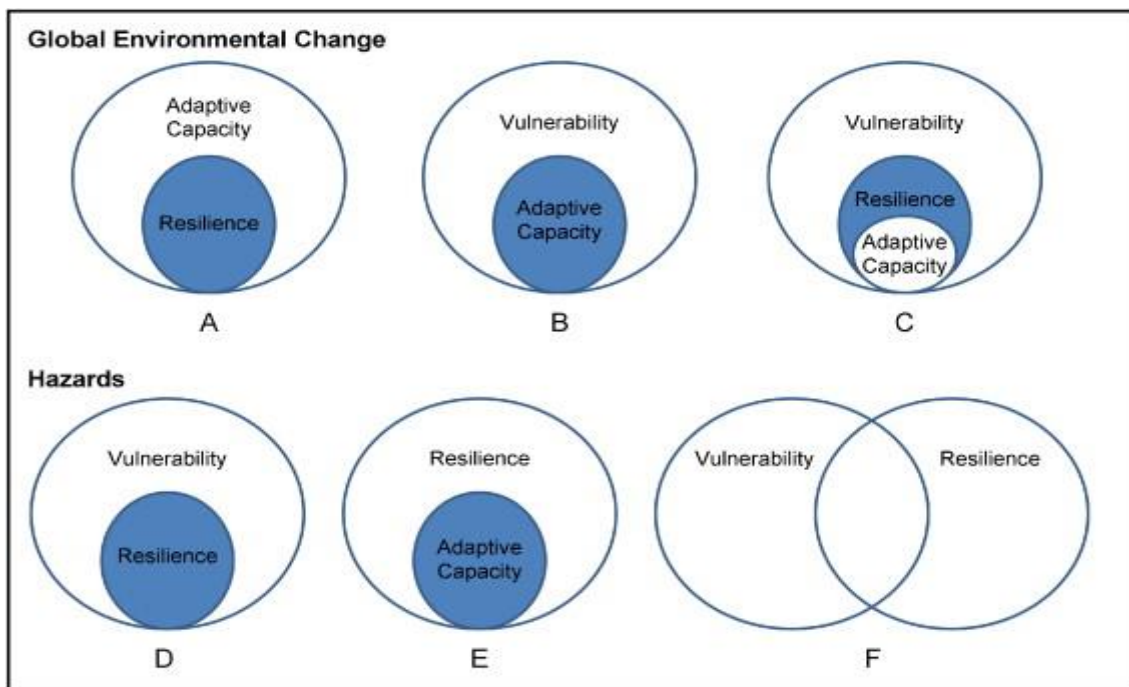


Figure 2-8 Conceptual linkages between vulnerability, resilience, and adaptive capacity (Cutter et al., 2008)

These works highlighted above have contributed to bringing clarity into the literature but the concepts are not entirely placed in their rightful subsets. From Figure 2-8 above, not the whole of adaptive capacity process fits into vulnerability and therefore there is the need to differentiate them appropriately as shown in the Figure 2-9 below. The subset of adaptive capacity that exists during vulnerability is the coping capacity as explained in the previous section. Also, not the whole of adaptive capacity is engulfed in resilience but as explained in the earlier sections, the adaptability part of adaptive capacity. The point of convergence of adaptive capacity literature in both vulnerability and resilience literature is shown by their appropriate names to introduce further clarity into this discussion. This clarity has been introduced into these closely related scholarships using the occurrence of a disaster as the focal point.

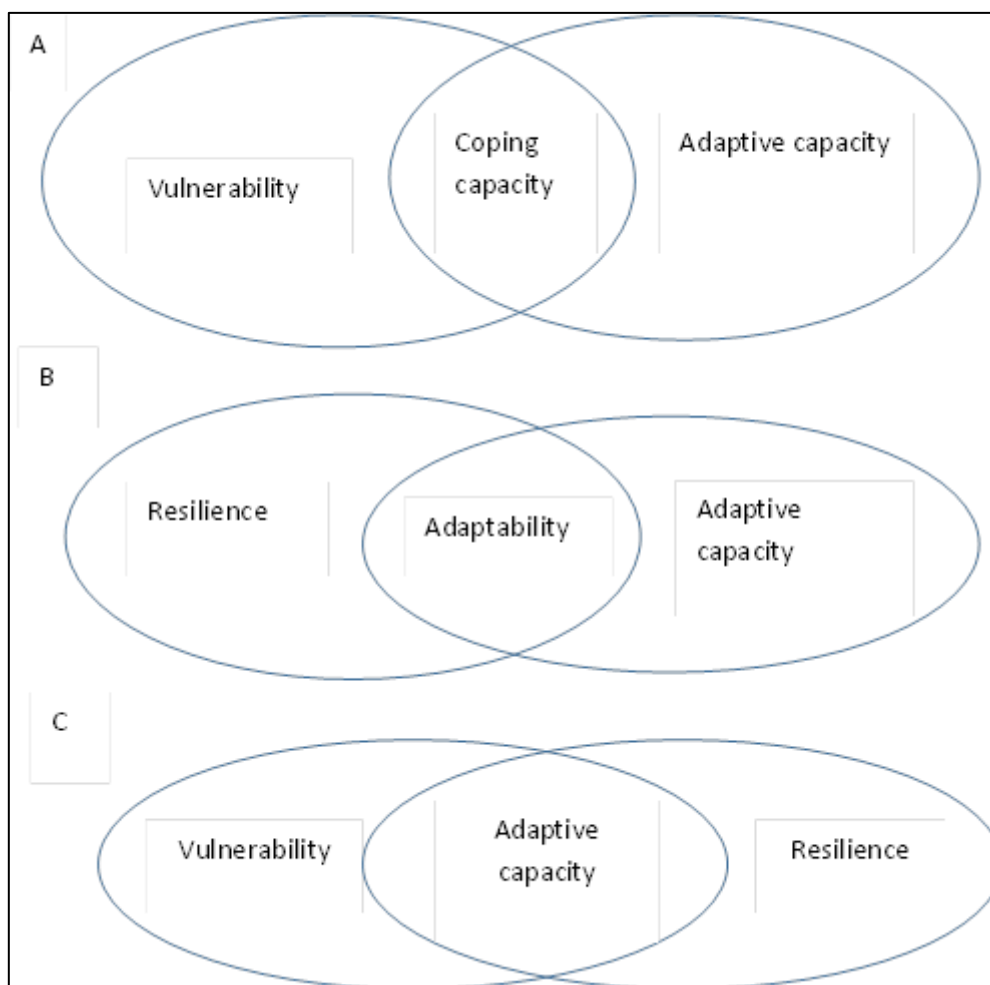


Figure 2-9 Framework of adaptive capacity showing links with vulnerability and resilience (A, B, C). (Adopted from Engle, 2011)

Adaptive capacity as explained is contextualized within both the vulnerability and the resilience literature. The question therefore is how can the coping capacity (the adaptive capacity that existed up until the impacts were felt) be maximised after the impacts to ensure that adaptation measures are sustainable. This calls for the transformation of coping capacity into adaptive capacity. This is achievable because coping capacity calls for stakeholders to draw on their skills, resources and experience to manage disaster (Berman et al., 2012). Therefore, a strong coping capacity is good for the adaptation process because it becomes easier for a system to transform to take advantage of the changing situation. Less transformation is required when there are good coping capacities. A system with a high coping capacity will need less

transformation to achieve resilience whilst on the other hand a system with low coping capacity will need more transformation assuming they are both hit by the same hazard which is above their coping limits.

2.4.5 How adaptive capacity has been measured

Various studies have developed adaptive capacity indicators by using indicators from the vulnerability and resilience literatures. These indicators have been moulded into indices (Schneiderbauer et al., 2013). Authors (like Adger et al., 2004; Brooks et al., 2005; Füssel, 2007) have considered works involving both generic and context-specific adaptive capacity. Indicators used to measure adaptive capacity by Marshall et al. (2010) includes; individual's perception, ability to plan, ability to learn and reorganize to cope with change". Specific measurements describe attachment to occupation, attachment to community, employability, family characteristics, formal and informal networks, and financial status (Marshall et al., 2010). Yohe and Tol (2002) developed a list of determinants of adaptive capacity to include-technological options; distribution and availability of resources; structure, human and social capital stock; access to risk spreading mechanisms; information and risk management; and the public perception of exposure and sources of stress.

Looking at adaptive capacity at the community level, Levine et al. (2011) through the Africa Climate Change Resilience Alliance (ACCRA) project focused on dimensions that contribute to the adaptive capacity of a system in Uganda, Ethiopia and Mozambique. These are the five characteristics that make up the Local Adaptive Capacity (LAC) framework: the asset base, institutions and entitlements, knowledge and information, innovation and flexible forward-looking decision-making and governance. Also at the local level, Marlin and Olson (2007) developed a tool for measuring the adaptive capacity of local institutions and it includes criteria such as the ability of elected leaders in the community to make choices related to climate change, to manage information ahead of time to decrease risks such as collecting information on flood plains, to share the information they have about climate change and possible adaptation strategies, the availability of a plan that is adaptive, forward thinking, and

addressing the risk of sea level rise and the presence of environmental action groups or similar groups in the community.

Bussey et al. (2012) explored how the history-futures interface can inform a set of concrete adaptation options to climate change for stakeholders in Australia. They profiled 33 historical case studies to identify common themes in the ways societies responded to stress. The case studies were intended to provide a context for thinking about adaptive capacity with stakeholders in four areas: human settlement and health; energy; agriculture, forestry and fisheries; and ecosystems and biodiversity. The case studies demonstrated that adaptive capacity varies with context and is affected by the complexity, technology, leadership, institutions and imaginative resources inherent to the social system under consideration.

2.5 Bridging Organizations

As explained in the previous section, transforming coping capacities to adaptive capacity is a role played by institutions (Berman et al., 2012). Gupta et al. (2010) defined an institution as “systems of rules, decision-making procedures, and programs that give rise to social practices, assign roles to the participants in these practices, and guide interactions among the occupants of the relevant roles”. The institution is made up of formal and informal, private and public, as well as civic organizations. In this research, in line with the explanations of Pahl-Wostl et al. (2010), formal and informal institutions refer to nature of processes of development, codification, communication and enforcement. Formal institutions are linked to the official channels of governmental bureaucracies. They have legally binding documents which stipulate their duty and rules of engagement. Correspondingly the duties can be enforced by legal procedures. Informal institutions refer to socially shared rules such as social or cultural norms which are not supported by any legally binding document. They are enforced outside of legally sanctioned channels. In Figure 2-10 Berman et al. (2012) explains that a community with a strong institutional system (skills, resources and experience) will be well placed to adapt to the impacts of flooding as compared to a community with weak institutions where the adaptive capacity

must be built from scratch. Since governance and institutions are critical variables that affect adaptive capacity, it makes adaptive capacity a property that human beings can shape and manipulate whether it is looked at within the vulnerability framework or resilience framework (Engle, 2011).

Instead of transforming coping capacities into adaptive capacity to aid adaptations, an institution can sometimes serve as a barrier to adaptation. Adaptation barriers are defined as ‘obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc’ (Moser and Ekstrom, 2010). Also, Adger et al. (2009) defined adaptation barrier as “the point at which an actor's objectives or system's needs cannot be secured from intolerable risks through adaptive actions”. These barriers are either due to the lack of vertical coordination or the lack of horizontal coordination within an institutional set up. Vertical coordination is the collaboration that exists between national level, municipal level and local level. The lack of coordination between policy makers at the top and the implementers at the local level makes adaptive measures sometimes end up as maladaptation. Horizontal coordination is the cooperation between organizations – formal and informal, public and private, and civil organizations. For example, Brown et al. (2010) assessed the perception of decision-makers and how state institutions, the private sector and civil societies respond to the complex challenges of climate change in the Congo Basin forest of Cameroon. They concluded that Cameroon has low adaptive capacity that is further constrained by weak linkages among government institutions and between different levels of government and with communities. Also, they suggested that civil society institutions play a role in enhancing government capacity to respond, particularly in relation to new international policies on climate change and forests.

It is the responsibility of formal institutional bodies to allocate resources, define the roles of stakeholders, enable actions and mediating trade-offs (Cook et al., 2010). However there are also informal interactions between stakeholders that play an important role in climate change adaptation (Berman et al., 2012)

because the interactions foster the collective action necessary for adaptation (Mubaya and Mafongoya, 2017). For an institution not to act as a barrier to adaptation, there needs to be greater cooperation amongst organizations within and across scales in order for knowledge exchange to be effective (Popp et al., 2014). This is the main idea behind bringing organizations. Bridging organizations have been described by Berkes (2009) as an organization put in charge specifically to enhance collaboration and knowledge exchange among organizations involved in the adaptation process. Westley & Vredenburg (1991), in the context of trying to achieve trust-based collaborative relationships amongst environmental response stakeholders involved in environmental response, said that a bridging organization needed to be a separate organisation from the already established stakeholder groups. However, Brown (1993) argues that bridging organizations are of “different shapes and sizes, varying in their degree of formalization, scope, and the number and diversity of stakeholders” hence the focus should be on the task of enhancing cooperation. The formation of another organization to enhance cooperation and improve learning among various organizations could serve as a barrier to adaptation especially in developing countries where the roles of organizations are poorly defined. Therefore, the role of bridging organizations has been played in most developing countries by NGOs. They do this through social learning groups like learning alliances and action alliances, socially embedded institutions, communities of practice, learning platforms or arenas and learning networks for sustainable development. For example, in Ghana the Ghana WASH Resource Centre Network (RCN) is the host of the National Level Learning Alliance Platform (NLLAP). This brings together different WASH stakeholder groups (NGOs, research institutions and ministries) with the aim of improving sector learning and dialogue to deliver quality and sustainable services in Ghana (Resource Centre Network, 2017). For stakeholders to coordinate and exchange knowledge, Azhoni et al. (2017) suggest that adaptation strategies in developing countries need to be designed in a way to benefit all organizations involved. This co-benefit will serve as a motivational factor in making all

organizations work together for the effective realisation of the adaptation process.

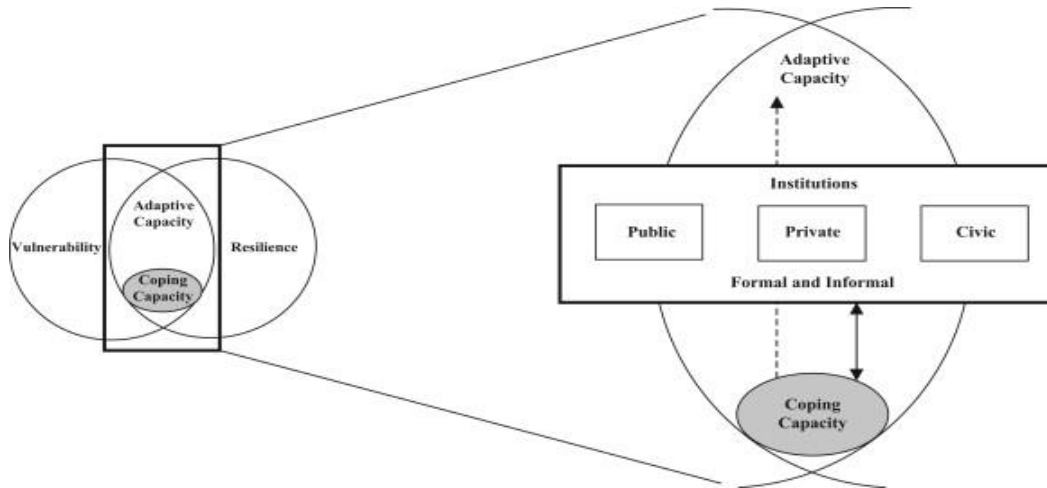


Figure 2-10 Framework on how coping capacity can be transformed into adaptive capacity (Berman et al., 2012).

2.6 How RCAA fits in the literature backdrop

Climate change impacts and vulnerability assessment depend on available time, situation on the grounds, region or place of assessment and purpose of assessment (IPCC, 2001). This has led to development of a lot of methodologies. Most of these methodologies are sector specific, region specific, spatial specific or purpose specific. Having discussed the three main literature scholarships in the climate change adaptation discourse, this section will look at various tools or methodologies that have been applied and how the RCAA fits into the literature discussed. The RCAA methodology “assesses how changes to climate interact with existing vulnerabilities in peri-urban and informal areas and then assesses how to adapt the existing plans of water providers to increase their climate resilience” (Heath et al., 2012). The description of this methodology has enshrined in it the broader concepts of vulnerability and resilience. This methodology has five basic steps: literature review; to identify the impact of climate change; fieldwork, to assess the existing vulnerabilities of communities and water providers; preparation of hydrological scenarios,

assessment of the impact of these scenarios on the community; and identification, selection and recommendation of adaptations for climate proofing water and sanitation services (Heath et al., 2012).

This methodology was developed from the IPCC assessment of vulnerability as an end-point. As already defined in previous sections, the end-point vulnerability methodology begins with projections of future emission trends, moving on to the development of climate scenarios and concluding with biophysical impact studies and the identification of adaptive options” (IPCC, 2014, 2007, 2001). This is however the first-generation impact assessments. This method was a top-down approach. Since the top-down approach often did not reflect the needs of the local people, researchers searched for methods which reflected the actual situation on the ground. The bottom-up approach of adaptation assessment was then conceptualized. As recounted by van Aalst et al. (2008), the bottom-up approach was first articulated by Feenstra et al. (1998) in the UNEP Guidelines but was fully captured in Lim et al. (2005). Unlike the first generation top-down approach, the bottom-up assessment involves local stakeholders and the assessment of vulnerability to current climate variability and extremes, as well as the current adaptation strategies, policies and measures. This assessment is based on the actual experience across different spatial scales. This assessment process is also based on empirical evidence and not theoretical (van Aalst et al., 2008).

This Adaptation Policy Framework (APF) described above has been applied across the globe in various projects and in development of various methodology and tools. This methodology has been modified and applied by various organizations (like World Bank 2005, GIZ 2008 and OECD 2009). Narrowing down to the water and sanitation sector, the APF has been adapted in various ways to develop methodologies for assessing the impacts of climate change on WASH. The RCAA is closely related to methodologies like DfID WHO vision 2030 (Howard et al., 2010), CRiSTAL (International Institute Sustainable Development, 2012) and USAID methodologies (USAID, 2007). Doczi (2014) reviewed 137 “tools” and categorized RCAA as a tool that “supports practical

program-level decisions on planned adaptation interventions specifically for the water sector”.

2.7 Gaps and opportunities

The purpose of this chapter was to bring more clarity into the climate change adaptation discourse by reviewing frameworks, looking at relationships between them and demarcating boundaries between the three major scholarships. Though frameworks used in resilience were not discussed, their positions in the climate change adaptation discourse were articulated. For vulnerability to be lessened, a system needs adaptive capacity to achieve resilience. This adaptive capacity is in a continuum and can be present even in a vulnerable system and may be referred to as coping capacity in such a system. Coping capacity ensures that a system responds to an occurrence of harm to avoid its potential impacts. Once a disaster occurs then the coping capacity, if any existed, is drawn on to develop the adaptability of the system and make it resilient.

Most literature on how institutions serve as barriers to adaptations are about developed countries and most of this literature presents an institution as a rigid system that needs to be “opened-up”. However, the complexity of institutions in developing countries presents a different type of situation. Though Barry Smit & Wandel (2006) perceived adaptive capacity to be context-specific and vary from country to country, community to community, between social groups and individuals, and over time, Dodman and Mitlin (2013) argue that the variation is actually due to differences in political structures, culture and power since they eventually affect adaptations. Exactly how an institution in a developing country is affected by stakeholder politics, power and culture is a growing body of literature that this research seeks to contribute to. In line with this thinking, this research will look at how stakeholder politics, economics and power affect the ability of stakeholders to implement adaptation policies across various ecological zones in a low income sub-Saharan country, Ghana. It will also look at ways of enhancing adaptive capacity of the urban WASH institution since the enhancement of adaptive capacity will reduce vulnerabilities and promote sustainable development (Smit et al., 2000).

3 METHODOLOGY

The main aim of this research is to investigate how to climate proof urban water and sanitation services to achieve resilience. Two different methodologies were applied to ensure that the specific objectives as mentioned in section 1.4 of this research were achieved. The RCAA methodology was applied to achieve specific objectives one and two and the results are captured in Chapter four and Chapter five. Adaptive capacity wheel was also applied to achieve specific objective three and the results are captured in Chapter six. Table 3-1 shows the methodological processes that led to the achievement of the specific objectives by highlighting the key questions asked, the type of data collected and the number of respondents.

Table 3-1 Methodological processes

| Methodology | Processes | Specific Objective | Key questions | Data source and method | Interviewees |
|---|----------------------------------|--------------------|--|--|--------------|
| Rapid Climate Adaptation Assessment (RCAA) | Literature review | 1 | What are the climate predictions for Ghana? | Key climate literature | 96 |
| | Vulnerability assessment | 1 | How, what and who is vulnerable? | Interviews, FGD and observations in 6 communities. | |
| | Hydrology scenario development | 1 | What are the probable scenarios? | Climate projections and fieldwork testing. | |
| | Impact assessment | 1 | What are the direct and indirect impacts? | Interviews, FGD, observations and vision 2030 technical report | |
| | Climate proofing recommendations | 2 | How can WASH services be resilient? | Interviews, FGD and vision 2030 technical report. | |
| Adaptive Capacity Wheel (ACW) | Adaptive capacity assessment | 3 | How do stakeholder politics, resource distribution and power affect their adaptive capacity? | Interviews- Adaptive Capacity Wheel (Grothmann et al., 2013) | 15 |

3.1 RCAA methodology

This section explains the methodological processes followed to arrive at the results in Chapter four and chapter five. It starts by providing an overview of the research approach and a rationale for the research design. This is followed by a description of the research design, data collection methods and data analysis approach. The section ends with a discussion of the quality assurance measures employed to ensure this qualitative research is trustworthy.

3.1.1 Research approach

Building on studies into the socio- economic and biophysical aspects of vulnerability, the research sought to understand the perspectives and experiences of people directly or indirectly involved in the urban WASH service provision and how they interpreted climate change. This is important because how they interpret climate change and its impacts on their daily management processes is important for achieving resilience of their services. Therefore, a qualitative research approach was employed to assess the impacts of climate change on urban WASH services. Qualitative research is defined by Denzin and Lincoln (2000) as “a situated activity that locates the observer in the world and consists of a set of interpretive, material practices that makes the world visible”. It helps “understand the meaning of social phenomena and focus on links among a larger number of attributes across relatively few cases” (Tuli, 2010). The complexity of the vulnerabilities of the urban WASH services and the multiple socio-economic and biophysical interactions necessitated an approach that would explore and develop an in-depth understanding of the situation. This complexity makes formulation and testing of specific hypothesis which characterises quantitative approach highly unlikely. Therefore, this qualitative approach was employed to understand the meaning people attach to their climate change experiences and how it impacts their WASH services in an urban poor community setting.

3.1.2 Research design

This section explains the rationale for the application of the RCAA methodology as well as explaining the various steps in the RCAA methodology. The scope of the

research and the reasons for selecting the communities and cities were also outlined in this section.

3.1.2.1 Rationale for RCAA

As explained in the previous section 2.2.2, there are a lot of specific methodologies that focuses on assessing the vulnerabilities of urban WASH services. Most famous amongst these methodologies are the CRiSTAL methodology (International Institute Sustainable Development, 2012), the USAID methodology (USAID, 2007) and DfID WHO Vision 2030 review (Howard et al., 2010). However, the CRiSTAL methodology and the USAID methodologies looks more at community resilience and not specifically WASH resilience whiles the WHO Vision 2030 review lacks systematic information on how the methodology can be applied by other researchers to assess vulnerability. Therefore to assess the impacts of climate variability on urban WASH services in Ghana, the Rapid Climate Adaptation Assessment (RCAA) methodology developed by Heath et al. (2012) was found most appropriate. This is a rapid methodology which makes researchers assess climate vulnerability and helps stakeholders to come up with ways of climate proofing water and sanitation services (Doczi, 2014). This methodology “assesses how changes to climate interact with existing vulnerabilities in peri-urban and informal areas and then assesses how to adapt the existing plans of water providers to increase their climate resilience” (Heath et al., 2012). This method was specifically designed for WASH services and it incorporates the bottom-up approach of dealing with climate vulnerability as well as making the community a major stakeholder. RCAA is not new to the African continent as it has been tested in urban poor communities in four different African countries (Zambia, Kenya, Madagascar, Mozambique) and hence its adoption in this research. The RCAA has 5 steps which lead to recommendation on how to climate proof WASH services as shown in Figure 3-1 below. Each stage is explained.

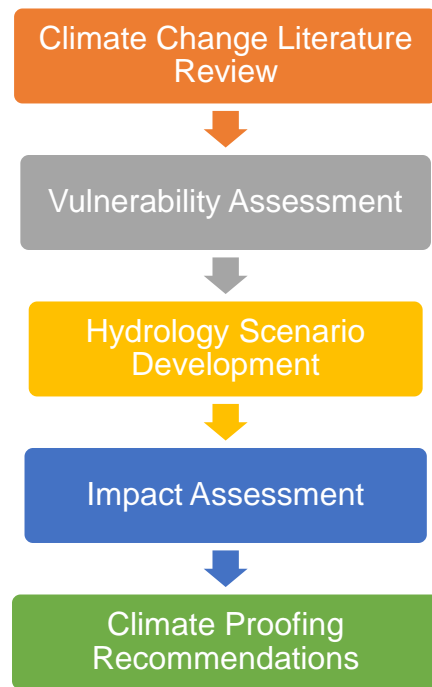


Figure 3-1 RCAA methodology

Stage 1 was called literature review in the RCAA but was adopted in this research as climate change literature to avoid confusing it with the literature review in Chapter two of this thesis. The purpose of this section was to understand how climate issues are handled in Ghana. This involves what the policies are, who is in charge and how things are documented to work. Ghana specific climate change literature were reviewed to understand the climate predictions for Ghana and how it impacts water, health, livelihoods and biodiversity, as their change also affects the population's access to WASH services. Ghana specific resources used included the National Climate Change Adaptation Strategy (NCCAS), UNDP climate change country profiles, first & second national communications to United Nations Framework Convention on Climate Change (UNFCCC). This review was made into a climate brief (as shown in the Appendix) which was used as an exercise book and given to interviewees.

In applying the climate change adaptation understanding to the WASH sector, as the RCAA sought to do, vulnerability was approached as an integrated vulnerability which comprises of the coupled human environment and the socio-economic component of the WASH sector. This includes assessing the potential vulnerability of the WASH service providers, all stakeholders, the management practices and the

technologies in use. The RCAA looks at vulnerability not only as that which remains after impacts and adaptation but also what remains is shaped by ongoing social and environmental problems.

Hydrological scenarios which forecast the future climate variability of the study areas were then developed in stage 3. The rapid nature of this research coupled with the wide window intended for adaptation plans did not allow for exact modelling of the hydrological scenario but rather a development of scenario based on the climate predictions. The scenarios are not quantitative but rather more generalised rather than specific due to the lack of localised quantitative data. The developed conceptual hydrological models were based on the experience of people within the community during the vulnerability assessment. These experiences were conjugated with the climate predictions for Ghana to arrive at the hydrological scenarios.

From the vulnerability assessment, the risk to WASH services was understood. In stage 4, these risks were used as the baseline and the climate scenarios were superimposed on them. How the different hydrological scenarios impacted on the biophysical and social components of the water system were assessed.

To ensure that the urban WASH service in Ghana is resilient to climate variability and change, a set of recommended adaptations were developed for WASH service stakeholders. At the vulnerability assessment stage, stakeholders were made to suggest adaptations during interviews and focus group discussions. These suggestions were reviewed together with the Vision 2030 technology fact sheets by Charles et al. (2010). This report was developed by World Health Organization to highlight “interventions that can be made to reduce the vulnerability of drinking-water supply and sanitation facilities to climate change” (Charles et al., 2010). These recommendations are developed to alter practices, processes and structures to contain potential damages or to take advantage of the opportunities presented by the climate change (Watson et al., 1996). The recommendations were categorized for each stakeholder since effective adaptation is not the work of only the central government but rather a collaborative effort between all stakeholders and they also encouraged the various stakeholders to apply a wide range of familiar principles for effective adaptation (UNDP, 2004)

3.1.2.2 Scale of analysis

In designing this research, the scale of analysis considered was that of an urban poor community WASH delivery system. This scale is at the community level in an urban poor setting. It is characterised by a public and private service provider providing WASH services to a densely populated community. The types of services they render are mostly pay per use and do not involve monthly bills to their customers. There are a lot of informal as well as formal rules in this system. The informal rules come into play when providers are dealing with their customers and their management practices. The formal rules are what exist between the various actors or stakeholders.

Though the scale of analysis is at the community WASH service delivery level, the services provided at the local level are not in isolation. Whatever transpires at the local service is influenced by the bigger scale of all the stakeholders. For example, the water service providers get their water from the GWCL and therefore anything that hinders the service provision of the GWCL will also affect that of the urban community service provider. Because of this interrelationship, though the scale of analysis is the community level, various stakeholders across various scales were considered in this research. Figure 3-2 shows the representation of the various levels that were assessed to understand the scale of the analysis. To climate proof the WASH services in urban poor communities, the scale of analysis employed was the community WASH delivery system.

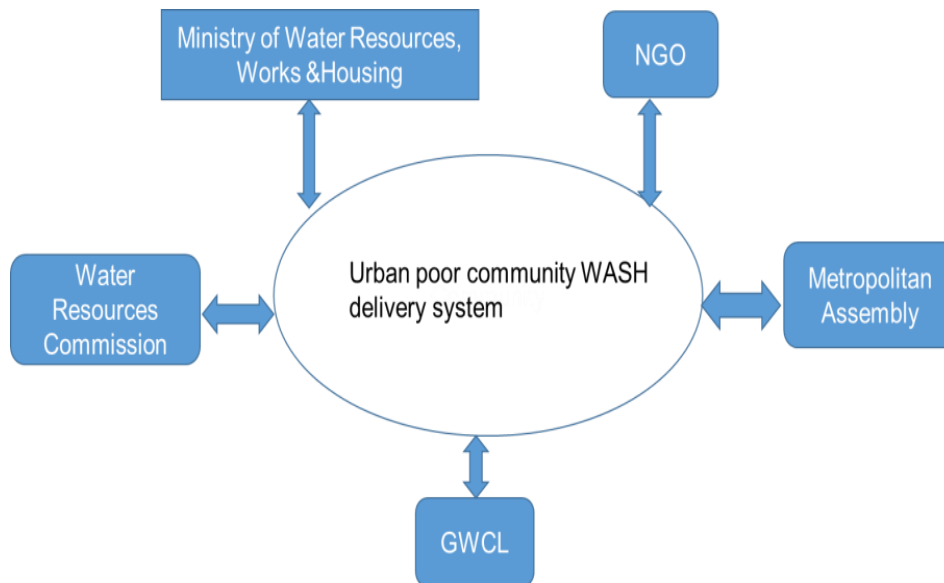


Figure 3-2 Scale of analysis

3.1.2.3 Selection of cities

The study was conducted in six urban poor communities; two communities each in Accra, Kumasi and Tamale. The six ecological zones in Ghana were divided into three sections; northern, central and southern, and a city was selected from each of the three sections. Tamale was selected from the northern half, Kumasi from the central half and Accra from the southern half. Also, these cities are located within different ecological zones. These ecological zones have been “delineated based primarily on annual total rainfall and major natural vegetation types” (Minia, 2008). These three sites were chosen because they are the three most populated urban cities in Ghana and within different ecological zones as well. Infrastructural developments in these cities are unable to match up with the population increase due to migrants from rural areas (Owusu and Oteng-Ababio, 2015). Statistics about the various cities (municipalities) are shown in Table 3-2. The table collated from (Ghana Statistical Service, 2014a, 2014b, 2014c) highlights the population, size of the municipality, climate conditions as well as the water and sanitation situation.

Table 3-2 Statistical information about cities under study

| | Accra Metropolitan Assembly | Kumasi Metropolitan Assembly | Tamale Metropolitan Assembly |
|--|-----------------------------|------------------------------|------------------------------|
| Population (2012) | 1,665,086 | 1,730,249 | 223,252 |
| Area (kilometre square) | 139.67 | 214.3 | 646.9 |
| Annual average rainfall (mm) | 809 | 1448 | 1111 |
| Annual average temperature (°C) | 26.6 | 26.3 | 27.9 |
| Main source of drinking water | (%) | (%) | (%) |
| Pipe inside dwellings | 31.8 | 42.8 | 39.9 |
| Pipe outside dwelling | 28.4 | 23.7 | 41.4 |
| Standpipe | 9.1 | 7.6 | 5 |
| Boreholes/tube wells | 0.3 | 12.6 | 2 |
| Protected well | 0.2 | 6.4 | 1 |
| Toilet facility used by household | (%) | (%) | (%) |
| no facility | 2.5 | 2.4 | 34.1 |
| WC | 33 | 42.5 | 10.1 |
| Pit latrine | 4.3 | 11.1 | 1.7 |
| KVIP | 13.8 | 7.2 | 7 |
| Public toilets | 41.9 | 36.2 | 44.8 |
| Others | 0.5 | 0.4 | 0.8 |
| Solid waste | (%) | (%) | (%) |
| Collected | 59.4 | 17.2 | 41.7 |
| Burned by household | 2.7 | 4.4 | 8.2 |
| Public container | 31.2 | 58.8 | 59.1 |
| Public (open space) | 4.7 | 15.6 | 14.9 |
| Indiscriminately | 1.1 | 1.9 | 10.4 |
| Burried | 0.3 | 1.6 | 2.2 |
| Others | 0.7 | 0.4 | 0.5 |
| Liquid waste | (%) | (%) | (%) |
| Through sewerage system | 8.2 | 5.3 | 1.7 |
| Drains into a gutter | 26.9 | 35.5 | 17.4 |
| Drains into a Pit | 4 | 3.5 | 3.6 |
| Thrown into street | 6.6 | 7.8 | 43.2 |
| Thrown into gutter | 47.1 | 32.2 | 21.2 |
| Thrown unto compound | 6.7 | 15.4 | 12.5 |
| Others | 0.5 | 0.3 | 0.3 |

3.1.2.4 Selection of communities

In each of the three urban cities, communities that matched a set of criteria specified below were sampled and two were chosen in consultation with their respective municipalities. The ease at which communities could be mobilised played a key role in the selection of the two communities selected from the water pool of communities that could have been chosen. Also, the communities were chosen based on the

experience of the municipality and the fieldwork partners (WSUP) have in working with such communities. The criteria for the selection of the communities were:

- Poor urban community-low income populations, limited access to potable water and limited access to sanitation facilities.
- Water vendors selling water to people who are not connected to the city's water grid.
- Toilet operators operating the public toilets that serve people without toilet facilities in their homes or compound.
- Vulnerable to either or a combination of flood, sea level rise or drought

The six selected for this research were Glefe and Jamestown in Accra, Kotei and Adukrom in Kumasi and Gumbihini and Nyohini in Tamale. The selected communities and the cities where they were chosen from are showed in the maps below in Figure 3-3, Figure 3-4 and Figure 3-5 .

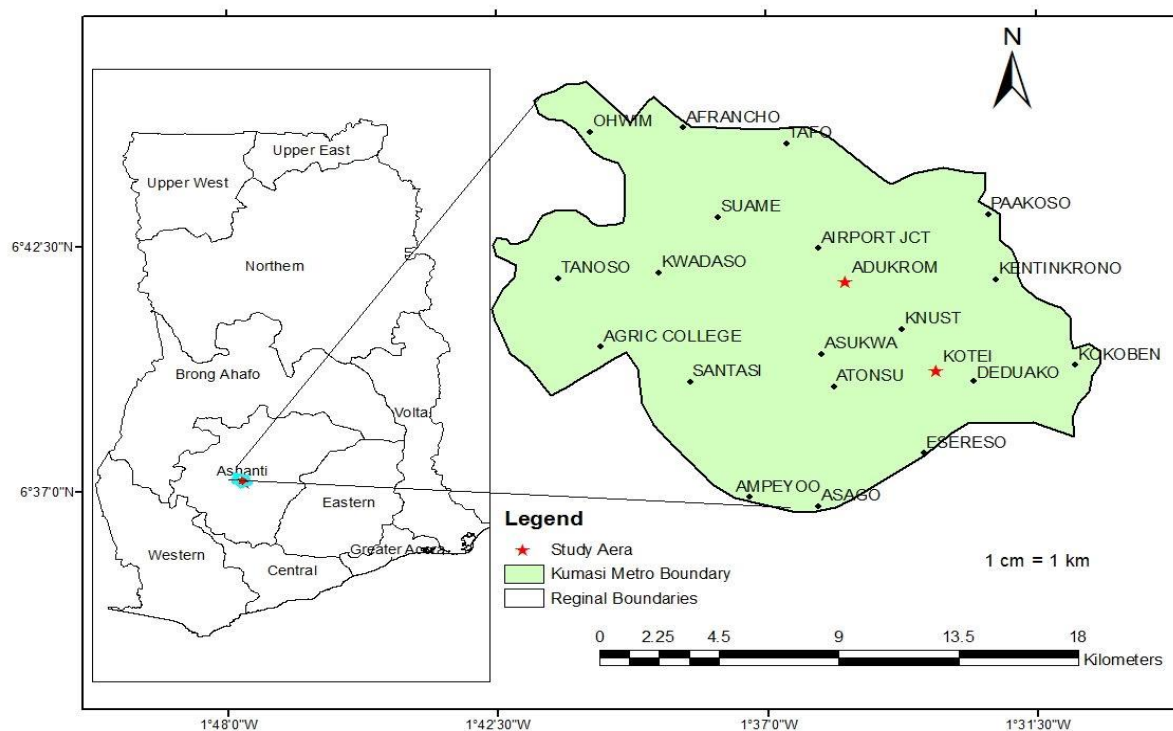


Figure 3-3 Map of Kumasi showing study sites (generated from ArcGIS 2013)

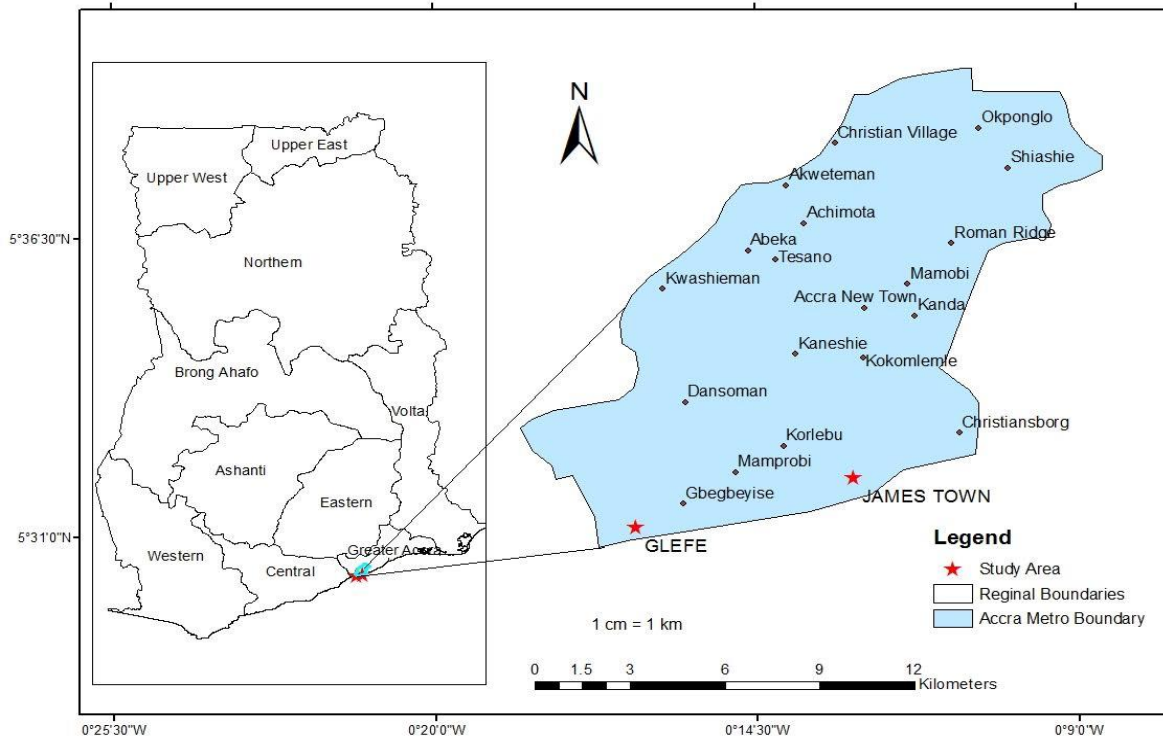


Figure 3-4 Map of Accra showing study sites (generated from ArcGIS 2013)

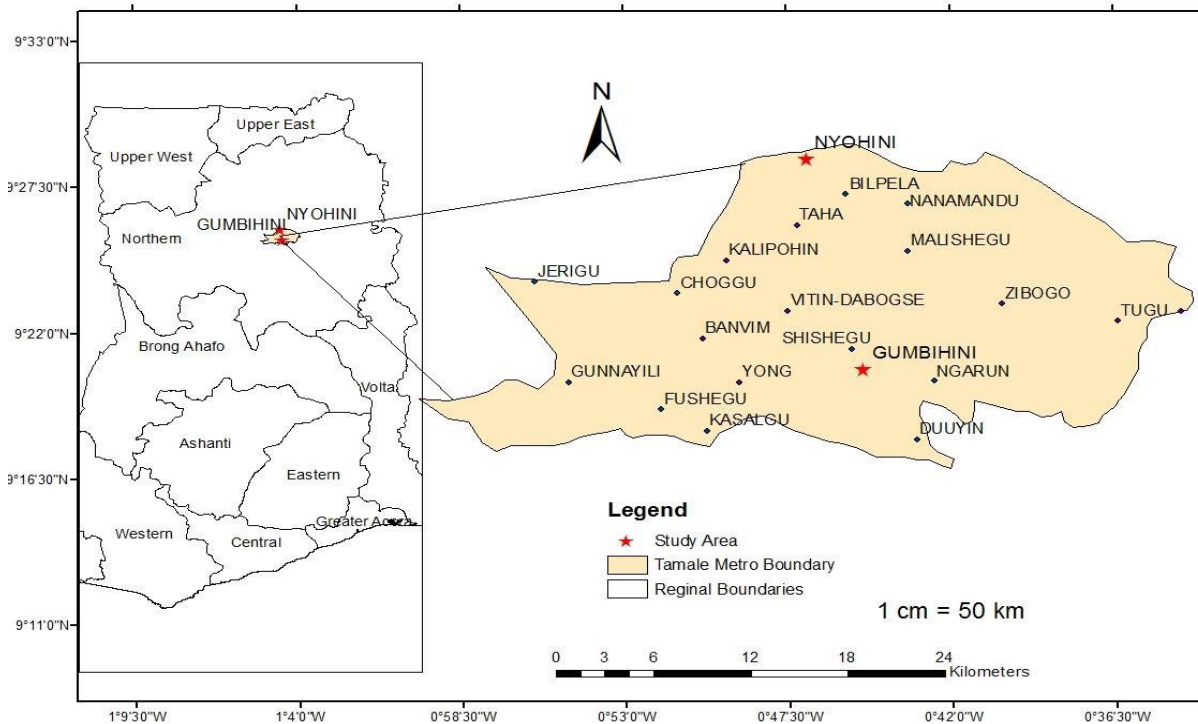


Figure 3-5 Map of Tamale showing study sites (generated from ArcGIS 2013)

3.1.3 Data collection

Three types of data collection techniques were employed during the fieldwork. These techniques ensured that important data was collected to enable the assessment of vulnerability, impacts and to develop recommendations to make water services climate proof. They were in-depth interview, focus group discussion and direct observation.

3.1.3.1 In- depth interview

96 people were interviewed to achieve the first and second objectives of this research. The interviews took place from December 2016 to January 2017 in Kumasi and from June 2017 to August 2017 in Accra, Tamale and Kumasi (for a week). Interviews were conducted with the community leaders, local service providers, Ghana Water Company Limited (GWCL), metropolitan planning officer, meteorological service department, ministries, researchers and NGOs. The number of stakeholders interviewed and the agencies they belong to are shown in Table 3-3. The interviews at the community level lasted for 20 minutes on the average and 35 minutes on the average for the other stakeholders. This provided “an opportunity for detailed investigation of each person's personal perspective, for in-depth understanding of the personal context within which the research phenomenon is located, and for very detailed subject coverage” (Ritchie et al., 2013).

Table 3-3 Interviewed stakeholders for RCAA

| Type | Organisation | | Number of Interviewees |
|-----------------------------|--|-----------------------------|------------------------|
| Government | Environmental Protection Agency | Agency (MESTI) | 1 |
| | Hydrological Services Department | Works agency | 1 |
| | Meteorological Services Department (Accra, Kumasi Tamale) | | 3 |
| | Ministry of Environment Science, Technology and Innovation (MESTI) | Ministry | 1 |
| | Ministry of Local government | Ministry | 1 |
| | Water Directorate(WD) | Water sector agency | 1 |
| International Organisations | AFD | French development agency | 1 |
| | GIZ | German development agency | 1 |
| | KFW | Development Bank | 1 |
| | The World Bank | IFI | 1 |
| | UNDP | UN agency | 1 |
| | UNICEF | UN agency | 1 |
| | USAID | American development agency | 1 |
| NGO | Global Communities | Int. NGO | 1 |
| | IRC | Int. NGO | 1 |
| | Water Aid | Int. NGO | 1 |
| | WSUP | Int. NGO | 2 |
| Private sector | GWCL | Urban water utility | 2 |
| | Zoom Lion | Waste utility | 1 |
| Academia | Regional Institute For Population Studies | University Institute | 2 |
| | IWMI | Research Institution | 1 |
| Community | Adukrom | Service providers | 7 |
| | | community leaders | 2 |
| | Kotei | Service providers | 10 |
| | | community leaders | 0 |
| | Nyohini | Service providers | 5 |
| | | community leaders | 1 |
| | Gumbihini | Service providers | 4 |
| | | community leaders | 1 |
| | Glefe | Service providers | 24 |
| | | community leaders | 0 |
| Jamestown | Service providers | 15 | |
| | community leaders | 1 | |
| Total | | | 96 |

Different types of semi-structured interview were administered to various stakeholders depending on their technical expertise. This allowed for dynamism in wording of questions as well as probes (Hutchinson and Wilson, 1992). Probes allowed for clarification of interesting and important issues raised by interviewees (Hutchinson and Wilson, 1992). During interviews, probes were used to explore and clarify any inconsistencies in the responses of the interviewees. These semi-structured interview schedules for the various stakeholder groups (attached in Appendix) were adopted as part of the methodology and modified to suit the local conditions. The interview topics discussed included the following.

Current Situation

WASH service providers were asked about general information concerning their facilities. The information included source of water, type of toilets, reliability of their facilities and any problems that prevents them from offering quality services to their customers. Service providers were also asked of their maintenance plans and whether they encountered specific problems in each season of the year.

Vulnerability of community

Interviewees were made to think of what they considered the community as a whole to be most vulnerable to. They were made to recall any experiences in the past with respect to how floods/drought/sea level rise affected their community.

Climate Change Awareness

Interviewees were asked to discuss what they deemed as climate change and whether they are observing a changing climate. They were asked whether they think it will affect their service provision and what measures they have put in place to ensure good service provision.

Climate change impacts

WASH service providers were asked what they thought would be the impact of floods/droughts/sea-level rise on their facilities. They were made to think of all the various processes the water goes through before getting to them. This included the

water sources (groundwater and freshwater), the distribution and supply networks and the management systems involved.

Adaptations

Interviewees were then made to suggest ways they deemed appropriate in addressing the impacts discussed earlier. They were asked to suggest technical, social and maintenance solutions to help them adapt their facilities to climate extremes. They were also asked of people or agencies they considered responsible for addressing their concerns.

3.1.3.1.1 Selection of individuals for Interviews

To understand climate change vulnerability on the urban poor WASH services, various WASH stakeholders were purposively sampled across different spatial scales. WASH stakeholders were purposely selected for interviews. Within each of the 6 communities, the traditional leader, youth group leader and female group leader if available were selected to understand the WASH problems in the community. Service providers (water vendors, toilet operators and bath stall operators) were also interviewed to know their problems and experiences on dealing with extreme events. These WASH services were selected to represent new and old facilities as well privately owned and publicly owned. Within the communities, all the WASH service providers were interviewed. Because of the variation in source, type of storage and treatment processes, saturation was not achieved before the whole population of WASH service providers were interviewed. The key below

Table 3-4 shows what purpose each selected stakeholder played in the interviews.

Table 3-4 Stakeholders and their purpose for the research

| STAKEHOLDERS | PURPOSES | | | | | |
|---|----------|---|---|---|---|---|
| | 1* | 2 | 3 | 4 | 5 | 6 |
| Traditional/Religious Leaders | ✓ | | | | | ✓ |
| Youth Leader | ✓ | | | | | ✓ |
| Female Group Leader | ✓ | | | | | ✓ |
| Service Providers; Water Vendors, Bath Stall and Toilet Operators | | ✓ | ✓ | | | ✓ |
| Ghana Water Company Limited zonal manager | | ✓ | ✓ | | | ✓ |
| Metropolitan Planning Officer | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Representative from Ministry of Water Resources, Works and Housing. | | | | ✓ | ✓ | ✓ |
| Representative from Ministry of Environment, Science, Technology and Innovation | | | | ✓ | ✓ | ✓ |
| NGOs | ✓ | | | | ✓ | ✓ |
| Researchers | | | | ✓ | ✓ | ✓ |

***Key for Table above**

1. To have a better insight into the WASH problems in the community.
2. To know the problems and experiences in dealing with extreme events.
3. To know at the local level, the impacts of climate change on WASH services and adaptation measures.
4. To understand what is being done on climate change (with reference to WASH) at the national level e.g. policies, frameworks etc.

5. To give insights into what has been going on to climate proof WASH services.
6. Adaptive Capacity.

3.1.3.2 Focus group discussion

Focus group discussions were planned for about 8-10 water consumers, but more people were anticipated due to the experience of Heath et al. (2012) during the development and testing of the RCAA methodology. However not more than 16 people were allowed in one discussion group as it would have been difficult to moderate and coordinate. The groups were made to discuss occurrence, frequency, duration and preparations towards extreme events in their communities. The impacts on their day to day activities were also discussed. This was then followed by a discussion of adaptations and stakeholder (local government, CSOs and NGOs) responsibilities. Women are most affected by the impacts of climate change (Singh & Singh, 2015) therefore at the focus group discussions women were encouraged to express themselves. It was only after this persuasion that the women started contributing to the discussion especially in focus group discussions in Tamale. Participants were made to discuss the following topics.

- Background

Here participants were made to recall their experiences in dealing with climate extremes. They were asked about the frequency and duration of the climate extreme events in their communities.

- Climate Change Awareness

Participants were asked to discuss what they deemed as climate change and whether they are observing a changing climate. They were made to recall lengths of season as the bases for realizing the change.

- Climate change impacts

The impacts discussed were both direct and indirect. The indirect impacts are how they think climate variability will affect infrastructure, food, people in the community and livelihood which indirectly affects water and sanitation services. The direct

impacts were what they thought would impact water supply sources (groundwater and freshwater), water supply and toilet facilities.

- Adaptations

Participants were then made to suggest ways they deemed appropriate in addressing the impacts discussed earlier. They were also asked of people or agencies they considered responsible for addressing their concerns.

3.1.3.2.1 Selection of individuals for focus group discussion

The participants of the focus group discussion were drawn from within the community. This averaged about 8-12 people that included the assembly man (political head of the community), representatives from the local traditional authority, the unit committee members and female group representatives. The sampling ensured that women represented over 25% of the participants.

3.1.3.3 Observation

The general conditions of WASH services were directly observed. Critical attention was paid to conditions of drains, flood marks on buildings and general hygiene practices during an observational walk through the community. Conditions of drains, water storage facilities, latrines, flood marks and other flood indicators were noted during the observational walk. The details were captured in a field notebook (Berg and Lune, 2012; Bryman, 2012). The purpose of this observation was not to sample households from the community but rather to observe the conditions of the WASH facilities. This helped in describing the community during the write up. Also, information given during interviews was verified during the direct observation walks within the communities.

3.1.4 Data analysis

The data collected from the field was organized by thematic analysis (Boyatzis, 1998; Braun and Clarke, 2006; Joffe, 2012). Thematic analysis is defined by Braun and Clarke (2013) as “a method for identifying, analysing and reporting patterns within data.” This type of analysis was employed because of its flexibility (Braun and

Clarke, 2006) and ability to generate rich and detailed account of data. A priori themes-which are the patterns expected from the adopted interview schedules (as shown in Table 3-5), were set before the field visits. The a priori themes were set to represent the service providers, management practices and the technologies involved, which forms the social and biophysical components of the WASH service provision. Verbatim transcription of the interviews was not done as Halcomb and Davidson (2006) recommends listening and coding as an appropriate technique to identify common ideas. Data from the Focus Group discussion were not coded in-depth but rather key issues were identified by listening to the audio files.

Rather than generate verbatim transcriptions for interviews, audio files were uploaded into NVivo™ 10 software. This data management software was used to store and manage the data. Recorded interview audio files were uploaded and labelled with coded names, and descriptions from field notes for easy referencing and identification and in line with confidentiality of participants. This made it easier to analyse the information. The data-sets were analysed for running themes by creating nodes in the software and assigning them to the audio length and the corresponding sentences or phrases are then typed in the software. The emerging themes which were coded were deduced from the data and examples are shown in Table 3-6 and more are in the appendix. Once the indexing was done, a thematic matrix was generated for each theme. This matrix showed each theme and words, phrases or sentences (text) that constitutes that theme. The matrix also showed the respondents whom the themes were generated from and how many times it came out in the text. Finally a One Sheet Of Paper (OSOP) analysis (Ziebland and McPherson, 2006) as shown in Figure 3-6 was used to develop themes into ideas. This is like a mind map and it gives a clear picture of how sub themes relate with major themes. Mapping of the themes was done on the OSOP and this made interpretation easier. Observations and the notes from field work were incorporated into writing chapters.

Table 3-5 Link between objectives, questions and themes

| Objectives | Questions | A Priori Themes |
|--|--|---|
| <p>To assess and compare across ecological zones, the impacts of climate extreme events (drought or flood) on urban WASH services.</p> | <p>When was the last flood/drought, how long did it last/what was the extent? Are you affected by: flooding/high ground water levels/heavy rainfall/runoff/ droughts/ low ground water? How did it impact the community? Livelihoods/health/business How did it impact your system? Water supply/quality Kiosks Demand Pipes Sanitation What support did you get and from which organization? What would be the impact of flooding/high ground water levels/heavy rainfall/runoff/ droughts/ low ground water? Supply, kiosks, demand, pipes and sanitation. How are your operational costs likely to change?</p> | <p>Duration experience Indirect impacts Effect on distribution Effect on Supply Effect on management Past support Operational cost Effect on distribution Effect on Supply management</p> |
| <p>To identify, discuss and recommend workable adaptations to climate proof WASH services in Ghana</p> | <p>What maintenance are you currently undertaking Extent of problems Availability of spares Number of days spent dealing with problem/number of staff Future (variability/Climate change) How do you adapt? Technical solutions Social solutions Maintenance What would solve the problems/ what adaptations do you suggest? Who will you seek help from and why? How could the utility/council/government help you adapt</p> | <p>Resources Technical adaptation Social adaptation Duty Role of stakeholder</p> |

Table 3-6 Examples of analytical themes

| Theme | Example of quotes |
|------------------------|---|
| Affiliation | <i>I have heard of an association but I don't know what they do</i> |
| Cleaning | <i>The floor tiles get dirty a lot during the rainy season hence there is frequent cleaning</i> |
| Dust | <i>During the dry season, the dust is too much"</i> |
| Effect on demand | <i>During the raining season my sales decreases because people harvest rain</i> |
| Effect on distribution | <i>My borehole is deep hence won't be affected by flooding</i> |
| Electricity | <i>We don't get water when there is 'lights out' but when there is light, water flows.</i> |
| Flushing | <i>People (customers) don't flush after use</i> |
| Maintenance | <i>We do maintenance as and when it comes</i> |
| Perceptions | <i>If we don't take care of our environment properly, definitely it will have an effect on us</i> |
| Quality | <i>I treat water every 4 months but I have forgotten the name of the chemical I use</i> |
| Source of water | <i>Drilled for domestic use but got extended for commercial purposes</i> |
| Uses | <i>People stand on the pot and it damaged the pots not long after they were installed</i> |

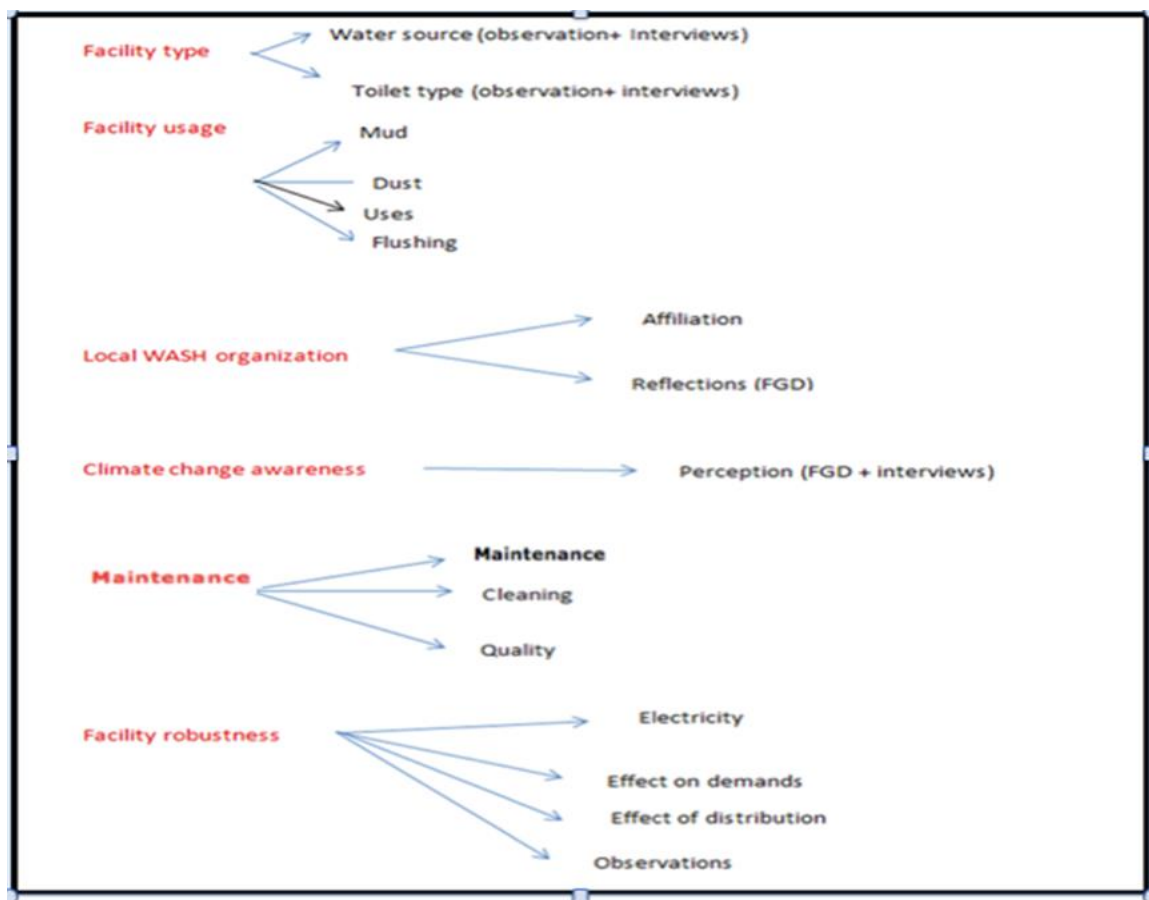


Figure 3-6 One Sheet Of Paper (OSOP) analysis

3.1.5 Quality assurance for qualitative data

3.1.5.1 Data triangulation

To verify the information gathered, probes, observations and focus group discussions were employed. Observations verified responses from the interviews and focus groups. The focus group also verified the information from the interviews. Also, the results from the impact assessment were verified by the stakeholders that were involved in the adaptive capacity assessment.

3.1.5.2 Trustworthiness of analysis

The data analysis process was systematically done and clearly documented. A computer software (NVivo™) was used to manage and code the data. Also coding book which explains the various codes was made available for another researcher to go through and bottlenecks were discussed.

3.2 Methodology for adaptive capacity assessment

This methodology describes how the adaptive capacity assessment was achieved. This methodology underpins the results and discussions in chapter 6. This assessment was done for a year and half to extend the RCAA and the rationale for this extension is discussed in the next section. It is followed by the research approach and then the data collection methods used to generate the results. This methodological subsection concludes with the description of how the data was analysed.

3.2.1 Rationale for adaptive capacity assessment

Adaptive capacity is denoted as the ability of a system to adjust, modify or change its characteristics or actions to moderate potential damage take advantage of opportunities or cope with the consequences of a changing climate (IPCC, 2007).

As explained in section 2.4 of this document, adaptive capacity is the combination of development choices, adaptation actions and local capacities that allows for effective action at the local level (Kuriakose et al., 2009). Dodman and Mitlin (2011) emphasized the importance of political structures, culture and power in issues concerning adaptations. To achieve this, there should be a proper understanding of

the diversity of social factors that propels or slows down adaptation processes. Adger et al. (2007) argues that social factors such as social networks, social capital, values, perceptions, interests, customs and traditions strongly determine the capability of social systems to adapt to risks related to climate change. According to (Grothmann et al., 2013) factors like technological and economic development are difficult to change within a shorter time frame as compared to social factors like how people perceive risk which can be changed relatively faster and easily. This necessitated the development of a methodology to systematically assess social adaptive capacity and social factors that hinder adaptation processes. This led to the development of Adaptive Capacity Wheel (ACW) methodology by Gupta et al. (2010). According to (Grothmann et al., 2013) it is the most comprehensive and operationalised framework for assessing social factors.

The Adaptive Capacity Wheel differentiates 22 criteria to assess 6 dimensions: variety, learning capacity, room for autonomous change, leadership, availability of resources, fair governance but it has been modified by (Grothmann et al., 2013) to include two more dimensions; adaptation motivation and adaptation belief and hence two more criteria. To assess the adaptive capacity of WASH stakeholders, this modified ACW by (Grothmann et al., 2013) was used. There are three circles and the inner circle shows adaptive capacity, the middle circle shows the dimensions and the outer-circle shows the criteria as shown in Figure 3-7. It looked at ways of enhancing adaptive capacity of the stakeholders by exploring the inherent characteristics of institutions to promote the capacity of society to adapt to climate change since the enhancement of adaptive capacity will reduce vulnerabilities and promote sustainable development (Smit et al., 2009) which leads to resilience.

The ACW was developed for top level assessment and this is the first time being applied in a multi spatial and informal sector like the WASH sector of Ghana. There was the need to explore the tensions between the various dimensions specified in the ACW by highlighting some of the overlaps in the dimensions assessed. Also, the feasibility of assessing the adaptive capacity of various WASH stakeholder groups across various scales, especially at the community level was explored. The reasons for arriving at any dimensions as appropriate for assessing the adaptive capacity of

all WASH stakeholder groups depended on how these dimensions could be rapidly assessed to practically improve adaptive capacity.

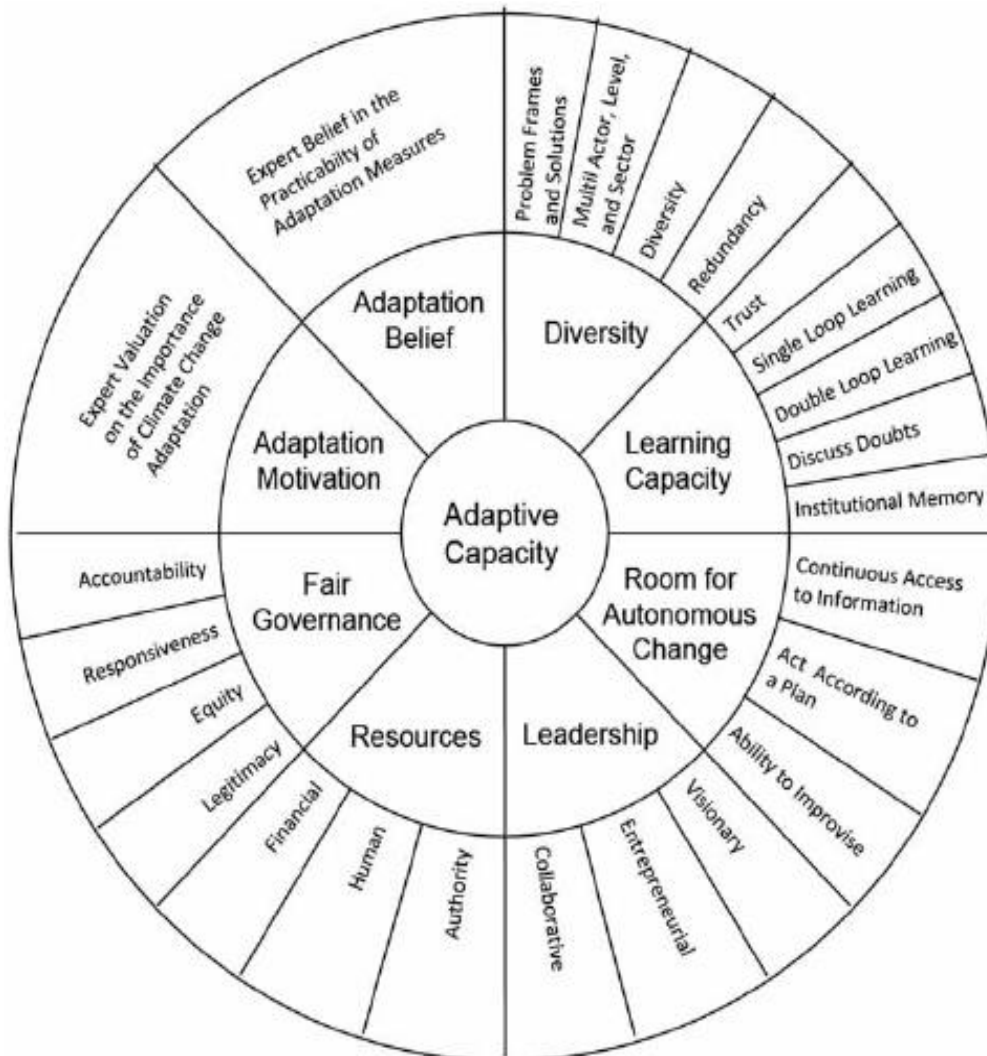


Figure 3-7 Adaptive Capacity Wheel (Grothmann et al., 2013).

3.2.2 Research approach to adaptive capacity assessment

A qualitative approach was employed to understand the complex interactions that support or hinder adaptive capacity of WASH stakeholders in Ghana. The Adaptive Capacity Wheel just like the ASPIRE (A sustainability Poverty and Infrastructure Routine for Evaluation) toolkit developed by Arup and Engineers Against Poverty (Engineers Against Poverty and Arup, 2009) emphasizes the importance of an institution in achieving resilience. However according to Woolf et al. (2016) the

ASPIRE toolkit primarily focuses on infrastructure assessment but this research goes beyond just the WASH infrastructure to understand the management practices and the capacity of the stakeholders. In this research, the institution under study is the urban WASH sector of Ghana. Gupta et al.(2010) defined an institution as “the inherent characteristics that empower social actors to respond to short- and long-term impacts either through planned measures or through allowing and encouraging creative responses from society both ex ante and ex post”.

The major concern in using the ACW methodology was the difficulty in capturing the informal complexities of the institution. These informalities whether described as intangibles (after Pelling et al., 2008) or as shadow (by Stacey, 1996) are hard to capture in a formal interview especially when the interviewees are representing their institutions. These posed difficulties in using the ACW methodology in the context of Ghana where inefficient WASH service delivery has increased informality of the urban WASH sector. To ensure consistency with the answers given, interviewees were asked to score the various criteria that make up the various dimensions of the ACW. The scoring was insightful in understanding the adaptive capacity of the sector. Though the main purpose of the ACW is to assess the inherent capacity of an institution to respond to change and not the workability of climate change related issues (Gupta et al., 2010), interviewees needed to tell the story as it was and not how it is supposed to be on paper. Genuine responses were important in understanding the inborn capacity of stakeholders which gives more insight to how their politics, economics and power affect their ability to implement adaptation policies.

3.2.3 Data collection

Only in-depth interview data were collected to understand the stakeholders' adaptive capacity.

3.2.3.1 In- depth interviews

15 Semi-structured interviews were conducted. The interviews consisted of open ended questions which were void of technical words. This was to remove any ambiguity in the minds of interviewees. The open-ended questions allowed

interviewees to talk in depth to describe vividly the situation on the ground and therefore aided in the development of recommendations to strengthen the identified weaknesses. The questions were organized under the eight dimensions of the adaptive capacity wheel which served as pointers during the interviews. The results of the Adaptive Capacity Wheel had to be descriptive to be a starting point for the discussion on how institutions can enhance the adaptive capacity of the WASH sector. They also helped clarify overlaps and contradictions between criteria. A qualitative approach gave more descriptions to the situation on the ground and therefore aided in the development of interventions to overcome the identified weaknesses. The interview schedules are attached in Appendix.

The definition of all the various dimensions of the adaptive capacity wheel (as elaborated below) were sourced from (Grothmann et al., 2013)

Diversity

Diversity is the incorporation of various actors, political/administrative levels, solutions and problem framing into the sector. Having various perspectives prevents constricted framework, which is helpful because of the uncertainty and complex nature of climate impacts.

Learning capacity

Learning capacity as a dimension assessed how easy it was for stakeholders to learn. This tried to understand if stakeholders could draw on experience and regularly check their own assumptions.

Room for autonomous change

Room for autonomous change as a dimension of the ACW, assessed how stakeholders in the sector can change and drive change. This looked more into how stakeholders can improvise. The questions asked included those listed below.

Leadership

This dimension the leadership style being implemented in the sector and the type of incentives present. Here, the objective was to understand whether the sector can be

driven by a visionary leader who are proactive and allow for the collaborative efforts amongst all stakeholders.

Resources

Resources assessed the availability of funding, qualified personnel and the possibility of implementing objectives.

Fair governance

This dimension assessed whether the rules in the sector are legitimate and equitable, and whether there is accountability. Fair governance as a dimension is moulded on democratic principles and fairness.

Adaptation motivation

Adaptation motivation as a dimension assessed the motivation of “stakeholders to realise support and/or promote adaptation to climate change”. The dimension also looked understood how stakeholders in the sector perceived risk and the opportunities of climate change.

Adaptation belief

Adaptation belief assessed whether stakeholders believed in climate change and whether they believed they can adapt. “This ability only partly determines if an adaptive response is taken”.

3.2.3.1.1 Selection of interviewees

At the end of the Rapid Climate Adaptation Assessment process, recommendations were made to specific institutions involved in the WASH adaptation process as listed in the Ghana National Climate Change Adaptation Strategy. Since the purpose of the adaptive capacity assessment is to understand how institutions are positioned to carry adaptations, these same stakeholders were interviewed to know how ready they were to carry adaptation plans. One ecological zone was chosen as a case study to understand the adaptive capacity of the urban WASH sector because the impacts of the developed climate scenarios were similar in all the three ecological zones as will be detailed in the next chapters. For easy access and cooperation of

interviewees- building on from the experience of the RCAA fieldwork, Accra was chosen to understand the adaptive capacity of the WASH sector. Accra is the capital and most populated city in Ghana and host the national offices of all these institutions that will be visited. Also contact was made with these stakeholders during RCAA fieldwork. Three respondents were interviewed from each group of stakeholders because more than one perspective of the groups' position and role in adaptation process was needed to understand their adaptive capacity. The stakeholder groups were the ministry of Water and Sanitation, Ghana Water Company limited, Accra Metropolitan Assembly, Researchers and NGOs. The organizations making up the interviewees are shown in Table 3-7.

Even though recommendations were designed for water vendors, in assessing the adaptive capacity, they were not interviewed again. These water vendors were not doing much to adapt and it was observed that most of the problems took us right back to these organizations that were interviewed during the ACW. Interviewing these water vendors would have been difficult as it was difficult to mobilize them. Also because of their level of education, this interview would have required a lot of interpretation of various terminologies into the various Ghanaian languages and the real meaning could be lost in translation. This will defeat the very purpose of understanding the true state of the capacity of the system.

Table 3-7 ACW interview respondents

| Orgarnisation | Respondents |
|---|--------------------|
| Water Directorate | 1 |
| Environmental Protection Agency | 1 |
| Ghana Meteorological Agency | 1 |
| Metropolitan waste department | 1 |
| Environmental Health Department | 1 |
| *Zoomlion Ghana Limited | 1 |
| Water Aid Ghana | 1 |
| Water and Sanitation for Urban poor Ghana | 1 |
| Global communities Ghana | 1 |
| International Water Management Institute | 1 |
| Regional Institute for Population Studies | 2 |
| Ghana Water Company Limited | 3 |
| | 15 |

*Zoomlion Ghana Limited is a private waste collection company contracted by the assembly to help in the waste collection.

3.2.4 Data analysis

The interviews were partly transcribed and the eight dimensions of adaptive capacity used in this work served as major themes where the interviewees' responses were discussed. The situation reported from the interviews were summarised under each criterion. A qualitative understanding of the adaptive capacity of the sector was presented. However, to represent this qualitative information into scoring, interviewees were asked to score each criterion on five-level scales: very low = 1, low = 2, medium = 3, high = 4, very high = 5. The criteria were converted to their corresponding dimensions by calculating the average of all the criteria that makes up that dimension. The average values were rounded up or down to the nearest whole number. For example, values between 2.50 and 3.49 were rounded to the nearest whole number that is 3. After calculating values for each dimension, these values were replaced by verbal values and colours. The verbal values and colours are 5=very high (dark green), 4=high (light green), 3=medium (yellow); 2=low (orange); and 1=very low (red). These colours then literally paint a picture of the level of the adaptive capacity of the WASH sector. From the presented adaptive capacity, areas or dimensions that needs enhancement can then receive recommendations on how to enhance their adaptive capacity thereby achieving a climate proof WASH service.

3.3 Ethical issues and considerations

This research followed an agreed, standardised and clearly defined ethical procedure. It was conducted with appropriate transparency and in accordance with the highest standards of: integrity, fairness and confidentiality as stipulated in the Cranfield University's implementing and monitoring research integrity policy (2015). These ensured that ethical approval was given by Cranfield University to conduct the research. In Ghana, because there was no national ethics board, ethical approval was sought from the leaders of the various communities during the community entry process. Participant's consent was sought before the interview either by verbally reading the consent to them or agreeing to sign after they have read it themselves. They were informed that the interview will be recorded and that they could withdraw from the project at any stage. However not all interviewees agreed to be recorded on tape and in such situations, only field notes were taken. The confidentiality of

participants was protected as quotes were not made directly to their names except when respondents agreed their titles (office position) can be used to show authority of their quotes. The details are in the consent form attached in the appendix.

3.4 Challenges and limitations

Most interviews of the WASH service providers took place around their services whilst they were still at working. This frequently interrupted the interviews and sometimes affected the flow of information as they had to pause in the middle of making a good point to attend to customers. Also, because there were a lot of activities going on around these facilities, sometimes it was difficult to hear the recorded interviews. The field notes taken were then used as a guide to understand such interviews.

The community entry was done with the help of Water and Sanitation for the Urban Poor (WSUP) - an NGO with experience in working with the urban poor was the partner for this research, used their experience in getting contacts in both Kumasi and Accra where they work. They helped build contacts with the assembly men (elected representatives) of each of the communities. These assembly men are the political heads of the communities and served as the link between the researcher and the local people (community). Community Entry (Tindana et al., 2011) was done to observe protocol and introduce researchers to the leaders of the community as well as to agree on dates for interviews. The cooperative nature of the communities made the research proceed eventually but with some delays. Unlike in Accra and Kumasi where WSUP helped with the community entry, it was difficult to mobilize the community leaders in Tamale and it delayed the research plans until the municipality were persuaded to play the lead role.

A limitation of this research was the use of simple conceptual hydrological scenarios. The lack of downscaled climate projections for the communities as well as variations in the climate projections meant that the developed hydrological scenarios were just conceptual and not from quantitative data. However, the conceptual nature of the developed scenarios helped to maintain the rapid nature of the RCAA. Detailed modelling of the scenario is however beyond the scope of the research.

In applying the RCAA methodology, recommendations on how to climate proof the WASH services were developed for all stakeholder groups (national, municipal and local level) directly involved in adapting to climate change. During the adaptive capacity assessment, only national and municipal level stakeholders were interviewed. The local service providers were not interviewed due to the technical language used in the wheel which would not have been appropriate to translate to the three Ghanaian languages as their meaning would have been lost in translation. Also, as a limitation, scoring the various adaptive capacity dimensions in this research was done by the interviewees instead of a group of researchers. The scoring for the ACW was crosschecked against the qualitatively rich interviews and the two datasets were consistent.

As a limitation, the focus group discussions were not split into male only and female only groups in each community. Having a heterogeneous group discussion would have helped me capture sensitive information which either sex (especially women) could not express in the mist of the opposite sex. Therefore, sensitive information could have been missed. Even having a homogeneous focus group discussion facilitated by me as an adult male Ghanaian would have also deprived me of some rich information. However, at the heterogeneous discussion, women were knowledgeable in locations and functionality of services whilst the men were concerned with the cost and both were discussed to agree on fair prices and right distance.

4 VULNERABILITY ASSESSMENT

This chapter discusses for each selected urban city within the ecological zone, the vulnerabilities of the WASH services. The assessment looks at who is vulnerable, what is vulnerable and how they are vulnerable. This chapter concludes by consolidating all the observations across the six communities to discuss the commonalities between the data. Evidence from the thematic analysis is attached in Appendix E.

4.1 Kumasi (Deciduous Forest)

As discussed in the methodology section, Kotei and Adukrom are the study areas. For Kumasi, this section looks at the WASH situation and how they are being impacted.

4.1.1 Current WASH situation Kumasi (Kotei and Adukrom)

From the interviews, focus group discussions and direct observations, this section captures the various technologies and management practices employed in the local wash service delivery in Kotei and Adukrom. This section discusses in detail the types of facilities in use, how these facilities are used by customers, the demand for the services, the service robustness, their maintenance culture and a unified local WASH body.

Facility type

For water supply, all the water vendors in Kotei depended on groundwater. The major water facility was a six standpipes water network served by a borehole and this was a community water system which was a partnership between the Kotei community, Ghana Water Company Limited and CARE International. Beside the community managed water, four other private water vendors also operate in Kotei. Most started their facilities to provide commercial service to the community but few converted their domestic facility into a commercial facility. A water vendor said he drilled his borehole for his domestic use but got extended for commercial purposes because people kept coming to collect the water for free but he could not afford his electricity bills. He then decided to commercialize it to benefit his family and the

community. In Adukrom, the vendors were supplied by Ghana Water Company Limited. The vendors pay a connection fee (depending on distance from the nearest distribution line) and their facility gets connected to the city's distribution grid. The vendors then buy storage tanks to ensure they provide uninterrupted water supply to their customers. The vendors pay a monthly water bill to the GWCL at a commercial tariff which depends on the volume they consume.

The toilet facilities in both Kotei and Adukrom were Ventilated Improved Pit latrines (VIP), pit latrines with slabs and flush toilets. These toilet descriptions are document in the WHO joint monitoring programme (WHO/UNICEF JMP, 2014). In Kotei, the community owns and manages one flush toilet with borehole as the source of water for flushing the toilets. The other toilets in the community were managed privately. In Adukrom, there was one public toilet which was pit latrines with concrete slabs and it was privately managed. The septic tanks at all the toilets in these communities are desludged routinely at a fee to ensure their facilities continue to function effectively.

Facility usage

The Toilet operators and managers interviewed had a lot of problems with the way their customers used their facilities. They all complained that toilet users did not follow instructions on how to use their facilities. Whilst most users defecate around the toilet pots, others prefer to stand on the pot which eventually breaks the pot. To prevent people from standing on the toilet pots, doors to the toilet cubicles were shortened to "expose people who stand on the pot" and this helped curtail the practice. An operator noticed that males used the toilet differently from females. Women disposed their sanitary pad and papers in the toilet bowl which blocks the toilet whilst men on the other hand do not clean the toilet bowl after they splash the toilet bowl with their faeces. The operators agreed that women gave them more problems in their usage of the toilets than men because women always insist on a hygienic toilet but they do not leave it in a good state after use. An operator said, "we have a lot of problems with women and children". A vendor believes that "people are inconsiderate in the way they use the toilet" and blames this on their lack of education.

Flushing of toilets after use was a big problem which toilet operators were concerned about. Either most users do not flush at all or flush before and after use. Due to the flushing habits, the community owned toilet in Kotei have changed their handle flush cistern to the push button flush cistern. This is because toilet users misused the handle especially when there is no water in the cistern and they keep trying to flush the toilet. An operator describes this situation as a cycle where people flush before use and leave it unflushed after use. The toilet visited in Adukrom is an improved pit latrine. It has no flush system and it is uncomfortable to use because of the smell especially during the rainy seasons according to the information gathered at the focus group discussion. During the day when the temperatures are high, there is unbearable heat in the toilet and women believe they could get an infection if they use the toilet during these hours. This made most people opt for open defaecation.

Facility demand

This section explored the pattern in the demand of the WASH facilities. The patterns looked at were seasonal, weekly and daily. From the interviewees of the service providers in Kotei, Sundays are the busy days for toilet operators. This is because on Sundays most people in the community stay at home instead of their usual trading which takes them out of the community. Water vendors on the other hand, have high demands in the mornings of weekdays. Though there is no seasonal pattern in the usage of toilet facility, there is a noticeable patronage of the water facility. Water demands are high in the dry season and this is because customers harvest rain during the rainy season. Most customers buy water just for drinking purposes during the rainy season.

The situation in Adukrom is quite different as there is a lot of pressure on the sole public toilet. It has only fourteen squat holes; seven for men and seven for women. It is very busy in the mornings and the evenings. Most users work outside the community so they use the toilet before going to work and after work. Water demand patterns also fluctuate seasonally. There are high demands for the vendor's services during dry season but this demand is decreased during the rainy season because people harvest rainfall for their water needs and only purchases water for drinking.

Facility robustness

Stakeholders were asked what they perceive to be the effect of flood and drought on their distribution system. For most customers who get their water from the Ghana Water Company, they were not in charge for the distribution system. On the distribution network, the Ghana Water Company district manager in charge of poverty endemic areas (urban poor communities) recalled a lot of seasonal experiences in Kotei and Adukrom. According to him, “pipes become hardened and give way during the dry season”. This is because most pipes are exposed to direct sunshine. There have been attempts in the past to replace all old PVC pipes with HDPE pipes but according to the utility district manager, “changing it is capital intensive”. The major problem that keeps reoccurring is pipe burst within roads and he attributes this to high pumping pressures in the rainy season. Leakages are also a problem and cause a lot of produced water to go to waste. “Good Samaritans” report the leakages to the Water Company. There are water ambassadors who also go around detecting leakages. People also build on service lines and this restricts the Ghana Water Company from getting access to their pipelines for maintenance.

Electricity looked to be the foundation on which WASH service providers operated and this affected the robustness of their facilities. According to the interviewees “once there is electricity, we always get water”. A vendor put it better by saying if there is electricity, there is water. “We do not get water when there is lights out but when there is light, water flows”. Also, water providers blamed their pump damaged on the frequent power outages with vendors saying, “pumps get burned due to power failure”. In Adukrom, electricity is also a major component of the water supply system. The Ghana Water Company depends on electricity to pump water to end users. There are frequent power outages in Kumasi and this also affects the Ghana Water Company. Vendors in their bid to provide uninterrupted service, rely on storage tanks to help them provide water around the clock.

Maintenance

This section investigated the maintenance culture of the WASH service providers. The main reoccurring costs are minor repairs and treatment of water in the storage tanks. Minor repairs of pipes are undertaken by local plumbers as a vendor said, “I

tell Ghana water about major problems but the minor repairs are done by a local plumber". "I have a plumber who lives next door and he repairs my pipes". Another also said, "my brother is a plumber and he repairs our pipes". Less than a quarter of the interviewed vendors still report their minor repairs to Ghana Water Company, as a vendor said, "I report my problems to the revenue collector from Ghana Water Company since he is the one I deal with". Another vendor explained how she stopped reporting repairs to the company by saying "I do the maintenance myself since Ghana water told me it is mine". Most water vendors treat their water before selling it on. The treatment processes include filtration and disinfection. The disinfections ranged from use of naphthalene balls (camphor) to chlorine dosed in storage tanks. The camphor is purchased from chemical shops or mobile vans but Soghoian et al. (2012) expressed concern that ingestion of camphor may increase the risk of toxic haematological effects. Whilst less than 20% treat their water routinely, the rest treat their water as and when there is the need to do so. The routine treatment was every four months. The water vendors believed their water was "not salty" but they use customer satisfaction on water taste to know when to treat the water. If there are complaints, water samples are tested in the Ghana Water Company KNUST branch (closest laboratory to Kotei). In Adukrom, because the water vendors are supplied from Ghana Water Company' main distribution line, they normally do not treat that water. All the treatment is done by the company. Vendors however complained that the quality of the water depreciates after it rains. "When it rains, the colour of the water is not normal". We sometimes see some black particles in the water. If they are sure it is not from their storage tank, they report the issue to the company through the revenue collector. Despite all these reoccurring cost, not all vendors save part of their income to maintain their facility. These types of vendors are sellers and not necessarily in charge of decision making and therefore just sell the water and account to the owners or the Water and Sanitation (WATSAN) board. The WATSAN board was made up of a chairman, vice chairman, a secretary and two trained technicians. All the board members were volunteers who have been selected by the community leaders to plan, implement and operate water and sanitations infrastructure for the community.

Due to power outages and frequent pipe bursts, those supplied by the Ghana Water Company experienced interrupted water supply and hence water providers relied on storage tanks. A vendor explains, “We only survive with big storage tanks” and this makes the price of water expensive. These Storage tanks play a very important role in the water service provision in Kumasi. The tank capacity was two to three days depending on the water demand. The tank maintenance is basically by washing, “I wash the tank every month with detergent” says a vendor. Pipe bursts on the other hand are a serious issue. The utility service admits that it is their duty to bury all exposed pipes but they are not resourced enough to do this. They have however started a process to change all PVC pipes to HDPE pipes. A stakeholder admitted “they replaced my PVC pipes with HDPE”. However, the situation is not different for the community managed system as a vendor attributed most system breakdowns to bad management. “You have to be serious with managing water because the process involved in getting water is not free. Another vendor advises water managers by telling them to be serious because it involves a lot of commitment. According to him, the community owned water supply system was not working because it does not belong to any individual and hence the WATSAN Board members are not committed to ensuring the water system functions.

Toilet operators empty their septic tank frequently during rainy seasons but less during the dry seasons. An operator said, “We enjoy dry season because we do not empty the septic tank often”. The water table in Adukrom is very high as confirmed by the Deputy Municipal Waste Director. There is a lot of lateral flow. A toilet operator said, “the septic tank gets full when it rains due to poor design”. It costs toilet operators a lot of money to empty the septic tank. Toilet Operators in both Adukrom and Kotei earn around 90 Ghana Cedis (£15, 2016) a day. They however pay 250 Ghana Cedis (£41.67, 2016) for emptying their septic tank. Also, most toilets stand a risk of having weak septic tank concrete slabs during dry seasons and this becomes visible as cracks. This according to the WATSAN board could be due to the short construction time of the toilet. This assertion could be true because Gowripalan (1990) suggest that visible cracks could be caused by inadequate curing. This poses danger to children who play around the toilet and other people who walk on it.

There is water and sanitation board that takes care of the daily activities of the Kotei community owned water and sanitation project. The board consist of 15 people of which four were women. The board believes they do not operate for profit but the community is the biggest beneficiary. During the design and construction of the facility, the board was not consulted. The operators for the community facility get paid 10% of their sales and this is designed to incentivise them to work hard. The toilet providers believe they are not paid well and their health is at stake. They perceived the smell and the heat from the toilets especially during hot afternoons could have an impact on their health. A vendor shared her believe “I believe I should be going for health check-ups”. “One problem is people want cheap things but we spend a lot on maintenance”. We do the maintenance as a board. We had to raise the height of the septic tank to avoid it overflowing during the raining season” and we have also dug our own borehole to provide water for the toilet. Concerning plans, the WATSAN board said, “We have plans to build more toilets for the community”.

Local WASH organizations

The water vendors and the toilet operators interviewed in Kotei did not have any association. Not even the six water vendors who worked for the community owned water supply system had a common union. One private water vendor belongs to a drillers association because he is a driller and he gets technical help from the group in managing his borehole. Though one vendor heard of an association in the past, she didn't join. They admitted that fellow vendors or toilet operators might be facing similar problems to those they experience and it would have been good if they had an association. Another vendor remarked that another toilet faced a similar problem with children wanting to use the toilet for free. Though it was solved, she does not know how. The vendors that work for the community owned water system noticed that the private boreholes had their pumps working always but theirs constantly developed faults. In Adukrom, though all the vendors get their water from the same company, they are not unified in one voice. Though most vendors appreciated the importance of unity, they still do not know why they are not together. A vendor was keen to join an association because according to her “we can regulate the price of water across board”. This idea of price regulation will need to be regulated by the

metropolitan assembly to ensure that their customers are protected from all the negative from the monopoly the association will enjoy within the community.

Climate change awareness

Stakeholders in Kotei were asked about their awareness and perception of climate variability. They were all aware the climate is changing but ascribed various reasons to why they think it is happening. A water vendor agrees that “more buildings, more people and things are advancing” so she expects the climate to change as well. A water vendor believed climate change was a “season as the bible says”. A stakeholder went on to define climate change as “a situation where things become abnormal and things happen when you do not expect them”. A vendor believed that the climate changing is the work of God and that “in God’s own wisdom that is how he has created the world” and that we are only at the receiving end of what God gives us. The reasons make the interviewees distance themselves from the causes of the phenomenon and have resigned to its impacts without thinking of what they can do to help themselves. The WASH service providers could tell the climate is changing from their own experience as they recalled that “This year, the rains did not come as expected hence maize did not do well”. Interviewees however believed they will be fine even if climate change intensifies and there is still water. This is because for most of the interviewees, seasonal variation of the water supplied by Ghana Water Company is the only way climate variability impacts their life. A water vendor acknowledges the need for people to care about the environment, “If we do not take care of our environment properly, definitely it will have an effect on us”.

In Adukrom, stakeholders also believed in climate change and talks of how it affects their farm. A stakeholder said, “I know about Climate Change and it even has an impact on my farm”. Another also said, “it affects my cocoa farm and now I have to grow a different variety of cocoa crop”. A stakeholder, simply defined climate change as “what you are expecting, you do not get”. The meteorological service in an interview explains that, the evidence of climate change in Kumasi is visible because rivers are reducing in size due climate change. Also, intense high temperatures are affecting crops. People in areas where there is less infiltration due to the clayey nature of the soil are most vulnerable to flooding in Kumasi because of high runoff.

These areas are also very low lying as compared to other communities in the municipality and hence receive more drained rain water than can infiltrate. Some of the areas include Aboabo, Ahinsan and Atonso S-line. Concerning what the Meteorological Agency does, the agency said, “We alert the populace of any extreme event through radio announcements”. He however admits that the structures to deal with climate change are weak and his department is understaffed. He also recalls that there have been a lot of seminars in the past but climate change was not the focus. “I have been to a seminar where climate change was discussed but it wasn’t the main theme of the seminar”. As far as the Ghana Water Company District Manager is concerned, there is no policy on water related to climate change operating at the district level. A stakeholder believes that adaptation to climate change is more of a national and international issue but the municipality must draw guidelines to help it adapt. Though interviewees are aware of climate change, they are doing little about it.

4.1.2 Current impacts of extreme events on WASH services in Kumasi

The current impacts of extreme events were assessed from the field visits to Kumasi. The main purpose of this section is to highlight the problems faced by WASH service providers and systems during both the dry and rainy seasons since climate change will affect these seasons. The interviews combined with field notes and observations were used to discuss the current impacts of climate change on WASH services in Kotei and Adukrom.

Water supply

Erosion in Adukrom was very conspicuous and can be attributed to engineered landscapes around the city which left the un-engineered surfaces in most poor urban communities at the mercy of runoff. This erosion has washed off the top soil of buried pipelines and has left pipelines exposed in Adukrom. This has increased the rate of pipe bursts, leakages and illegal connections. Exposed pipes serve as points for illegal connection and this increases nonrevenue water. Though the Ghana water company does not measure directly their nonrevenue water, they estimated about

46% for the whole of Ghana. The 46% includes meter bypass water, unauthorized connections and unbilled services.

Leakages and pipe burst are common in Adukrom, where the Ghana Water Company Limited supplies water to the vendors. This has been attributed to the seasonal rise and fall in the water demand pattern - high water demand during dry seasons as compared to rainy seasons where people harvest rainwater - which causes low and high pressures during dry and rainy seasons and causes PVC pipes to burst. These leaks may serve as points where contaminants ingress into the distribution network. This is likely to happen during dry seasons when there are low pressures in the supply system. The low pressures also lead to loss of productive time as children and women spend more hours collecting water. These lead to intermittent water supplies and may even damage the infrastructure.

Pump breakdown due to power cuts known locally as “dumsor” causes water to be rationed. This electricity fluctuation is due to the decrease of the hydropower potential of Ghana (Ghana National Adaptation Plan, 2013). This problem has caused the community owned water supply system in Kotei not to function. As at the time of the field work (December to January), the Community water system was not functioning. They have had three pump breakdowns in the past 2 years. They attributed this to frequent power cuts. This has led to an intermittent water supply which has caused vendors to use storage tanks. The use of storage tanks has increased the cost of water supply. Water supplied by the GWCL is rationed so vendors buy tanks to store water to help them sell water always but there was a community owned water supply system under construction in Adukrom during the field visit. This is collaboration between WSUP Ghana, Ghana Water Company and the three other communities. This will go a long way to improve the current WASH situation in the community. The overhead storage tanks and their tank holders are shown in Figure 4-2.

Toilets

Due to high demand for the few toilet facilities, there are usually long queues outside the toilet during peak times. During the rainy seasons, most people are unwilling to queue up in the rain and prefer to defecate in plastic bags and throw them in runoff

water. This is a poor hygiene practice as it contaminates the runoff and could cause cholera and dysentery. Moreover, high rainfall intensity during the raining seasons coupled with high water table in Kotei, increases the rate of desludging septic tanks. For example, the community managed toilet had its septic tank sited on the uphill of the toilet building and water gets trapped between walls of the septic tank and the toilet building. The trapped water seeps through the ground and causes the septic tank to overflow. In Adukrom for instance, the septic tank gets inundated and sludge is washed out leading to pollution in the environment.

Waste collections

Most people in these two urban communities normally burn their waste during the dry season. They are however unable to burn them during the rainy season and hence they dispose the garbage in drains. The runoff in the drains is not always able to carry the load and this block the drains and causes stagnation. The community needs to be sensitized on waste disposal because this stagnant water serves as breeding grounds for mosquitoes and causes malaria and odour. On the other hand, the problem is compounded by overflowing skip containers in the community which serves as breeding grounds for flies. Human scavengers are at risk of disease from the disposed waste. There is no space for more skip containers as these lands have been used for building houses. With the population growing, there will be more waste generated and this may cause cholera and diarrhoea. The road that leads to the landfill site becomes inaccessible to trucks during rainy seasons. The haulage distance from Kumasi to Dompouse coupled with the likelihood of vehicles getting stuck, makes waste disposal difficult during the rainy seasons. This causes a corresponding backlash as there is a slow rate of waste collection in the communities. Furthermore, this poorly engineered landfill site in Kumasi is supposed to serve as disposal site for both solid and liquid waste because of its impassable conditions during rainy seasons makes septic tank emptiers (vacuum truck drivers) dispose of liquid waste in rivers. This leads to health problems for downstream communities.

Hygiene

Interviewees perceived that dust produced during dry seasons in these communities is getting more intense each passing year. Constant human and vehicular activities around the standpipe get dust into the air and it then contaminates collected water. Most customers use uncovered basins to collect water and it can easily be contaminated with dust. Also during dry seasons, the water supply system becomes more intermittent and therefore there is sometimes no water available for flushing toilets. Unflushed toilets expose toilet users to faeces. Smelly toilets during the hot hours of the day make it uncomfortable for toilet operators and toilet users. Also, maggots are sometimes seen during the rainy seasons from the toilet in Adukrom and this is a sign of poor hygiene.

Burning of rubbish in the community instead of disposing of it in skip containers has a lot of health implications. Boadi and Kuitunen (2005) noticed a correlation between burning of waste and incidence of respiratory health symptoms amongst adult in their work done in the Accra Metropolitan areas. Intense rainfall is also speeding up erosion which has caused a lot of gullies in the communities which collects water during the rainy season and this serves as breeding grounds for anopheles mosquitos that cause malaria (Robert et al., 2003). As shown in Figure 4-3 drained water from around the standpipe is collected in the soak away pit and this serves as breeding grounds for mosquitoes.



Figure 4-1 Exposed inch pipeline and burst inch pipeline



Figure 4-2 construction of an overhead tank



Figure 4-3 Ineffective Soak away in Adukrom.

4.1.3 Summary of ecological zone

In Kotei and Adukrom, the WASH facilities available are Boreholes, public toilets (VIP, pit latrines, flush toilets) and piped water from GWCL. The demand for the use of the WASH facilities varies seasonally and daily. Vendors were unhappy with usage of toilet facilities. The water was supplied by GWCL were treated in the storage tanks and the quality of borehole water deteriorated after rainfall. The robustness of the water supply systems in both Kotei and Adukrom are affected adversely by intermittent power supply. The WATSAN board in Kotei were responsible for emptying and renovation of septic tanks and managing the community water supply system. Adukrom is not open defaecation free whilst Kotei has no cases of open defaecation. In both communities, no local WASH organisation exists. Stakeholders in the both community know the climate is changing but were not familiar with the science involved.

4.2 Accra (Coastal Savannah Ecological Zone)

This section explains the WASH service provision situation in Glefe and Jamestown in Accra. It highlights the vulnerabilities in the WASH service provision as well as their climate change awareness. This section also discusses the current impacts of extreme events in the communities in the two communities.

4.2.1 Current WASH situation in ACCRA (Jamestown and Glefe)

From the interviews, focus group discussions and direct observations, this section captures the various technologies and management practices employed in the local wash service delivery in Jamestown and Glefe. It also discusses in detail the types of facilities in use, how these facilities are used by customers, demand for the services, the service robustness, the maintenance culture and the absence of a unified local WASH body.

Facility type

In Glefe, the WASH facilities were public toilets, bath stalls (Figure 4-4) and water vending points. Most vendors managed these three facilities together and it was often located on their compound. They sit in front of the facility and take the fees depending on the service one demands. Out of the 24 vendors interviewed, four managed only public toilets and five managed water selling points together with bath stalls. The remaining interviewees managed all three facilities together. The water vendors were supplied by GWCL and they paid monthly bills at a commercial tariff to the GWCL. Two vendors had saline boreholes which they use for flushing toilets. The toilet types available were pit latrines with concrete slabs. Solid waste in Glefe was not properly disposed and this left the community with a lot of solid waste in the open. The community had drains choked with garbage and a lot of garbage around homes as shown in Figure 4-5 and Figure 4-6. Probing further at the focus group discussion, it was understood that the garbage was used to fill water ways to reclaim land for building houses.



Figure 4-4 Bath stall in Glefe



Figure 4-5 chocked drains in Glefe



Figure 4-6 Unmanaged solid waste in Glefe

Facility usage

Toilet operators did not seem particularly impressed with how their facilities were being used. “We tell them not to defecate around the pot but they still do and we have no choice than to clean it”. Other customers prefer to stand on the pot because they fear contracting skin diseases when they sit on the toilet pots. “Most women are scared of getting “White” when they sit on the toilet pot”. These facilities have unpleasant smell but most vendors claimed they clean the facilities daily with Dettol and Bine 20 disinfectant as shown in Figure 4-8. They also said they judged a poorly maintained toilet not by the stench but by the presence of maggots on the toilets. Open defecation is practiced in Glefe as shown in Figure 4-7 and this has reduced the income of toilet operators.



Figure 4-7 Open defaecation along the beach of Glefe



Figure 4-8 Toilet cleaning disinfectant

In Jamestown, the situation is similar to that at Glefe, squat holes were constructed on the pit latrine. Asked why they did not install toilet pots, a vendor said, “they will stand and destroy them in less than three days”. Most of the public toilets were found

close to the beach and they complained of users carrying debris on their feet into their facilities especially during the rainy seasons.

Facility demand

In Glefe, most people harvest rain water during the rainy season and do not buy as much as they do in the dry season. Most people including the vendors do not drink the water from the taps but rather buy sachet water for drinking. The demand for the bath stalls peaks in the mornings and evenings of weekdays when most people return to the community from their daily jobs. In Jamestown, vendors said there was high demand for their water service. Around 95% of the people in Jamestown do not have access to household toilet and are supposed to resort to public toilets but instead toilet operators noticed that most people practiced open defecation. An observational walk along the beach showed that the community is not Open Defecation Free (ODF) as fresh human faeces were seen around the beach. Though vendors admitted that open defaecation reduced their sales, there were also of the view that they sometimes left people with no other choice as they do not operate 24 hours a day.

Facility robustness

This section gathered from the interviewees what stakeholders perceived to be the effects of both rainy season and dry season on their facility. This started by understanding the effect on the water distribution system and the impact of hydroelectricity on their services. Stakeholders in Glefe and Jamestown were asked what they perceive to be the effect of flood and drought on their distribution system. For most customers who got their water from the Ghana Water Company, they were not in charge of the distribution system. There were a lot of exposed pipes in the community and this increased pipe bursts. Two respondents from the GWCL estimated that the non-revenue water for Accra was almost 50%. The connection fee for most urban poor areas in Accra was high because the distribution lines were not very close to these communities. Vendors had to pay more to buy long pipes. In trying to cut down on the cost, pipelines were sometimes laid through drains and this exposed the water system to contamination during pipe bursts. The pressures in the distribution network are low and places within the community do not have water at

all. This is because vendors pump directly from the main pipelines. There is a current World Bank project called the GAMA project which will extend the distribution lines to urban poor communities in Greater Accra Metropolitan Area (GAMA). The distribution lines will be made more efficient under the GAMA project.

Also, all the water vendors served by GWCL, fill their water storage tank with the mains pressure. They suspected that other stakeholders had connected pumps into the main lines and were pumping water into storage tanks. This made it difficult for vendors up the hill to get access to water. “The only time we get water is when there is lights out in Glefe”. This is because the pumps in the main lines do not work during power cuts hence the water is able to reach the higher parts of Glefe. Water vendors excavate holes under broken pipes to get access to water when the pressure is very low as shown in Figure 4-9. In Jamestown, there is intermittent water supply and vendors pump water from the mains and store in drums. When there is electricity, vendors get water; this is more common in the rainy season as the power cuts are not as often as in the dry season. “When it rains, we get water in our taps and it (rains) corresponds with electricity”.



Figure 4-9 Hole dug in the ground to access water because of low pressure in the distribution system

Local WASH organization

The water vendors and the toilet operators interviewed in Glefe did not belong to any organized body. In the past, the need for this body has been realised by a vendor who had tried to bring all the water vendors together but failed. He cited his inability to provide refreshments for the vendors after their meeting as the cause of his failure. Asked on what they think would be the advantage they stand to gain from the association, they explained that “we can have a one price so that we can keep everyone in business”. Probing further, the vendors recalled “A lot of people used to sell water but are out of business now because they kept reducing the price of their water to attract customers. In the end, they could not pay their water bills and got disconnected by the GWCL”. In Jamestown, vendors also do not have an association to voice out their grievances to stakeholders. A vendor recalled “I went to the Ghana water (GWCL) office but because I was an individual they didn’t treat my queries with urgency”. Though most vendors were in favour of an association to primarily help them set water prices, a vendor warned that their meeting times could be an opportunity for people to steal their water or deny the community of water if they lock up their facilities.

Maintenance

The main maintenance costs are tap replacements and treatment of water in their storage tanks. All vendors and operators managed the facility as their daily source of income. They save daily with the mobile banks. They make a fixed deposit every day and one day’s deposit per month is retained as the bank’s monthly commission. A vendor said, “I manage this business with all seriousness because this feeds my family”. Over three quarters of the water vendors however said high monthly water bills are a threat to their business. “I sometimes have to borrow to pay the water bills”.

There were a lot of water storage tanks in Glefe. Most of them were concrete tanks. A lot of the concrete tanks were constructed above the ground. A vendor said, “the groundwater table is very high that is why our tanks are not underground tanks” Though these tanks occupy space in already congested homes, vendors are happy to expand their tanks to be able to make more money. “Bigger tank means more

money for me so no one will complain of space in this house”. Most of the water vendors used naphthalene balls, sodium dichlorisocyanurate chlorine tablet (Aquatab) and alum for treating the water in their tanks, which they do after washing the tanks. The vendors recalled that they normally disinfect regularly during the rainy season and during outbreaks of cholera. Aquatabs are given to water vendors by the Environmental Health Department (EHD) of the Accra Metropolitan Assembly during cholera outbreaks. One vendor complained that she could not use the Aquatab because her customers have in the past accused her of dosing her water with a charm. In Jamestown, most of the vendors use naphthalene balls and alum to treat their water. Vendors however are not trained on the quantity to dose. A vendor said, “I use my own discretion but I make sure it is not too much to kill (people)”. Disinfectants are dosed directly in storage tanks. The washing of tanks was done at two to three weeks intervals.

Minor repairs of pipes are undertaken by local plumbers and water vendors. “Initially, I used to pay someone to repair my pipes, but I do it myself now”. Vendors in Jamestown use white cement (which is a rapid setting cement for emergency repairs, filling and patching) to repair their burst or leaking storage tanks. Beside all these costs, one major problem that hampers the water vending business is the high water bills they pay to the GWCL. A vendor said, “I think I am billed by the sizes of my storage tanks but they forget I hardly get water (running through the tap)”. Actually, the vendors are billed based on their meter readings but there is clearly a lack of trust of GWCL. A customer explained how she always borrows to settle her bills just to stay in business. Most vendors seem not to be happy with the service. “The water flows at odd hours and we have to stay awake to store as much as we can”.

Toilet operators empty their septic tank frequently due to high water table and groundwater seeping into their tanks. The toilet operators pay only 200 Ghana Cedis (£33.33, 2016) to desludge their tanks, which is a low rate. This is because Glefe and Jamestown are close Lavender hill which is the final disposal site for liquid waste in Accra. The toilets fill up quickly during the rainy season especially those closer to the beach. One of the toilet operators desludge directly into the sea because his septic tank is inaccessible to vehicles, but he complains of backflow

during high tides. This direct desludging is meant to stop with the sea defence project as the project will come with an access road which will help trucks to get access to facilities and desludge them.

Climate change awareness

The climate change awareness and how stakeholders in Glefe and Jamestown interpreted climate change impacts on their WASH services were assessed. Most stakeholders are aware of varying climate. They interpret this in their daily life and can tell that rainfall patterns are not like they use to be. A stakeholder said, “I cannot dry my cassava in the open again because I do not know when it will rain”. Another stakeholder said, “the rainfall pattern changed this year from June-July to March and it was not as frequent as it used to be”. The awareness is also because both communities are coastal communities and have fishermen who are aware of the climate because their livelihood depends on good weather. Stakeholders at the community level admitted it was difficult for communities to plan when they can dry foodstuffs in the sun due to the variability in the weather.

Jamestown and Glefe are both coastal communities and the impacts of sea level rise was assessed. Asked whether they think the level of the sea is rising, a stakeholder said, “the sea keeps coming closer”. Another stakeholder said this concerning the sea, “It used to be far from the shore but now it is too close”. Though interviewees believe the level of the sea is rising, 75 % of stakeholders still believe it is only divine intervention keeping them alive. “It is only God who protects those who live closer to the shore from being washed away”.

4.2.2 Current impacts of extreme events on WASH services in Accra

The current impacts were assessed from the field visits to these two communities. The interviews combined with field notes and observations are used to discuss the current impacts of climate change on WASH services in Accra. These impacts take into consideration the vulnerabilities in the WASH sector as observed in the communities and the possible impacts of they are facing during dry and rainy seasons in Ghana.

Water supply

Glefe being a coastal community is built on beach sand. Vendors are unwilling to pay for the deep burial of pipes so they are only buried the shallow depths and covered in unconsolidated sand which is easily eroded by human activities and rainfall, leading to the exposure of the pipelines and increases in the rate of pipe bursts, leakages and illegal connections. This coupled with connections that bypass the water meter, other unauthorized connections and unbilled services contributes sets non-revenue water for Accra at around 50% (this is according to the GWCL distribution officer in an interview).

Leakages may also serve as points where contaminants ingress into the distribution network. This is likely to happen all year round since water vendors pump water directly from the mains in all seasons. The rate at which contaminants will spread in the supply system will be increased by the pumping. This is a serious health issue since most of the pipes that connect to the water vendors run through choked drains and stagnant water. A leakage around such areas will easily contaminate the water and cause health problems for the community.

There are a lot of constructed concrete storage tanks in use by water vendors in Glefe due to the intermittent water supply caused by low water resources. This has increased the cost of water supply to customers. Their services depend on how much water they can store. Water from the GWCL is rationed so vendors buy tanks to store water to help them sell water always.

Toilets

Open defecation is a practice in Glefe and this might increase diarrhoea and cholera cases in the community. It becomes worse after rainfalls because people cannot access toilet facilities because the walkways used to access toilets get submerged even though the toilet itself does not get submerged as shown in Figure 4-10. The public toilets are not in use until the water on the walkways dry up. People are forced to defecate in drains or engage in "Shit water transport"-they defecate in plastic bags and throw them into the running water.



Figure 4-10 Toilet designed against flooding

Waste collections

Solid waste is not properly managed in Glefe. There are insufficient numbers of skip containers. Figure 4-11 shows overflowing skip containers. This according to the assembly is due to how the area was developed. It is difficult for trucks to get access to pick up skip containers. Solid waste is just left few metres from the immediate environment of the one who generated it. This becomes grounds for human scavengers as seen in Figure 4-11. During rainfall, the runoff carries all these waste into drainage channels and makes them inefficient. The intensity of the runoff is predicted to increase in Ghana and especially in coastal savannah ecological zone. With inefficient drains, partly also due to non-existent drain slope, there is overflow of drains which floods Glefe. The rest of the solid waste transported by the runoff into the sea causes the desalination plant in Accra to be shut down because the waste clogs the suction vents. The GWCL will then have to pay more for bulk water from the desalination plant company and this raises the cost of water production in Ghana. The problem comes back to affect poor urban areas such as Glefe because they cannot pay for the high cost of potable water. This puts the community at risk of epidemics.



Figure 4-11 Untransferred skip containers overflowing and serving as scavenging grounds for children

Hygiene

The location of most of the water vending points exposes the water to contamination with solid waste. Constant human activity around the standpipe, for example children playing or customers walking to buy the water, gets beach sand into collected water and contaminates it as most customers use uncovered basins to collect water. Unclean toilet facilities expose toilet users to direct faeces and increase the risk of contamination. Smelly toilets during the hot hours of the day make it uncomfortable for toilet operators and toilet users who must shower after using the toilet. Also, maggots and worms are sometimes seen around the squat holes during the rainy seasons from the toilet in Glefe and this is a sign of poor hygiene. Also because of lack of connected drains, grey water from bathhouses is collected in containers before being thrown onto the street as seen in Figure 4-12 and this serves as breeding grounds for anopheles mosquitos that cause malaria.



Figure 4-12 Grey water collected in containers

4.2.3 Summary of ecological zone

To summarize the findings from this ecological zone, the type of WASH facilities presents in both Glefe and Jamestown are public toilets, bath stalls, boreholes and piped water. Demand varies seasonally for water facilities and daily for bath stalls. Vendors are unhappy with usage of toilet facilities and open defaecation is common in both communities. The water vendors are supplied by water from GWCL and are prone to contamination due to pipe bursts. The water systems in these communities are affected by intermittent supply of electricity. Vendors carried out their own maintenance like replacement of water pipelines and treatment of stored water in the storage tanks. In both communities, no local WASH organization exists and attempts to set up such organizations in the past failed in Glefe. Stakeholders in the both community know the climate is changing but were not familiar with the science involved.

4.3 Tamale (Sudan Savannah Ecological Zone)

This section explains the WASH service provision in Gumbihini and Nyohini as well as their climate change awareness. This is then followed by the discussion of the current impacts of climate change in the communities.

4.3.1 Current WASH Situation in Tamale (Nyohini and Gumbihini)

From the interviews, focus group discussions and direct observations in Tamale, this section captures the various technologies and management practices employed in the local wash service delivery in Nyohini and Gumbini. This section discusses in detail the types of facilities available, how these facilities are used by customers, the demand for the services, the service robustness, their maintenance culture and a unified local WASH body.

Facilities type

The types of WASH services in use in Nyohini and Gumbini were public toilets, boreholes and piped water sale points. A walk through the communities revealed a lot of boreholes that were not in use. At the focus group discussions, they clarified that these boreholes were constructed by NGOs but ran dry or became salty or the hand pumps broke down. Because of that, the community operates a few boreholes from which water can be collected for free and are managed by people assigned by the traditional leaders of the community. There are also private water vendors who are supplied by GWCL and they pay monthly water bills at commercial tariffs to the GWCL. In Gumbihini, there are four boreholes in operation and one dries out during dry seasons and there are two private water vendors. In Nyohini, there are six functioning boreholes but four are salty.

Facility usage

The community owned water facilities' vendors complained about how the boreholes were used. They complained that children who normally collect water misuse the hand pump and it cause it to malfunction frequently. They however admitted that it was difficult to regulate the way people use the hand pumps. Toilet operators were not happy about how their facilities were used. According to the toilet operators, their customers sometimes behave like "they will never visit the toilet again". The toilets

have no toilet pots fixed on them in both communities. These toilets have squat holes and people sometimes dispose of sanitary pads and diapers in the squat holes. These blocks and fills up the toilet quickly. At the focus group, stakeholders also complained that the toilets are not hygienic and makes people rather prefer to openly defaecate.

Water Quality

The water supplied by the GWCL according to their water quality engineer is of good quality and they ensure that the water meets both local and international standards for drinking water. They ensure this by routinely sampling water at random from homes in all communities for laboratory analysis. They are then able to tell the quality of the water that gets to the customers. At the community level, most water vendors dose their water with chlorine or alum in their storage tanks to ensure customers are served quality water. The interviewed vendors could not tell how they quantified the dosage as they admitted to using their own discretion. According to the interviewed stakeholders in both communities, their boreholes become salty after a while after its construction and it made it difficult for drinking but it served other domestic purposes.

Facility robustness

Most of the distribution pipes were exposed in both communities. Probing further during interviews, stakeholders attributed this to frequent erosions because of perennial flash floods. Constant burning of garbage in the open in both communities during dry seasons has caused distribution pipes to melt and this increases leakage in the system. On how to detect leakages, the GWCL said they relied on concerned citizens to inform them. They also suspect leakages when they detect high turbidity present in the community level sampling. Also affecting the robustness of the WASH service delivery is the frequent break down of hand pumps. These hand pumps are normally installed by NGOs who donate them to the community. A stakeholder said at the focus group discussion that the only time they saw the donors are when they hand over the facility to the community. They therefore struggle to repair or replace damaged parts. This was evident as old boreholes were abandoned and newer ones were being used. Though electricity was not a major problem for the water vendors

and toilet operators in both communities, it affected the GWCL delivery to both communities. The few boreholes that functioned were fitted with hand pumps and do not depend on electricity. Power cuts within the communities do not have any effects on the water supply system but rather the water supplied by GWCL is affected when there is power cut at the headworks or pumping stations. Power cuts however are not as frequent as in Accra or in Kumasi because Tamale uses relatively low power as compared to the two other cities. Here population and facilities play a role as there are more in the other two cities.

Maintenance

Maintenance used to be a problem in the past for the community operated water supply system which in the past included a GWCL supplied standpipe. They were previously supplied by the GWCL but were disconnected because they could not pay the bills as most people in the community took the water for free. According to the manager of the community water supply, people were not willing to pay for the water and they had no money to fix minor leaks which increased their bills. Water is currently sold at a price of 30 pesewas (5p, 2016) per 34 litre bucket in Gumbihini and 20 pesewas (3.3p, 2016) per 34 litre bucket in Nyohini. Water vendors save the money they make and sometimes must borrow from friends and family to maintain their facility. A vendor however explained that they do not have any collateral to acquire loans from banks and that is why they resort to friends and family to ensure they are always in business. On how they protect their facilities from the perennial floods, both communities filled empty fertilizer sacks with sand to direct flood water away from their WASH facilities as shown in Figure 4-16. They however acknowledged that in doing so they end up directing the water to other people's houses. Most of the people in the community are farmers and have easy access to subsidized fertilizers from the government. They therefore use the sacks to protect their facilities after they have used the fertilizers on their farms.

According to the toilet vendors in Gumbihini, they desludge their septic tank every month and they pay 100 Ghana Cedis (£16.7, 2016). In Nyohini, they desludge the septic tanks twice every month during the rainy season and they pay 100 Ghana Cedis (£16.7, 2016). There was however a variation in price as the municipality's

vacuum emptier charges 100 Ghana as compared to that acquired from the University of Development Studies (UDS) which was 120 Ghana Cedis (£20, 2016). They however charge 10 pesewas per person for the use of the toilets and find it difficult saving the “little drops to make a mighty ocean”.



Figure 4-13 Skip container overflowing



Figure 4-14 Exposed pipelines



Figure 4-15 Abandoned borehole



Figure 4-16 Sack filled with sand to divert runoff

Local Wash organizations

The water vendors and the toilet operators interviewed did not belong to any association. There was fewer water vendors operating as compared to other communities visited in this research. In both communities visited, there were six

private water vendors and just two vendors managing the community water supply system. The vendors were in support of an association to help them get fair water bills from the GWCL. According to one vendor, “most people get disconnected because they cannot pay the high bills” and an association can help negotiate fair bills for them. Though there is no association, the community is directly involved in the WASH needs of the people in the community. They select caretakers for both the public toilet and the boreholes and this caretaker reports back to them.

Climate Change Awareness

Stakeholders in Gumbihini and Nyohini were aware concerning issues of climate variability. They reported a shift in the past three years of their perennial flooding which used to occur from August to September, this shows their awareness of climate issues. They also recounted that the last drought they experienced was in April 2016 which lasted for almost three weeks as compared to that of the previous year which lasted for three months. This observation was confirmed at the meteorological agency. The awareness of the local stakeholders on climate issues can partly be attributed to the fact that most of them are farmers and depend on the weather as a guide to know what farming activity is right at every point in time. The stakeholders assigned various reasons to why they think the climate is changing. 50% believed it was a natural phenomenon and they were just at the receiving end of what nature gives them. A vendor said “I am helpless and cannot do anything about climate change. It is bigger than me”. Also, others believed the gods were responsible for climate change and hence if humans live a righteous life, the rainfall patterns will get back to normal.

4.3.2 Current Impacts of extreme events on WASH Services in Tamale

The current impacts were assessed from the field visits to Tamale. The interviews combined with field notes and observations are used to discuss the current impacts of climate change on WASH service. The main purpose of this section was to understand the problems faced by WASH service providers and systems during both the dry and rainy seasons.

Water supply

Nyohini is a low-lying community and is prone to flooding. This flooding is not always due to excessive rainfall in the community. Runoff from upstream of Tamale finds its way to Nyohini. This has increased the rate of erosion in the community. Most un-engineered surfaces in Nyohini show big gullies due to erosion. This erosion has washed off the top soil of buried pipelines and has left pipelines exposed. This increases the rate of pipe leakages and burst. This causes a disruption to the water service. Flood water solid and liquid waste as well as other contaminants and this can pollute the groundwater through abandoned boreholes in both communities. There were no proper aprons around these boreholes and had only their borehole base in place. Already, drought is having a lot of impact on the water supply services in Nyohini and Gumbihini. Most boreholes run dry during extended drought periods and this brings a lot of pressure on the few working systems in these communities. The drought on the other hand increases demand for water in the community but the demand can be met because not all the systems function around that time of the year as most of their boreholes dry up. Compounding the problems is the increase in the leaks due to the pipes expanding and contracting and low pressures which causes pipes to burst.

Toilets

Extended drought which people in both communities explained comes with high temperatures cause cracks in septic tanks due to the inadequate curing during construction. These cracks are sometimes opened to insects and they contaminate food in the community. Faecal sludge gets exposed to the environment due to flooding and the community suffers from cholera and dysentery outbreaks during and after flooding. Open defecation is practiced in both communities and most stakeholders at the focus group discussion blamed it on the toilets not operating all day. Most times, people defecate around the public toilets during their nonoperational hours. Long queues are associated with the toilet at peak times. The long queues deter people from using the facilities and they defecate openly. The

toilets are not in good hygienic conditions and this encourages people to practice open defecation.

Waste collections

Droughts make solid waste dry and easy to burn in the open in the community. Also during the rainy season because of the difficulty of burning waste, garbage thrown in drains blocks them and causes stagnation. The stagnant water serves as breeding grounds for mosquitoes and causes malaria and odour in the community. Skip containers were normally open and rainfall reduces the volume available to waste. There was a skip container in each of the communities and it gets filled up easily without a proper collection system. Overflowing skip containers in the community serve as breeding grounds for flies. Human scavengers get contaminated with the disposed waste.

Hygiene

During the harmattan season, both Gumbihini and Nyohini become very dusty. This dust is released into the air especially around the water vending post due to human activities and it contaminates water collected in uncovered containers. The septic tank in Nyohini has collapsed and this exposes the community to raw faeces. This is likely to increase the cholera cases in the community especially during rainy seasons. Unflushed toilets expose toilet users to direct faeces and increase the risk of contamination. Smelly toilets during the hot hours of the day make it uncomfortable for toilet operators and toilet users. Also, maggots are sometimes seen during the rainy seasons from the toilet in Nyohini and this is a sign of poor hygiene. Grey water is not properly disposed of in the community and this serves as breeding grounds for mosquitoes in pot holes. Grey water is not properly managed in both communities as they just run out of bath sheds onto the streets. People sometimes collect the grey water in open containers and dispose them off in the streets. The grey water gets trapped in pot holes and serves as breeding grounds for mosquitoes.

4.3.3 Summary of ecological zone

Public toilets, boreholes and piped water were the WASH facilities found in Gumbihini and Nyohini. Toilet operators were unhappy with the way customers used their facilities. Water from the main distribution line is treated by GWCL. Vendors treat the water in the storage tanks with alum or chlorine. In Tamale, electricity supply was constant. The water systems in these two communities were not dependent on electrical pumps. Local power cuts have no influence on the water supply system in both communities. Vendors carried out their own maintenance like replacement of faulty pipelines and treatment of stored water with Alum or chlorine in the storage tanks. No local WASH organization existed in any of the communities. Stakeholders in the both community know the climate is changing but were not familiar with the science involved.

4.4 Commonalities between case studies

After assessing the climate change awareness and stakeholders' interpretation of the impacts of climate change on their WASH services, the results showed a similar trend amongst all the local stakeholders interviewed. In terms of climate change awareness, stakeholders were aware of the changing weather patterns -they noticed that rainfall patterns are not like they use to be and the dry season especially in the north is becoming dryer and hotter, but not the science behind why this could be happening. These assertions were confirmed by the meteorological services department and they were also confirmed by the projected trends of Minia (2008) and McSweeney et al. (2010). Most stakeholders attributed the climate variability to a greater force beyond humans (gods or God). In placing the action of climate change to a deity, stakeholders were then resigned to the consequences or the impacts of it. This trust in deity, also gives most people in the urban poor communities hope that there will not be any further extreme event. The question now is whether climate variability is affecting their lives even with their beliefs and the answer is yes. They admitted that climate variability has made planning difficult. It is worth noting that most of these people work or depend on climate sensitive sectors like fishing (those in the coastal communities) and agriculture.

From the three cases presented above in this chapter, there are a lot of similarities in the way climate change is impacting on the WASH services in Ghana. The impacts on the water supply, toilets, waste collection and hygiene across all these three ecological zones as highlighted in the individual cases are also similar. The vulnerabilities observed mostly resulted from intermittent water supply, poorly managed solid waste and lack of spatial planning. This is evident in the communities as there are different types of storage tanks in use, unconnected drains with non-existing slopes and WASH facilities that are too close to the already eroding shore line. Interviewees were not familiar with the concepts of climate change but rather they saw the impacts in practice. As captured in the earlier sections, they attributed climate change to God or development. Though these stakeholders see the impacts on their services, they have no direct plans in place. This calls for policy and programs to be put in place. These policy and programs however cannot be successfully employed without understanding the impacts of climate change on these existing vulnerabilities. Hence the next section will develop climate related scenarios and assess their impacts on these existing vulnerabilities. The impacts of climate extremes on WASH must be taken seriously as Sinisi and Aertgeerts (2011) warns that WASH service providers should prepare for the consequences of droughts, floods and sea level rise or “risk compromising access to safe drinking water and adequate sanitation”.

5 POTENTIAL IMPACTS ASSESSMENT

This chapter presents the potential impacts of climate change on the existing vulnerability. To achieve this, this chapter begins with an understanding of how climate change projections informed the development of the hydrological scenarios. This is then followed by the understanding of the potential impacts of these developed scenarios which have climate change projections for Ghana as their basis. This chapter concludes with climate change recommendations aimed developed for various stakeholders to achieve resilience.

5.1 Hydrological scenario development

Though this section is in the results chapter, the hydrological scenarios that will be highlighted in this section are assumptions derived from literature. It is in this chapter for therefore in this section for clarity and in line with the RCAA methodology used. There have been lots of works in the past to predict Ghana's future climate. However, there are two works which extensively looked at the climate projections in Ghana. The first work is that of McSweeney et al. (2010) which used past metrological data to make future climate predictions for the whole of Ghana. The second work was done by Minia (2008) for the Ghana Environmental Protection Agency (EPA) it made climate predictions for each of the six ecological zones. These two are characterized in Table 5-1 below, to foresee the possible climate trends in Ghana.

Table 5-1 Climate prediction in Ghana

| Parameters | UNDP | EPA |
|--|---|---|
| Baseline | 1960-2003 | 1961-2003 |
| Type of projections | Country wide | Ecological zones |
| Data sets | WCRP CMIP3 | ECHAM4, CSIRO using CHAM4/SCENGEN |
| Emission scenarios | B1, A1B and A2 | A1F1 |
| Precipitation projections | Uncertain about annual precipitation Seasonally, decrease in January through June and increase in July through December | Annual rainfall will decrease in all ecological zones. |
| Temperature projection | Mean annual temperature increases by 1.0 to 3.0°C by the 2060s and 1.5 to 5.2°C by the 2090s | An increase of 0.6 by 2020, 2.0 by 2050 and 3.9-4.0°C 2080. |
| Sea Level projection | 0.13-0.43 m under SRES B1 0.16-0.53 m under SRES A1B 0.18-0.56 m under SRES A2(by 2090) | 0.16-0.58 m under SRES A1F1 (by 2080) |
| <p>Emission Scenarios</p> <p>A2 - High population growth and slower Economic development</p> <p>A1B - Very rapid economic growth and low population growth</p> <p>B1 - Low population growth but with rapid economic growth</p> <p>A1F1-Fossil fuel intensity</p> | | |

Using the ecological zone as the unit of analysis, Minia (2008) projected that rainfall will decrease by the end of each projection year (2020, 2050 and 2080) in each of the six ecological zones. Percentage decrease in rainfall at end of each projection year tends to increase from Sudan Savannah in the north to

Coastal Savannah in the south. For example, from 1.1% to 3.1% at the end of the year 2020, from 6.7% to 12.3% at the end year 2050, and 12.8 to 20.5 at the end of year 2080 as shown in Figure 5-1. As shown in Figure 5-2, (McSweeney et al., 2010) was uncertain about the annual rainfall predictions for the whole of Ghana after using the three different scenarios(A2,A1B,B1) explained above. From the different models assembled by (McSweeney et al., 2010), half the models projected an increase in the annual rainfall averaged over the country and half projected a decrease.

For temperature, (McSweeney et al., 2010) was certain about the future projections under the three different scenarios (A2, A1B, B1). They predicted that the mean annual temperature will increase by 1.0 to 3.0°C by the 2060s and 1.5 to 5.2°C by the 2090s for the whole of Ghana as shown in Figure 5-3. For the various ecological zones as shown in Figure 5-4, mean annual temperature is projected to increase at the end of each projection year. For instance, temperature is projected to increase from 0.8°C in 2020 to 5.8°C in 2080.

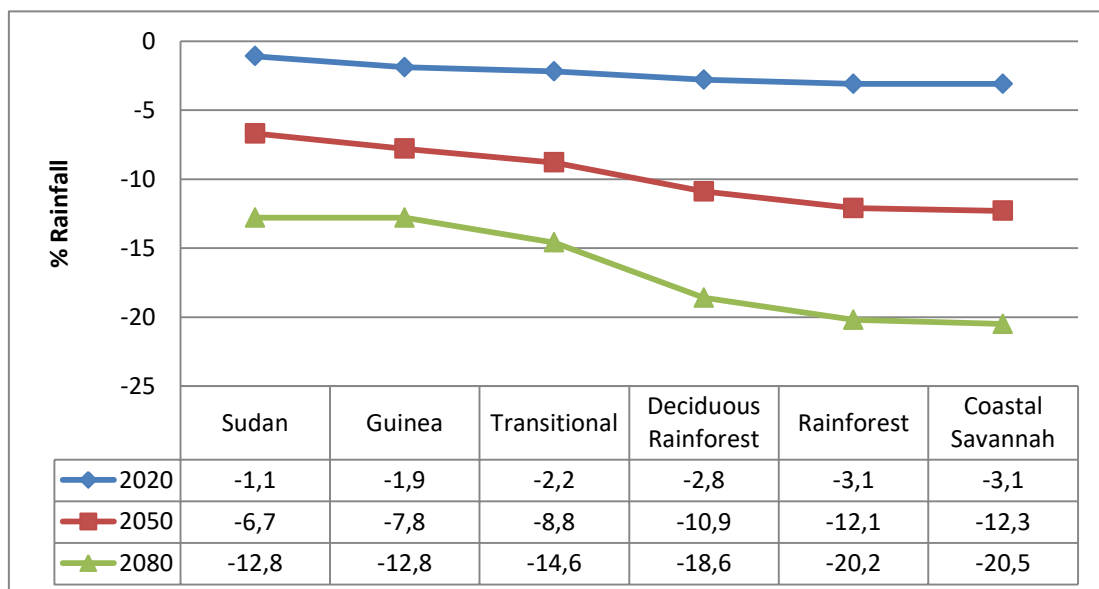


Figure 5-1 Projected mean annual rainfall within ecological zones

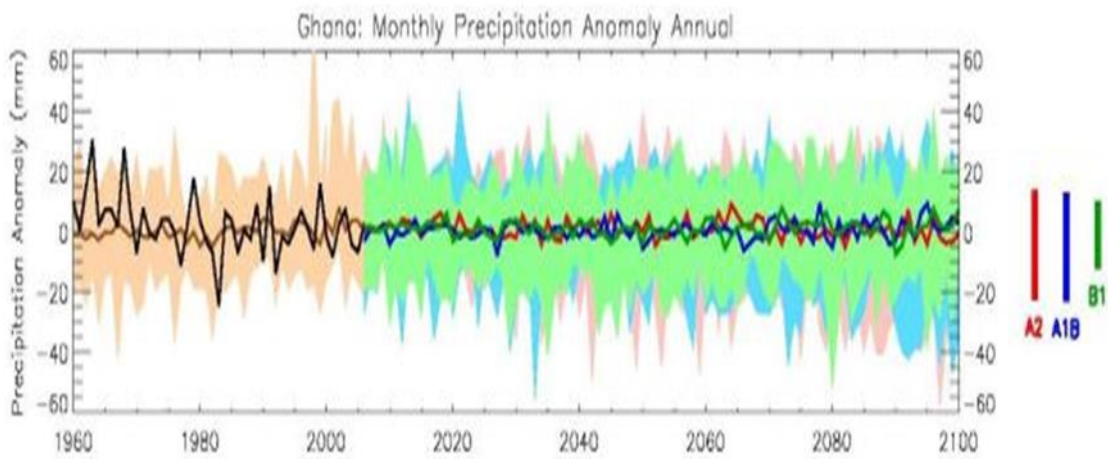


Figure 5-2 Projected mean annual rainfall across the whole of Ghana

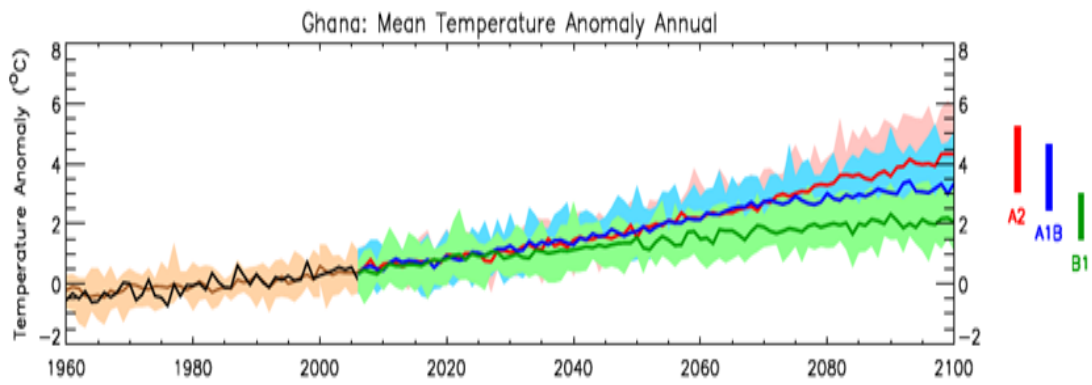


Figure 5-3 Projected mean annual temperature for the whole of Ghana

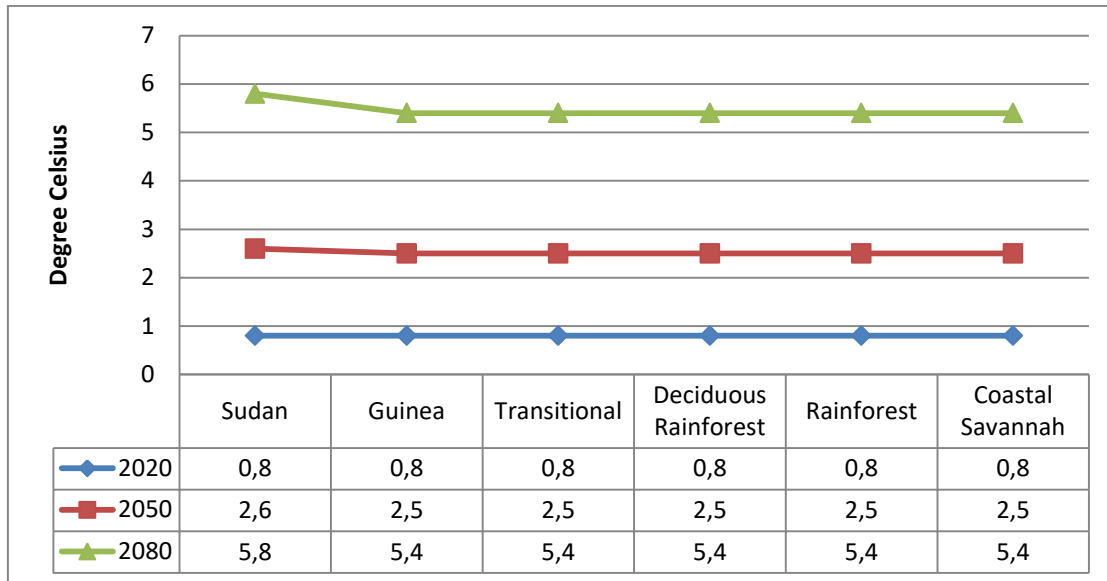


Figure 5-4 Projected mean annual temperature change

5.1.1 Developed scenarios

The three scenarios are less available water, localized flooding and sea level rise.

5.1.1.1 Less available water

Both McSweeney et al. (2010) and Minia (2008) predict an increase in high temperatures. Though there is uncertain around precipitation, the annual volume of rainfall is projected to decrease across all ecological zones. In line with this, the United Nations Environmental Programme (2010) also predicts that Ghana will be water stressed by the year 2050. This will bring about insufficient water for demand since available water will decrease. This includes less surface flow, drop in surface water levels, and decreased groundwater levels (Charles et al., 2010). The issues considered under this scenario are that groundwater recharge will decrease with a corresponding fall of the groundwater table

5.1.1.2 Localized flooding

From the climate predictions, the frequency and intensity are expected to increase across all ecological zones. The increase in the frequency and intensity of rainfall will exacerbate localized flooding. Increase in rainfall intensity and frequency combined with unplanned infrastructure in poor urban communities will result in localized flooding (Campion and Venzke, 2013) This will alter land surface and water pathways to result in an increase run-off with more erosion.

5.1.1.3 Sea level rise

The sea level of the Gulf of Guinea is projected to rise by 1m by the year 2100 and could lead to loss of over 1000km² of land with 132, 000 people likely to be affected. The east coast especially the Dansoman suburban in Accra is particularly vulnerable to flooding and shoreline recession (EPA, 2008). This is likely to cause saline intrusion into groundwater.

5.2 Potential Impacts of climate change on WASH services

The potential impacts of the developed scenarios on the existing vulnerabilities are qualitatively assessed in this section. These scenarios were developed from climate change predictions for Ghana. These impacts are either direct impacts that will possibly affect the WASH management, technology and the community.

5.2.1 Impacts of localized flooding

The types of improved water supply facilities (WHO, 2014)) in the six communities are protected wells (boreholes), community-managed drinking-water system and public standpipes. The impacts of the scenario on these facilities are as discussed.

This scenario will potentially cause a lot of problems for the WASH services. For those with their water source as groundwater, the water quality will deteriorate during floods. Whether a good sanitary seal is present or absent, the borehole could still be contaminated. For boreholes with sanitary seal in place, the

aquifer can still be contaminated by infiltrated contaminated water. The contaminated floodwater will infiltrate into the aquifer through opening such as other broken boreholes sharing the same aquifer or soakaways which were commonly used by vendors to drain water from their vending area. Similarly, boreholes without a good sanitary seal will be contaminated directly from floodwater. Contaminated groundwater poses a big risk to the health of the water consumers.

Floodwater might carry increased sediment load because of open defaecation and this may exceed the water treatment capacity of water the vendors when it ingresses into the pipe network. Vendors needs to be introduced to more treatment techniques as currently most of these vendors have no training on how to treat the water and just do 'trial and error' with the quantity of treatment chemicals. These increased sediment load may also reduce the dam capacity at the headworks which though are outside the study areas are the main sources of water for GWCL. The floodwater will carry on its way to the headworks higher concentrations of chemicals (pesticides) and microbial contaminants from farming activities along the rivers banks. This may affect the treatment processes at the various headworks in Ghana. Consuming such water will pose a lot of public health risk to the consumer.

The cost of water treatment will increase after flooding since more coagulants, alum and chlorine would be purchased due to the heavy load of solid waste and eroded sediments. This might lead to a shutdown of the treatment facility or increase the overhead water production cost. High cost will cause eventually cut most people in the urban poor community off the supply as they cannot afford the water anymore. This will increase the already stressed water supply system in urban poor communities. The stressed water system will pose a serious health and livelihood problems to the community as water-borne diseases are likely to increase.

Erosion may damage standpipes and even pipelines not buried deep and may cause permanent loss of boreholes. If standpipes or boreholes are destroyed,

there will be temporary loss of supply. Entry of contaminated flood water into water supply pipes at leak point or bursts areas may cause widespread contamination of the water supply system. This will compromise the health of water consumers. There is also a public health risk from contaminants entering the standpipe during heavy runoffs.

Septic tanks may overflow or get inundated. This will cause contaminated water to flow around people's homes during flooding. Since some septic tanks are not properly constructed as observed in Kotei, it will be easy for faeces to leave the septic tank and cause pollution downstream during flooding. On the reverse, as loads are carried around in the flood, this can result in Silt and solids being deposited in the septic tanks. The desludging as discussed in the earlier section is a major cost to the toilet operators and in their bid to recover the cost will transfer it to the customers and result in increased toilet prices. People who might not be able to afford it will use unimproved sanitation and another flooding will repeat the process.

In summary, the possible impacts of localised flooding will be negative and it poses a lot of public health issues to the urban WASH services. Though the quantity of water does not seem to be affected, the quality and accessibility will be affected by the flooding. On a bigger scale away from just the WASH facilities to the community at large, flooding will destroy their livelihoods and affordability of water will then be an issue.

5.2.2 Impacts of less available water

Less available water will cause the lowering of groundwater table. Lower water table means there is less possibility of the groundwater getting contaminated. Lower water table also means that toilet operators do not have to spend money often to desludge their septic tanks. As a positive of this scenario, a lower groundwater table means fewer disturbances in the septic tank and which is a necessity for the efficient functioning of the septic tank. The saved desludging cost can be use the money to improve other aspects of their facility to ensure they render quality service to their customers.

On the negative side, water shortages may intensify and potentially cause water rationing in the urban poor communities. Water vendors will not be able to save enough water as they cannot afford large tanks. Their customers will be forced to depend on limited water which is likely to increase public health risk because water usage will be prioritized and most personal hygiene use of water may be overlooked. Also, intermittent water supply will result in low pressures within the system and this may allow ingress of contamination into the water distribution network and cause public health risk. This will be risky partly because water vendors are not trained on how to treat stored water before selling it on to customers.

Since the skip containers are uncovered, instead of it being filled with water and waste as in the case of rainy season, the volume of the container will be used for storing only solid waste. More waste can be stored in the skip containers. Less available water will mean dry waste and this will increase the bulk density of waste in the uncovered communal skip containers. Since compaction is achieved by increasing the bulk density of waste, less amount of money will be spent in compacting denser solid waste. The low water table will positively ensure that the groundwater is not contaminated by leachate at the landfill site.

Less available water will mean rationed water supply to most vendors who are currently not planning for this situation. Vendors believe drought “will cause stagnation and borehole fractures may dry up”. Technically, low available water will result in low pumping yields and this will increase water rationing or increase the cost of pumping which will eventually expose the community to unhygienic conditions. They will resort to unhygienic water sources and be exposed to water borne diseases.

5.2.3 Impacts of sea level rise

With sea level rise comes increase in groundwater salinity but currently the boreholes in the coastal communities visited were only used for flushing toilets which makes the salinity less important. The lagoons around these communities especially Korle lagoon near Jamestown flood a lot due to sea level rise (Rain

et al., 2011) and inappropriate solid waste management. Waste thrown in the water course ends up decreasing the total volume available for water to flow and hence the water finds its way into the community. Assessing the impact of sea-level rise on a vulnerable coastal community in Accra-Ghana, Addo and Adeyemi (2013) presents the two major factors contributing to floods and erosion as increase in storm surge and higher sea levels. The shoreline is changing rapidly (almost 1.3m/y) which indicate a relatively high rate of erosion (Amoani et al., 2012). This erosion will expose pipelines and increase the rate of pipe burst, illegal connections and leakages. Most WASH infrastructure are close to the sea and at risk of sea level rise and storm surges. However, the sea defence project seems to be an immediate solution but will cause similar problems to other coastal communities without defence as these communities will serve as entry points for the impounded water.

5.3 Climate proofing recommendations

As part of the RCAA methodology, this section presents how to climate proof the urban WASH services in Ghana. This section is in this chapter because it forms part of the RCAA methodology and is consistent with the flow of information as well as the structure of the thesis. These adaptation options were arrived at from the focus group discussions with the community, interviews with stakeholders and direct observations. Using the suggestions from the stakeholders and observations as a basis, various feasible and workable options have been developed. Adaptations on WASH technologies were sourced from the vision 2030 literature (Howard et al., 2010) as shown in Figure 5-5. Options were only included if they were no regret options and will help improve the services and its resilience to climate variability. These adaptations were then allocated to the stakeholders directly involved in making the urban poor WASH services climate proof. These adaptations have been developed to reduce sensitivity, alter exposure or increase the resilience of the WASH services sector which according to Adger et al. (2005) form the cornerstone of adaptations.

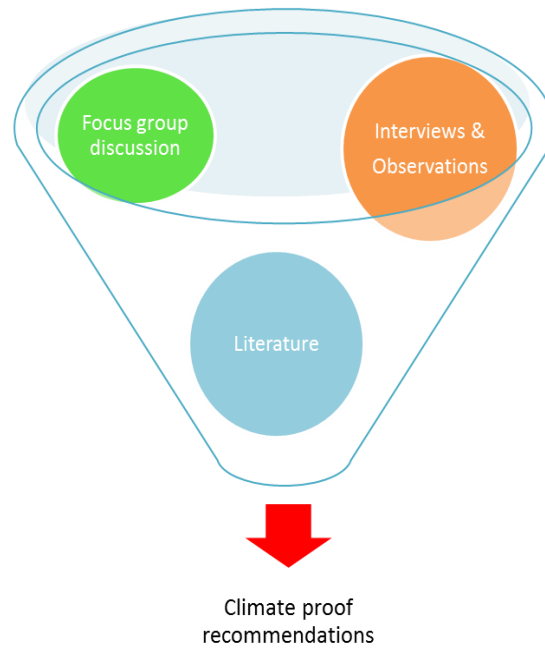


Figure 5-5 Recommendations development process

5.3.1 Community level

Solid waste disposal needs to be taken seriously in the communities by all stakeholders. There should be law enforcement as stated in the by-laws of the assembly to ensure that the community is not littered with solid waste. The assembly as part of its responsibilities should ensure that skip containers are provided at various vantage points in the community and these containers should be covered and emptied regularly to avoid overflow.

5.3.2 WASH Service Providers

To ensure that the urban WASH service is climate proof, WASH service providers have need to be proactive as part of doing the adaptation measures outlined in this section. Firstly, WASH service providers in each urban poor community need to form an association. It is easier to deal with a group than individuals which is evident as the water utility finds it difficult to address individual grievances of service providers. Forming an association will not only give local service providers a common voice but also serve as a forum where

people discuss common problems and come out with solutions to improve their services. The wash association can acquire storage tanks on loan for its members to pay overtime. This will ensure they provide uninterrupted water supply to their customers. This can be modelled after the WSUP household toilet provision project in Kumasi and Accra (WSUP, 2016), where WSUP facilitates the acquisition of loans from banks for landlords. WSUP then contracts a trained artisan to build the toilets. The landlord pays the loan over time. Civil society organizations and the private sector can help acquire loans to purchase durable storage tanks for water vendors so they pay overtime and this will improve water services in urban poor communities in Ghana. Because water service provision is run as a business in urban poor Ghana, service providers must devise a better saving scheme to take care of their maintenance needs as well as servicing any loans they might have acquired. They can engage the services of mobile bank operators “Susu”. They can save daily with them and make withdrawals for maintenance when need be. Also as a group, WASH service providers can be educated by experts to understand the needs to understand the risk of contamination during extreme climate events. This will arm service providers and prevent widespread contamination during and after extreme events. This will primarily improve their services and increase their resilience in the long run. However, to prevent maladaptation, this association should be monitored to avoid price hacks due to them monopolizing their service provision since defeat the very purpose of providing affordable and accessible water to the urban poor.

Secondly the recommendations explained in this paragraph are simply good WASH management practices that will ensure continuous access to a sustainable WASH service. Toilet operators must raise the height of the walkway to their facility above flood levels as walkways in Glefe were observed to be inaccessible. The elevated walkway will ensure that users get access to the toilet facility even during flooding. This will go a long way to decrease open defaecation as inaccessible toilet facilities was cited by interviewees as one of the reasons people practice open defaecate. Also, water vendors must ensure

the standpipe is properly drained. This according to the WHO vision 2030 will ensure the pipes are resilient in the face of flooding. Draining the standpipe will prevent mosquitoes breeding around the standpipe area especially after flood. For WASH vendors with mechanized boreholes must protect their pumps from power fluctuations by installing power surge protectors as climate change will exacerbate the power fluctuations.

5.3.3 Meteorological service department

The Ghana Meteorological Agency (GMET) has a core mandate to “provide efficient and reliable meteorological information by collecting, processing, archiving, analysing and dissemination of findings/meteorological information to end users” (Ghana Metrological Agency, 2016). GMET in Kumasi and Accra were understaffed especially at their monitoring stations. Climate data is essential in detecting early warning signs which will then give communities ample time to brace themselves for extreme weather events. Therefore, the department needs to employ qualified people to ensure they get accurate data from their monitoring stations. The agency needs to seek funding to be able to remotely monitor their stations. This will come with the task of building the capacity of staff should also be embrace the change. After the agency can collect, process, archive and analyze comes the task of information dissemination. The Agency should find an effective way to communicate expected climate extreme conditions to the vulnerable communities. The interviewees suggested the use of information vans as it has proved to be effective in disseminating cholera information especially in Accra. Communicating information early will give community enough time to prepare for any climate extreme event.

5.3.4 Ghana Water Company Limited

As the main body in charge of water supply in urban Ghana, they are mandated to ensure that consumers get access to safe drinking water before, during and after extreme events. They can achieve this by doing the following recommendations. Climate change will increase the frequency of pipe burst in

these urban areas as already explained in previous section, therefore company must have a programme in place to track and repair all leakages and ensure that they get access to all their service lines. This will result in an effective service provision by reducing Non-Revenue water. To achieve this, the company must collaborate with the municipal planning unit to ensure that permits are given for buildings in only allowed places. This will prevent people from building in a way to restrict access to the company's service lines. As part of ensuring that their service is efficient, track and prosecute vendors who pump water directly from the main pipelines. This will deter other vendors from pumping water directly from the pipe mains. This will also ensure the pressures in the pipelines are maintained.

In the urban poor communities, the importance of the water vendors must not be overlooked and hence GWCL must put in place a better communication channel with water vendors. This will be made easier if water vendors have an association so they can meet them routinely to explain policies of the company and help address the fears of vendors. They can use the same forum to educate water vendors on the different treatment processes needed in storage tanks during extreme climate events. High water bills that water vendor complained about could be explained at this forum as well to motivate them to play their role responsibly in the urban WASH service provision.

GWCL must not leave out the community at large and therefore they must raise awareness among the public of the risk of contamination during floods and the possible reduction in drinking-water availability. Public health advisory notices with advice about dealing with extreme climate events should be disseminated to urban poor communities. This can be in the form of flyers which show in pictures what treatment is needed during floods. The pictorial representation is important since a lot of people in such communities are not educated enough to read and write. Also, community information vans seem to be a way the assembly gets their messages across in the community thence it can be employed by the company.

5.3.5 Metropolitan Assemblies

The Metropolitan Assemblies oversee sanitation in these community and they are mandated to make sure the community is safe before, during and after any extreme event. On how to adapt, the Deputy Municipal Waste Director in Ashanti region suggests that the municipality needs to “provide more skip containers, educate the people to use the skip and enforce the law by prosecuting offenders”. In addition to this, the municipality needs to draft all these recommendation into their By-laws. This will be a blueprint on what the assembly needs and how to achieve it. With this blueprint in place, it will be easier for the sector to be driven and coordinated.

The assembly must also acquire modern equipment for effective waste collection (skip trucks, tipper trucks, rollers, compactors). This will require an initial huge capital but once they are acquired and properly managed, they will ensure effective waste collection. Also, the maintenance department needs to build the capacity of their human resources to ensure the equipment function effectively throughout their design life. To ensure that contractors working with the municipalities collect waste on time from the communities, records of all tipping vehicles and their tipping times should be kept. This can be tallied to know the frequency of waste collection and haulage time of contractors from their respective zones.

Increased flooding will require desludging of septic tanks, therefore there needs to be an environmentally safe way of disposing this sludge. Accra and Kumasi need a new liquid waste treatment plant to stop the direct emptying of effluent at places where flood water will not carry it back into the community. The assembly needs to seek funding to construct this facility so they can recover the cost over a period. Once the liquid treatment facility is in place and to recover the capital, operations and maintenance cost, septic emptier (vacuum drivers) must be tasked to properly dispose of waste at landfill site. There will be no incentives but rather an enforcement of their duties, since they have zones, the only way the assembly can certify contractors to be working should be the

amount of waste they bring to the landfill site. Since records will be kept (bullet point above) at the landfill site, total hauled waste can be calculated for each contractor working in a zone. This will be a monitoring tool to ensure proper disposal of waste. Alternatively, the assembly can consider expanding the network sewer lines once the treatment facilities are in place. This if effectively managed will prevent the direct emptying of effluent at places where flood water will not carry it back into the community.

5.3.6 NGOs

NGOs, whether local, regional, national or international, are catalysts in the adaptation process. As climate change intensifies, there will be the need for more adaptation programs which if uncoordinated can defeat the purpose of its implementation. This means that programmes of NGOs must be clearly documented and kept at the district assemblies. This will help other NGOs to know which communities needs prioritization to avoid duplication of similar programmes. This will make coordination of adaptation programs easier for the achievement of the common goals (like SDGs) rather than each NGO trying to please its donors. A well-coordinated sector will put a stop to “the districts become a dumping ground for any program at all” as noted by an interviewee from Kumasi Metropolitan Assembly.

NGOs should educate communities on hygiene practices and the need for people to keep their environment clean. Since solid waste management is a big challenge in all these communities, the need for proper disposal of refuse should be emphasized by NGOs when educating the communities. Also, NGOs should continue to educate communities on the impacts of extreme events on their water supply system. This will reduce the risk of the public to contaminations during extreme events. The education must be structured to raise awareness amongst the public of contamination issues during extreme events. For urban WASH to be resilient, NGOs must facilitate the formation of local WASH associations and play the advocacy and lead roles in helping water vendors acquire storage tanks so they can pay over time.

5.3.7 Researchers

Researchers complained of the receiving less attention in the sector. They complained that their research recommendations are not utilized. The recommendation to researchers is to work closely with these stakeholders so that their research can be as practical as possible. Climate change with its uncertainty will bring a lot of questions up in the minds of stakeholders and hence the need for researchers to be available. Stakeholders would want to know best ways of adapting, how to avoid maladaptation projects and a lot that will demand researchers to be up to the task to ensure that the urban poor WASH sector is resilient to climate events.

5.4 Summary of chapter

This chapter has developed climate scenarios and assessed its potential impact on WASH services. Recommendations have also been developed for the various stakeholders involved in the WASH sector. However, the difficulty is how easy these stakeholders can pick up these recommendations to ensure that the WASH services are resilient. What hinders them from adapting? How is the urban Wash sector in terms of adapting to climate change? Achieving resilience goes beyond these recommendations to a broader context of how the stakeholders are affected by politics, socio- economics and power play. The next chapter therefore will understand how these factors affect the ability of stakeholders to take up adaptations. It will look at the WASH sector and unpick factors that hinder or enhance the adaptive capacity of the sector.

6 ADAPTIVE CAPACITY ASSESSMENT

This chapter assesses the adaptive capacity of the WASH sector in Ghana. The analysis shows the various dimensions and explores which characteristics of this sector enhances or hinders its adaptive capacity. This chapter further outlines the challenges and opportunities and concludes with the reflections from applying the methodology to the urban WASH sector in Ghana.

6.1 Adaptive capacity dimension analysis

This section highlights the results of the adaptive capacity assessment from the fieldwork. The headings are the dimensions of the adaptive capacity wheel which also served as topic guides during the interviews.

6.1.1 Diversity

This section explains from the fieldwork how the institution allows for all kinds of problem framing as well as allowing actors within an institution to come up with their own solutions. The WASH sector has a clearly demarcated boundary. In the urban setting, the water is provided by the Ghana Water Company Limited and the waste and hygiene is under the management of the metropolitan assemblies (local government). Though the sector has clearly demarcated boundaries in terms of duties of various organizations, it is however flexible when it comes to policy programs and policy implementation. Actors have the freedom to frame their own problems and come up with solutions to deal with these problems.

Because of the complexities of problems in the WASH sector especially in the urban poor communities, there are a lot of actors trying to solve these issues. This multi-actor friendly environment gives various actors room to operate and this sometimes results in duplication and overlapping of projects. The difficulty of the municipality to track all these developments cannot be over emphasized as they do not have the resources to do that. There is problem solving going on at the community level that the assembly is unaware of and from the top, they are also planning different programs for communities. There needs to be

coordination in this sector to streamline all developments towards achieving the set targets.

There are diverse arrays of public and private partners involved in this sector. The sector also encourages different problems perspectives and different solution. There are no town hall discussions of policy implementation plans, though there are clearly demarcated duties for actors. This calls for WASH adaptations to be framed in locally-relevant ways.

6.1.2 Learning capacity

This dimension sought to ascertain whether there is trust among stakeholders and if they can recollect and learn from past events. This was probed further to find out if they have changed their approach in management style in recent years. The water utility company and the metropolitan assemblies work closely together on issues concerning urban poor WASH. Also, there is mutual trust amongst all the public organizations in charge of WASH. This encourages them to work together to ensure that urban WASH delivery is efficient. Though there is trust amongst public organizations, they do not give their best as they are aware of each other's problems and even if they solve theirs, collectively the problems will still exist. This leads to a highlighting each other's failings and instead of looking at problem solutions they end up blaming it on the "weak institution" as the reason why the problems keep occurring.

Even though there is awareness of each organization's difficulties and mutual respect, there is great mistrust between organizations that provides service and the people they provide services for. Organizations though mandated to perform their duties do not face any legal consequences for failure to deliver. The people who are supposed to benefit from this service on the other hand have a duty to pay for service rendered them and they also sometimes do not fulfil their part of the contract and blame it on the delivery not being satisfactory. For most customers, bill payments are not transparent enough for customers according to the reports the urban water company receives. They either complain about overpricing or inefficient delivery system. This further deepens the mistrust between the service providers and their customers. Customers resort to other

services and the water utility company also have no option than to disconnect them from their grid.

It was observed that the institutions did not have a range of proactive strategies but rather most of their actions toward climate change adaptation were reactive. This makes the organizations wait until a disaster occurs before they gather resources to remedy the situation. Interviewees could recollect past events but according to them, there has not been much change in terms of how things are done. The respondent from the municipal waste department said, “we will go down if anything happens again”. According to the ministry, people become motivated to take up adaptation programs right after a disaster occurs but their enthusiasm dies down as they gradually get frustrated by inability to rally collective support from all stakeholders.

There is a lot of mistrust especially between public organizations and private organizations and the people they provide the services for. The sector only encourages single-loop learning (Pelling et al., 2008) in direct response to events as actors try to find a workable solution. However, no institutional memory is built up from these events and this makes double loop learning (Argyris, 1977) impossible since actors do not reflect on their own strategies and goals. The sector practices a reactive learning rather than proactive learning.

6.1.3 Room for autonomous change

Interviewees were asked how easy it was for them to access information and how they could act according to their plans. This probed to know whether actors knew what to do in times of crisis and who to consult if they needed help to perform their duty. The urban water utility service has established a complaints unit for their customers to register their displeasure about the services they render. The waste management unit however has no such service and they are looking to establish such a unit at the assembly. The assembly however is supposed to communicate their plans to the municipality on radio at least once a year since this forms part of their Functional and Organizational Assessment Tool (FOAT) (Government of Ghana Ministry of Local Government and Rural

Development, 2013). The Government of Ghana as part of its efforts to improve the performance of the district and municipal assemblies in terms of efficiency, accountability and delivery of basic community services introduced a performance base grant system known as the FOAT. Every year, the assemblies are assessed on a set of agreed indicators and highly performing assemblies get rewarded financially as their discretionary funding is increased by the District Development Fund (DDR) which is contributed to by Ghana's development partners like Japan, Germany, and United Kingdom.

According to the NGOs and the researchers, information acquisition is slow within institutions due to bureaucratic processes. All the respondents were of the view that time is a very important factor in addressing climate related issues and it would be efficient if the bureaucracy was reduced. However, most actors unofficially find alternative ways by using "their contacts" to acquire information from their organization as well as other organizations. According to the respondents, this is "sometimes the only way to get a job done". "If you go through the right communication channel then it will take ages but you have to use what you have to get what you want in order to meet your target", a respondent from the municipality explained. This way of doing things seems to be working well in the WASH sector though the disadvantage is the difficulty in tracking the flow of information and to verify how authentic the information is.

In the urban communities, the organizations use announcement vans to communicate to the community. These are very effective especially after an outbreak of disease or after a disaster occurs. Radio adverts have also served as means of communication in the past as most interviewees recounted. The issue here is the complexity and dynamics of such communities makes it hard for them to be reached individually. They however try to get their information across and hope the rest will hear by word of mouth.

There are alternative ways of acquiring information and plans are normally abandoned after being frustrated. There is a high degree of room for autonomous change. Because reactive learning is practiced, actors do not go according to a plan. This introduces flexibility and autonomy which allows for

different actors within this institution to improvise and find alternative solutions. There are also few forward-looking plans to support actors in the sector according to the respondents.

6.1.4 Leadership

This explains whether visionary leaders are supported and there is collaboration within the sector. This also explains the direction in which the sector is moving and whether there is a focused goal. The leadership in this sector is politically driven. This means that if WASH service provision is not a core vision of the government - which is mostly their vision, then these institutions are not fully empowered to deliver their core mandates. The direction of the sector is basically dictated by the politicians and their willingness enhances the adaptive capacity. Though it is difficult to tell how effective leadership is from this research, from probing and observation from vulnerability assessment as well as interviews with researchers and NGOs, the leadership style always provides a clear vision but not a carefully followed plan to achieving this vision. Also since the leadership is predominantly politically driven, it is not always able to bring all people together since people are generally not interested because of their political affiliation. This also affects project continuity as leaders are often changed even under the same political regime. Each leader might come with personal plans of how to achieve the vision. This stalls programs like adaptation plans and reduces the capacity of stakeholders to adapt.

Most people interviewed were of the view that on paper, WASH looks a priority but in reality, it is not. Their reason being that WASH programmes are never prioritised when budget is being allocated. Their programs are not always backed fully by the government especially at the local government level and according to the researchers and NGOs, the sector ministry does not “walk the talk”. This will reduce the capacity of institutions especially since WASH is not given all the attention it deserves. The ministry sets out its plans but looks elsewhere for help to achieve its target. The ministry normally looks to INGOs and NGOs to help it provide services for the urban poor. This sometimes comes with an uncoordinated development since these organizations have their targets

which are sometimes driven by their donors and may not necessarily be what is needed by the urban poor communities in Ghana.

The sector ministry is expected to lead by “walking the talk” in WASH adaptation. It is also expected to coordinate various actions at the ministry level and the assembly is also supposed to play the coordination role at the assembly level. The politically driven leadership in the WASH sector means parties do not structurally cooperate because power always comes into play. This hinders structural collaboration because of a fear of power play. There is no forward-looking “visionary” leadership in the sector which incorporates issues of climate change adaptation into the sector’s management.

6.1.5 Resources

The ability of institutions to generate the necessary resources was the major concern for understanding this dimension. This was understood since it supports the effectiveness of an institution especially in terms of carrying out adaptation plans. Human and technological resource has been a problem to adaptation and the provision of resilient services according to interviewees. The lack of technological and human resources was blamed for the inability of service providers to provide sustainable services to most people especially those in the urban poor. There are not enough personnel to undertake all the roles to ensure that the service provided is efficient. For instance, the sector needs a lot of human resources to fill up vacant waste management positions which are available from the central government level through to the assembly level and down to the community levels especially in the discussion of waste management. These people are non-existent or highly untrained for the complexities of their job and since they are not highly motivated, adaptations and for that matter good service provision suffers.

The use of technology on the other hand has not been progressing smoothly as they lack the capital to purchase them for the sector. The respondents’ response of “lack of financial resources” cannot be over emphasized in this research. The WASH institution believes it can solve all its problems if only the government provided them all their budget allocation. According to the ministry,

the urban water supplier can acquire loans and then service the loan as an organization. Their major concern is that the tariffs are not helpful for them in terms of cost recovery. They therefore try to avoid difficult areas like the urban poor communities because of difficulty of revenue

Others are of the view that availability of resources is not a problem but rather accessibility of resources is. This they explained by saying there is immediate response after a disaster occurs. Government is able to quickly engage both the private and public sector to work harmoniously by providing them with financial resources as well. This short-term measure does not always result in resilience. But until an emergency occurs, they always get the “there is no money” answer. The developing nature of the economy has made institutions prioritize the addition of new infrastructure over the sustainability of their entire infrastructure. Since climate change discussion is best situated within the sustainability of infrastructure to continuously provide services, adaptation plans always come second to infrastructure development.

For resources which comprises of human, financial and authority, it was scored as low by most interviewees. There is little financing in the WASH sector. With the little resources allocated to the sector, priority is given to infrastructural modernization rather than adaptive capacity. This also translates into knowledge development and the availability of personnel. Authorities have clear duties but their adaptation responsibilities are not mandatory.

6.1.6 Fair governance

Fair governance is known to support the adaptive capacity of institutions. The extents to which policy processes support equity, respond in time and are accountable were understood from the perspective of the stakeholders. Fair governance is presumed to exist in almost all democratic countries however, from the field visit it was realised that the WASH sector is only a priority on paper and does not translate into action. The WASH institution concentrates on providing new services (new infrastructure to new people) by expanding coverage without considering the sustainability of these services. Since climate change discourse is rooted firmly in the sustainability of services, there is also a

difficulty and that has accounted for the low adaptive capacity of the WASH sector in Ghana and likely the case in the most developing countries.

The governance in the WASH system according to the public sector is unfair and biased towards private sector especially in waste collection. The Private Public Partnership (PPP) which is aimed at benefiting both helps benefiting only the private sector. They get their profit from work done whilst those in the local government sector believe they could have done the job if only government invested in them. According to the private waste company, the private sector also thinks it is unfair as they sometimes must further provide basic amenities to the public sector to enable successful supervision and monitoring of PPP projects.

When it comes to the issue of equity, the public sector believes the private sector has an undue advantage over them in the discharge of their duty. They believe the unfairness comes from the fact that any time the government has engaged the private sector for any WASH related work, funding is made readily available to the private sector and this according to them ensures successful completion of their duty. They would have done more as a public sector if only they had all their budget allocations and this would have ensured that WASH service delivery in Ghana was efficient. A respondent from the assembly cited an instance where after the 3rd of June 2015 major floods in Accra, most private sectors came on board and the public sector were made to play the support role or they were completely side-lined. Fair governance of the institution was scored as medium. Though there is democratic governance, there are no fair divisions between private and public organizations. Civil societies have the room to operate and can perform their roles due to equity.

6.1.7 Adaptation motivation

Interviewees were posed with questions that sought to understand the psychological reasons behind their capacity to adapt. These questions were meant to give more understanding on why they do what they do and serve as a check on what is happening. The questions ranged from what they perceive as risk, what they can do about the risk and how they can be motivated to take up

climate change issues if they are not motivated. Most actors interviewed perceived that the threat of a changing climate is low. They explained that climate change might not have any impacts on their WASH services except for the water resources. Those that perceived the whole WASH services to be at risk to climate variability were not enthusiastic about what they can do to adapt to the situation. They just believe that the institution has a lot of priorities and concentration on adaptations will not be beneficial to them especially as there are other sectors competing for the resources. They explained that there are lots of pressing issues with the service provision that they are so engrossed in and will find it difficult to concentrate or add “any other business” to what they are already doing.

For the lack of motivation, most actors complained of the lack of incentives and lack of needed resources to work cordially to achieve their targets. One respondent from the assembly recounted how “plans are left on the shelves because of lack of funds”. This gradually kills the enthusiasm of workers especially of young graduates who come in with a lot of energy and exuberance. “It is difficult to change the system and you are likely to be changed by the system” another actor lamented. From the assembly waste department’s respondent, “There are no collective efforts from all other actors and no matter how hard you try even with all the resources if you are not supported, you will give up”. The lack of motivation on the institution and the rules of the game were also blamed. According to them, the system does not reward exemplary workers. People who work hard are not awarded or recognized. This they said would have been a form of example for other actors to follow their lead as everyone likes to be recognized. On the other side of the coin, the institution does not punish less enthusiastic or “lazy” workers. Based on salary, people on the same pay grade earn the same and there is no distinction between performing and non- performing workers.

Generally, the adaptation motivation was scored low. This is because most of the urban poor communities’ flood often and the institution are expected to be motivated and proactive in adapting rather than apportioning blames. There

should be new ways of communicating Climate Change adaptation to actors and persuading other stakeholders to recognise adaptation as an important issue and hence the score of very low.

6.1.8 Adaptation belief

Interviewees were also asked about their role in the process and whether they think their role is realistic in the current socio-political settings of the country. Respondents cited various reasons why climate change adaptation in the urban poor WASH is not effective. This section however probed further to understand why the institutional capacity is at the state it is now. They were asked about their beliefs and it was understood that adaptations are not always considered because they believe they have a lot of coping skills from an individual and institutional perspective. This belief stems from the daily encounter of people with a lot of risk. In a typical urban poor community, a lot of things are dangerous and risky open defecation, disposing off garbage at unauthorised places at night. This has made them develop insensitivity towards risk. This believe makes it difficult to convince many people to take up adaptation measures especially in the poor urban areas.

The main belief here is “when we get to the bridge, we will cross it” according to a respondent from the water utility provider. This is because policy makers struggle to get adaptations to work and get frustrated over time. It is also partly because it is not easy for one to demonstrate the need for adaptation. People therefore wait till a disaster happens and then the institutions can build support for adaptations. The belief here is they will work better reactively than proactively. Because of the difficulty in persuading stakeholders to take up adaptation measures, they wait till something happens and they use it as an argument to get all the stakeholders on board.

Most of the actors believe in the few adaptation plans, believe that there are adaptation measures available and they are realistic. They are aware of the role they are supposed to play in the ensuring that adaptation measures work toward achieving resilience. They believe it can be achieved if they had the

necessary environment to work in. Most also believe that following through adaptation plans is the way to go in dealing with climate change.

The adaptation belief understood from of actors is high. They believe there are few adaptation plans and these plans are realistic and can be achieved. They however believed in themselves rather than set organizations to achieve resilience in the urban poor communities.

6.1.9 Summary of section

Though the ACW is represented by the mean total score of all the interviewees, this section highlights the mean scores of the various stakeholder groups. The metropolitan assembly generally had the lowest ratings of the institution in most of the dimensions as shown in

Table 6-1 and Figure 6-1 below. This is because at the municipality level, WASH issues compete with other sensitive sectors and they are normally not prioritised. On the hand, the ministry –which is the lead player in the sector relatively, scored most of the dimensions high. The different appreciation of the adaptive capacity of the sector itself signifies that there is a lot work needed to be done to enhance the adaptive capacity of WASH sector. Also, the state of the adaptive capacity of WASH sector in Ghana is shown below in Figure 6-1. This representation is for communicating the strengths and weaknesses of the sector to the actors. From the table, a scoring of 5=very high, 4=high, 3=medium, 2=low, 1=very low.

Table 6-1 Stakeholder groups' assessment of adaptive capacity of WASH institution according to the scores given during the interviews

| Dimensions | Ministry of Water and Sanitation | GWCL | Accra Metropolitan Assembly | Researchers | NGOs |
|----------------------------|----------------------------------|------|-----------------------------|-------------|------|
| Diversity | 4 | 3 | 1 | 3 | 3 |
| Learning capacity | 3 | 3 | 2 | 3 | 3 |
| Room for autonomous change | 3 | 3 | 2 | 3 | 2 |
| Leadership | 4 | 4 | 2 | 2 | 3 |
| Resources | 2 | 2 | 2 | 3 | 2 |
| Fair governance | 4 | 2 | 2 | 3 | 2 |

| | | | | | |
|-----------------------|---|---|---|---|---|
| Adaptation motivation | 2 | 2 | 1 | 2 | 2 |
| Adaptation belief | 4 | 3 | 4 | 4 | 4 |

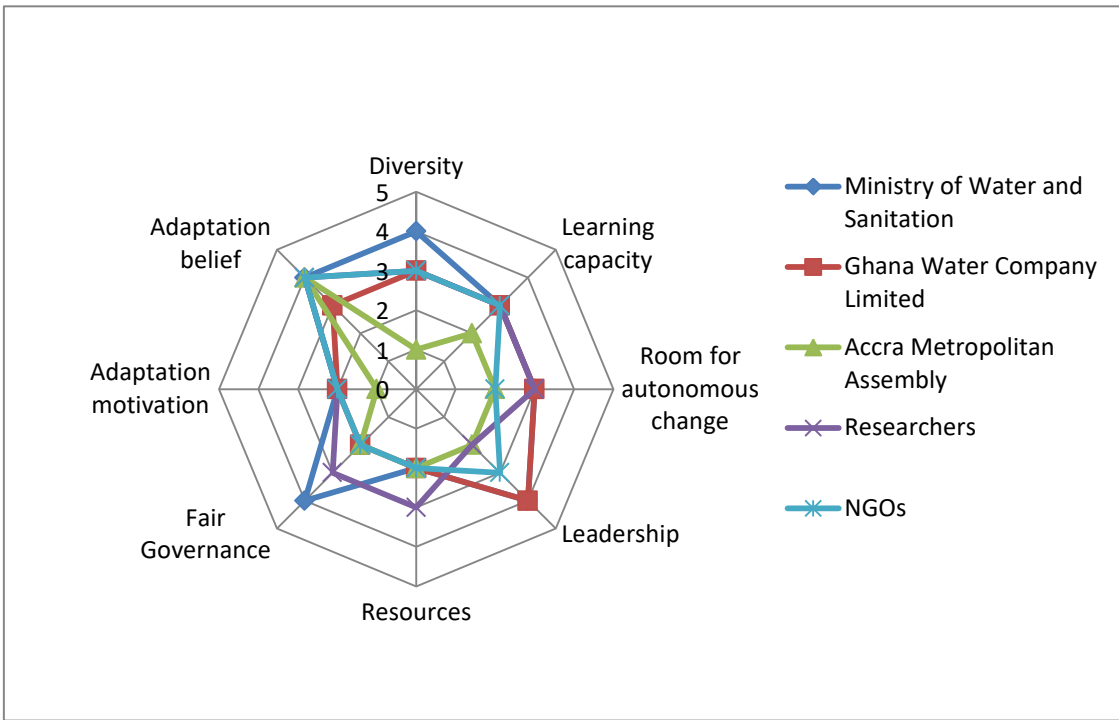


Figure 6-1 Adaptive capacity of WASH institution

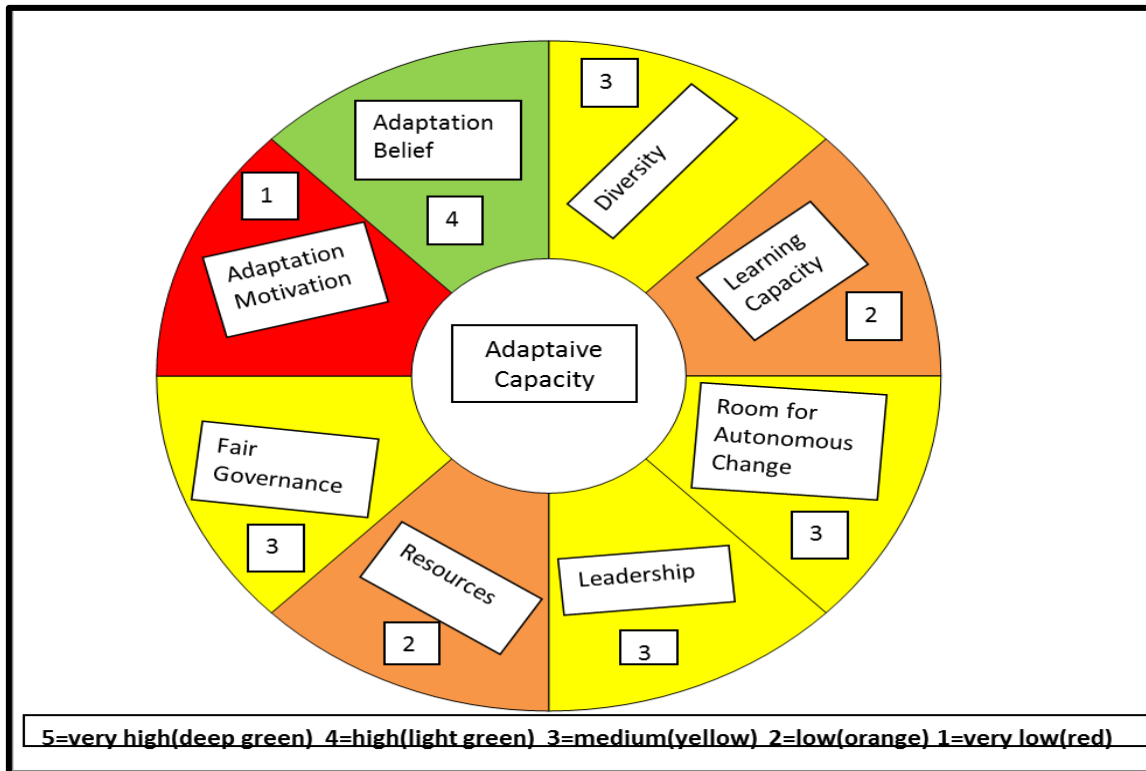


Figure 6-2 Adaptive Capacity Wheel of the Urban WASH sector of Ghana

6.2 Enhancing adaptive capacity

This section presents what the challenges are and what can be learned from it to enhance the adaptive capacity of WASH stakeholders to achieve resilience. It discusses the challenges (learning capacity and adaptation motivation) and ways to improve them. It is followed by the discussion of the opportunities in enhancing adaptive capacity.

6.2.1 Challenges

Learning capacity was scored as low partly because there is still mistrust between social actors. This mistrust does not encourage high learning capacity within the WASH sector in Ghana. This mistrust has been built over the years and has increased reactive coping strategies especially at the community level. This has further contributed to the complexity of the informal WASH sector at various spatial levels. This is consistent with work done by (Clarvis and Allan, 2014) in Chile where they found the lack of trust and cooperation in the water sector as a hindrance to adaptive capacity in Chile water which serves as a

model for other water sectors in south America. Improving learning capacity can contribute to the enhancement of adaptive capacity by providing a way to change decision-making or the way of doing things even as uncertainty intensifies (Lebel et al., 2010). The general human capacity is low and hence learning capacity too is low. Unlike the private sector which can boast of professionals, the government sector is unable to attract professionals. Without professionals in the sector, the understanding of the problems and uncertainties will be inhibited. Increasing the human capital will ensure that excluded or marginalized voices are incorporated in decision making and this will encourage the development of new ideas, social- technical transition and alternative policy discourses.

Actors admitted to not learning from past experiences. Things have not changed since the last major flood (June 3, 2014) occurred. This is contrary to the fear of making mistakes and sticking to routines which Argyris, (1990) anticipates as a being a hindrance to learning from past experience. This is rather due to lack of continuity in learning and according to Gunderson and Holling (2012), learning makes actors use their experiences to change their understanding of climate related issues. There is no institutional memory as a result of various actors representing their institutions at various times at seminars and this does not encourage continuous learning. Because various actors do not report back to their organization what they had learnt, it stays with them and never gets applied to enhance their adaptive capacity. There is no desk officer in charge of climate change issues in these organizations. The establishment of this desk will ensure there is a focal person to ensure there is continuous learning within the organization. This desk officer can also be tasked with ensuring that climate change issues are considered at WASH planning stage.

The adaptation motivation of actors in the WASH sector was very low. This is because adaptation is not an immediate priority in the WASH sector of Ghana, like in many developing countries; the WASH sector is concerned with increase in access, affordability and coverage at the expense of a sustainable and

efficient system. However, the fact that climate change threatens all these goals makes it worth considering and needs to be given equal attention. Also for most people in the WASH sector, they do not perceive climate change as a risk to WASH services and could be a reason for the low adaptation motivation. Berkhout (2012) argues that the perception of risk by an institution shows how actors respond to adaptations. Reactive adaptation is the current practice, however this type of adaptation does not improve the long term ability of the sector to cope with future climate change but rather it is a short term measure use to regain stability (IPCC, 2001) This is why stakeholders get frustrated because after a crisis occurs, short term measures are put in place and these are not sustainable. Low adaptation motivation results in lack of willingness to adapt and this hinders adaptation (Grothmann et al., 2013).

6.2.2 Opportunities - Flexible and mouldable system.

From the results, the adaptive capacity assessment of the urban WASH institutions showed that the learning capacity and adaptation motivation of actors were low even though adaptation belief was found to be high. With high belief in adaptation, one will expect actors to be motivated as well. This shows that the motivation of actors goes beyond what they believe in to a broader sense of the characteristics of the institutions and how they can apply what they believe in to achieve a desirable system. The WASH sector is politically driven, lacks resources and lack of trust, and these does not motivate actors therefore it hinders adaptive capacity. To achieve a more desirable state, a system needs to have more adaptive capacity by integrating climate change into urban WASH services (Huq and Ayers, 2008). This should be done by first communicating adaptation not as “any other business” but rather it should be integrated into all WASH planning processes. This will help change the perception that adaptation is luxury and “Ghana as a country is not at that level yet”. Though climate change has been integrated into the national development policy, it lacks the involvement of the people at the community level especially those in urban poor communities. The top-down approach needs to give way to a more participatory approach. This will increase the trust and advance the social empowerment of

the urban poor. Social empowerment is the “ development of a sense of autonomy and self-confidence, and acting individually and collectively to change social relationships and the institutions and discourses that exclude poor people and keep them in poverty” (Blomkvist, 2003). This will ensure that the adaptive capacity of institutions is enhanced to improve resilience.

7 DISCUSSION

This chapter begins by testing the hypothesis that “the vulnerability of WASH services is spatially and socially differentiated in Ghana”. It further looks at where this research sits in terms of theoretical contribution to the adaptive capacity literature. It also reflects on the two methodologies applied in this research and further suggests ways of improving on them.

7.1 Cross-ecological comparative

The Ghana National Climate Change Adaptation Strategy (2014), states that “Ghana’s vulnerability to climate change is spatially and socially differentiated because each ecological zone have unique physical and socio-economic characteristics that define their sensitivity and resilience to climate change impacts” The vulnerability of a system is because of its climatic issues, physical and socio-politico-economic issues affecting the system. The questions resulting from this statement- are the WASH vulnerabilities in each ecological zone different? Is there a need for ecological zone-specific policy initiative and programmes to address the impacts of climate change in Ghana? To answer these questions, the previous chapters have discussed from interviews, observations and focus group discussions the vulnerabilities in the six communities across three ecological zones. Therefore, the purpose of this section is to bring into focus similarities, differences and patterns in the cases presented from the three ecological zones that were discussed in the previous chapter.

7.1.1 Similarities

This section highlights the similarities in the cases presented and what they mean for the research as a whole. They are organized under similar topics for which the baseline vulnerabilities were presented for the various cities.

Facility type

There were similar improved water and sanitation facilities that were in use in the six communities visited. As mentioned earlier, they include: boreholes,

piped water systems and community owned water supply systems and ventilated improved pit latrines.

Facility usage

The purpose of exploring this theme in all the communities was to understand if the WASH services have specific problems they face during the two different seasons in Ghana. For all the six communities, demand for the WASH services was observed by the local service providers to vary seasonally, weekly and daily. The daily demand for toilet facilities in all three zones was high in the mornings and evenings. The weekly demand variations for the three zones was mainly since most of the people in these communities traded or worked outside the towns, hence the pressure on the facilities were relatively lower on weekdays than on weekends. The seasonal variation was mainly because the walkways to the toilets were mostly inaccessible during the rainy season thus making open defaecation the preferred option regardless of the health impacts. Flooding causes the sludge to be washed out with runoff water. Despite the varying patterns observed in the usage and demand of WASH facilities in the three ecological zones studied, the major similarities that cut across all three zones are the inappropriate use of the toilet facilities- mainly due to lack of education and the reduced demand for water vending services during the rainy seasons

Facility robustness

This theme explored how these facilities were performing under climate variability and climate extremes. The possibility of erosion in all the six poor urban communities is very high. This is predominantly due to the poor landscaping associated with such communities and the three zones studied as part of this work were similar. During intense rainfall, the runoff water washes off the topsoil, thus exposing buried pipelines. The exposed pipelines are then prone to bursts and leakages. Subsequently, dry seasons are accompanied by low pressures in the supply system and it increases the rate of leakages which serves as openings for contaminants to ingress into the distribution network. This negatively affects the quality of water being supplied to these communities

by GWCL despite the company's efforts to treat the water to meet local and international standards. Vendors however, partly treat the water in their storage tanks before supplying to the communities. The treatment method is left to their discretion.

Furthermore, as explained earlier, local service providers observed that there was high water demand during the dry seasons and low water demand during the wet seasons in these communities. The fluctuation in pressures associated with the seasonal variation of water demand caused pipes in the distribution networks to burst. Again, pipe bursts during the dry season may be attributed to the exposure of the pipes to direct sunshine. These frequent pipe bursts, coupled with the inability of the GWCL to replace them due to lack of funds negatively impacted the robustness of the WASH facilities in the three zones. Additionally, during the wet seasons, the high rainfall causes water to seep through the cracks that were formed in the septic tanks during the dry seasons, thus making them overflow. This was evident in all three zones but more pronounced in the towns in Tamale during the perennial floods because the facilities were older. The overflow of these septic tanks caused an intolerable stench, thus making usage of the toilet facilities provided in these areas unbearable. Another point worth noting is the fact that GWCL relied on the supply of electricity to pump water to these towns. The inconsistent supply of water by GWCL due to frequent power cuts in the dry season had negative impacts on the robustness of the water facilities. Though most of the water vendors installed pumps to pump water into storage tanks to consistently supply water to the communities, the effectiveness of these pumps still relied on the constant supply of electricity to the communities. In some occasions, the fluctuations in the electricity currents caused the pumps to breakdown. Notwithstanding the fact that all the three zones shared similarities with regards to the impact of power cuts on the robustness of the WASH facilities, except that the impacts were less pronounced in Tamale because most of the boreholes were fitted with hand pumps. This is attributed to the relatively low electrical load of the Tamale city because of the smaller population and less industrial demand as compared to the other two cities in this study. Regardless

of this, the frequent breakdown of hand pumps for boreholes in Tamale remained an issue. This shows that all the facilities assessed were not robust to climate variations and had issues which were specific to the different seasons of the year.

Maintenance

Inadequate operation and maintenance affects WASH service levels (Batchelor and Smits, 2011) and hence there was a need to understand the maintenance culture of service providers in the three ecological zones. Despite challenges associated with WASH services maintenance, WASH service providers in the six communities made efforts to maintain their facilities. All six communities shared similar maintenance cultures and these include replacement of pipelines, pump repairs, cleaning of the toilet facilities, and emptying and renovation of septic tanks. However, the frequency and scheduling of these maintenance works varied from one vendor to the other. The common practice with maintenance was reactive approach by all service providers.

Local WASH association

Local WASH organizations are necessary for addressing common challenges faced by WASH service providers in a community. It was clear from the interviewees' accounts that none of the communities had an effective local WASH group in place, even though the two communities in Accra (Glefe and Jamestown) had attempted and failed in the past.

Climate change awareness

The perception of risk is very important in achieving resilience and the interviewees were aware of the variations in climate patterns and to some extent have noticed the impacts of these changes on their WASH facilities. Most of these vendors were aware of the weather from their knowledge in fishing or farming which is weather sensitive. They admitted to the difficulty they have predicting the weather in the past years. However, all the service providers had a very basic understanding of the science of climate change and this is due to

the lack of climate education, which is associated with people in poor urban communities like those studied in this thesis

7.1.2 Differences

From the different cases presented in this chapter, there are differences which will be highlighted in this section. The section will explore whether these differences are just a case of the communities chosen or are particularly related to the ecological zones. Also, the importance of these differences to the climate change vulnerability will be explained. Comparing within and across ecological zones the current vulnerabilities faced by the WASH sector, few differences were realised. These differences observed or interpreted from the interviewees were however not all due to fact that the communities were in different ecological zones. Some of the differences were due to the nature of the population density of the community. For example, Glefe and Jamestown both in Accra had bath stalls which were not seen in the other communities. Within the same coastal zone, Clemenz (2016) assessed the vulnerability of the WASH services in two communities in Accra (Chorkor and Shiabu) and they had no bath stalls. This shows that the stalls depend on availability of space for the locals to construct their own wooden bathrooms outside their compounds.

7.1.3 . Pattern

To solve WASH problems, Batchelor (2013) suggest the need to systematically identify the root causes. This section has set out to do exactly that and concludes that though different urban poor communities in different ecological zones in Ghana were studied, the root causes are similar across all the six communities within different ecological zones and therefore WASH systems are already failing to meet their core mandates. This conclusion is consistent with work done by (Heath et al., 2012) and (Clemenz, 2016) where they also observed that the vulnerabilities of WASH services to climate change in Ghana and some other low and middle income countries were due to WASH management problems. Heath et al. (2012) in developing the RCAA assessed the vulnerability of WASH services in communities in Lusaka (Zambia), Naivasha (Kenya) and Antananarivo (Madagascar) and concluded that the

adaptations needed for addressing this vulnerability was good water management practices. Also Clemenz (2016) in his Masters theses assessed the impacts of climate change on two coastal communities (Chorkor and Shiabu) in Accra, Ghana and concluded that the vulnerabilities were due to lack of adequate solid waste management and the lack of hydrological sound drains. These problems are societal, infrastructural or resource-related or a combination of all as highlighted in this thesis in section 4.4, the vulnerabilities observed mostly resulted from intermittent water supply, poorly managed solid waste and lack of spatial planning. This work has answered the question of whether the vulnerability of WASH is unique to each ecological zone by systematically proving that they are similar and hence common vulnerability reduction programmes for WASH services can be employed across urban poor communities in Ghana.

Similar vulnerabilities across the ecological zones call for similar adaptations across all urban poor communities in Ghana. Therefore, the RCAA recommendations as seen in chapter five of this thesis could be designed for the various stakeholder groups even without the better understanding of the resources and governance constraints that the ACW revealed. These recommendations were aimed at tackling the root causes because the service is unable to even meet its core mandate. This observation from the results is consistent with observations made by UN Water, (2008) - 'the capacity of the WASH sector to even carry out its core mandate of service provision is very poor, particularly at the decentralised (local government) level'. This therefore calls for the type of adaptations to be "no regret" options No regret adaptations are decision options that environmentally and economically justifiable now and continue to be justifiable no matter the future climate (Willows and Connell, 2003). These types of adaptation measures are important because of the complexity of the urban poor WASH sector. The "no regret" adaptations as developed for the various stakeholders in chapter five of this thesis will ensure that the robustness of the services is improved even if there are no extreme climate conditions. This is very critical to this research especially because of the conceptual nature of the hydrological scenarios which makes the assessment

broad brush stroke. These actions can be picked up by all stakeholders since they make environmental and socio-economic sense. They ensure that the urban poor WASH services are not maladapted but rather resilient.

Even though the urban poor stand to suffer more from climatic changes than other urban residents (Paton and Johnston, 2001), they have not received much attention in Ghana and in most low and middle income countries as they compete for attention on limited resources. This research even with its “broad brush strokes” demonstrated the need for a practical call on the urban WASH sector in Ghana to take adaptations seriously and seek funding for WASH services to achieve resilience.

7.2 Contribution to the adaptive capacity literature

According to Hill and Engle (2013), institutions are necessary agents for transforming coping capacity to adaptive capacity. From the results, the overall adaptive capacity of the institution was low however there were signals that pointed to the fact that there are a lot of ways actors have coped and will cope with situations. Apart from the lack of resources which seems to be a major problem in most lower and middle income countries, the issue of mistrust within the institutional setup hinders the learning capacity of the institution (Pelling and High, 2005). The issue of mistrust increases the power of informal sector as most stakeholders over the years have had to look within themselves for coping strategies rather than depend on formal organizations. Formal institutions because of their set rules and responsibilities can enhance their adaptive capacity better than the informal sector where there is no coordination and collaboration which leads to more reactive adaptations.

Ideally, formal organizations sets standards and priorities, resolves conflicts and ensures that there is cooperation among players (Huntjens et al., 2012) and all these enhances proactive capacity. These organizations because of their set rules have rigid operations which act slowly and are difficult to change. In most of the developed country specific literature on adaptive capacity, rigid institutions are primarily seen as hindering factors because they are robust structures that generally resist change (Powell, 1999). In such countries, Pahl-

Wostl (2009) argues that they suffer from “over regulations” put in place by rigid bureaucratic processes. The question here is how to “open up” institutions and make them more flexible. However, the results from this research show that the institution assessed is already flexible and opened-up. This flexibility results from the fact that even though the Ghanaian WASH sector is politically driven, it encourages diverse problem framing and different solutions so that different actors can use different approaches rather than being constrained to work within a policy directive. Low institutional adaptive capacity has resulted in individuals not trusting formal organizations for protection or looking at them as the torch bearers when it comes to adaptations. This has increased the complexity of the WASH institution. This research seeks to contribute to the evolving literature on how to enhance the adaptive capacity of flexible institutions. Within this flexible yet complicated institution lie questions like at how can adaptations effectively take place at all levels? What will be the “rules of play” and how can maladaptation be avoided?

To answer these questions, there is the need to understand the tensions between the top-down and bottom-up approach with the focus on how to enhance the adaptive capacity of individuals in the WASH sector. The aim of this discussion is not to prioritise one approach over the other but rather to draw positives from both approaches to inform the enhancement of the adaptive capacity of a flexible and multi-level institution like the urban WASH sector in Ghana as shown in Figure 7-1. At the base of the vertical urban WASH spatial level are the local WASH service providers and individuals involved in the provision of services. As explained already in the previous chapter, these individuals have had to survive by making sure their services survive. In their quest to survive, they have developed a lot of coping methods. These coping methods have mostly been developed reactively to survive. However, the question that remains is whether these coping capacities can stand the test of time and result in resilience.

Whilst the top–down approach is concerned with making sure that policies are set out to translate aims and objectives into actions at all levels, a bottom-up

approach is concerned with shaping the detailed content of policies as through multi stakeholder participation at the local level (Elmore, 1979). Hence an adaptation framework is needed to provide a supportive context for individuals and local-level adaptation decisions since adaptation is not only the duty of larger scale organizations. This will ensure that the various activities at the local level do not distort the high-level frameworks at the national level or cause maladaptation. For example, as witnessed from the field visits in the communities, some water service providers pump water directly from the main GWCL pipelines into their storage tanks. This action decreases pressure in the pipes and allows ingress of contaminants. Even though to the service provider it is a “solution” to his problem, his actions are putting service delivery at risk. Though these issues can be put down to mistrust, even with adequate trust and resources at the local level, the success of planned adaptations depends largely on the role formal organizations and non- governmental organizations play (Westerhoff et al., 2011). This thought is highlighted by Amaru and Chhetri (2013) when they suggested that the bottom-up approach can be effective only with the collaboration of formal organizations. This is not to say that it will be easy to incorporate the local stakeholders into the decision processes as Sherman and Ford (2013) recognises that past attempts to incorporate local stakeholders in the top-down approach has proved difficult. However, it is important to put in efforts to ensure that it achievable.

To conceptualise this discussion, it looks to build on earlier discussions of Engle (2011) on how adaptive capacity reduces vulnerability. This discussion however looks at how best to allow informality as discussed above to operate at the local level and coordinate it with structures and guidance. This research proposes that to enhance adaptive capacity of the WASH sector, the informality because of coping when coordinated and guided will give the flexible and easy to deform institution rigidity which is needed to sustain the institution and avoid maladaptation to ensure that the sector is resilient to climate change issues.

From Figure 7-2 below, which is a modification of Engle (2011), more informalized institution means low proactive adaptive capacity as seen in row 1

of the figure. The uncoordinated reactive coping capacity of various actors eventually leads to high vulnerability because of small adaptive capacity. On the other hand (row 2 of the figure) an efficient and effective formalized institution results in high adaptive capacity which lessens vulnerability thereby achieving a more desirable system. For example, it will be easier for Ghana Water Company Limited to enhance their collective adaptive capacity just by changing their leadership style or encouraging solution generation at all levels within the company, not just in senior management. This shows that the more structured or shaped the institution is, the higher the adaptive capacity and the less the vulnerabilities hence the more resilient the system. The word structured used here does not mean rigid because rigid institutions do not encourage things like learning capacity, visionary leadership amongst others which are critical for enhancing adaptive capacity but rather well coordinated to build resilience . Therefore, to conclude, this research recommends that larger-scale institutions can also enable adaptive capacity at the lower- and individual level by providing structures and guidance for collective action which is needed for adaptation. As a practical example, Ghana Water Company limited can educate water vendors on how to treat their water in their storage tanks to avert the spread of diseases. As shown in row 3 of Figure 7-2, informality, if left to operate but supported and guided, will enhance the adaptive capacity across various spatial scales and this will make the institution less vulnerable to climate related risk. Providing structures and guidance will ensure coordination and build trust and this will avert the situation observed by Pahl-Wostl (2009) as existence of strong environmental regulations on paper but are not implemented in practice.

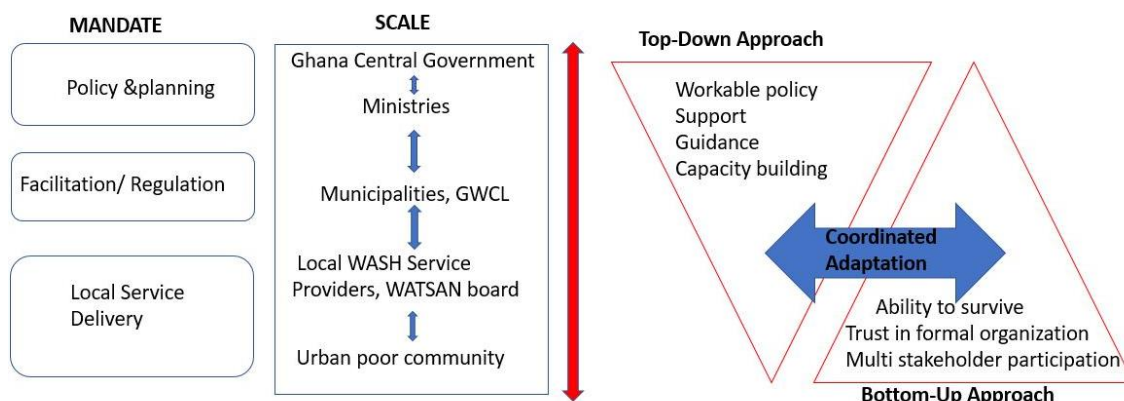


Figure 7-1 Understanding the right balance between top-down and bottom-up approach

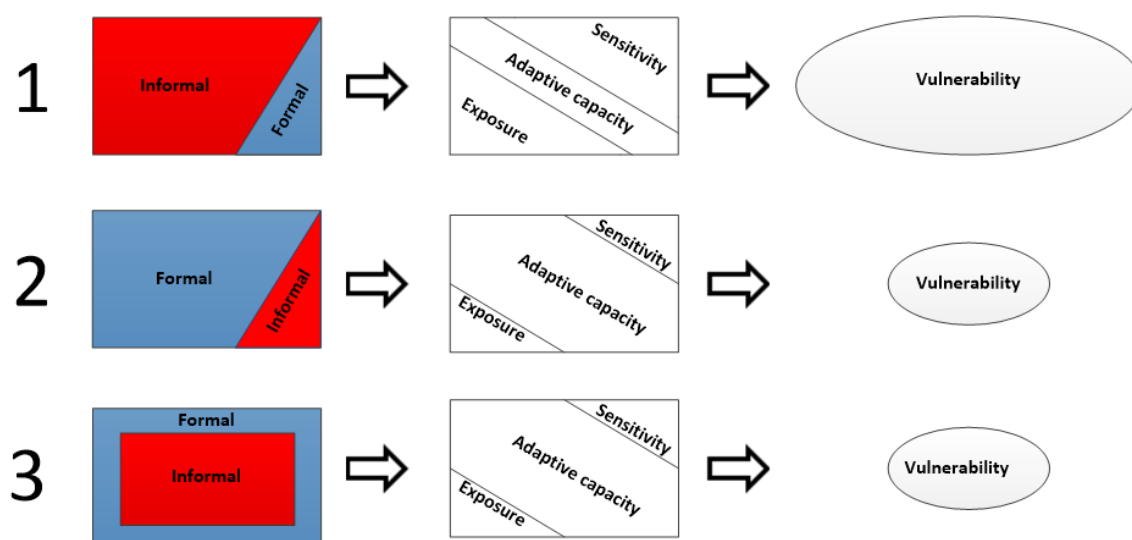


Figure 7-2 showing how adaptive capacity influences vulnerability and formal sector. (adopted from Engle 2011)

7.3 Reflections on the ACW methodology

From the results, adaptive belief, adaptive motivation, learning capacity and resources were the dimensions not scored as medium. Whilst adaption belief was scored as high and adaptation motivation was scored as very low, both learning capacity and resources were scored as low. Grothmann et al. (2013) in applying the ACW observed that the medium score is normally chosen by interviewees when they want to avoid deciding. Could this point to the fact that stakeholders were able to express themselves better under these dimensions?

Could the enhancement of these adaptive capacity dimensions enhance the adaptive capacity of stakeholders? Could these be assessed across scales? Could these dimensions then be applied to assess the adaptive capacity of WASH stakeholders across all spatial levels? First, we look at the dimensions that are subjective. The inclusion of the assessment of adaptive motivation and adaptive belief in the wheel by Grothmann et al. (2013) was to ascertain how to stimulate an individual to carry on adaptations. Enhancing learning capacity will enhance diversity by encouraging the involvement of different actors, different opinions and different problem problems and solutions in the adaptation process. Assuming there was no mistrust, actors will be willing to work together and share a common vision in achieving resilience and this will stop duplications and uncoordinated efforts. Also, enhancing the institutional memory which enhances adaptive capacity also develops expertise, knowledge and human labour which are all ways of enhancing the resources dimension. An institution that has trust, able to learn from past mistakes and encourages monitoring and evaluation is attractive to investors and can make good use of financial resources to achieve resilience. Though the argument can be that willingness of stakeholders to adapt without resources cannot bring about resilience, at least their adaptive capacity is enhanced. Folke (2006) argues that enhancement of adaptive capacity is important in achieving resilience

For the ACW methodology to be employed across the multi-scales of the urban WASH sector, the assessment of adaptation motivation, adaptation belief and learning capacity of all stakeholder groups are recommended. This is because it can be assessed rapidly and often to ensure that there is constant improvement in the psyche of actors from the community level through municipal level to the national level. This can be changed quicker than the other five dimensions. These findings inform a discussion for other researchers and those in practice to explore the possibility of assessing and improving these dimensions to enhance the adaptive capacity of WASH stakeholders to achieve resilience.

7.4 Progressing the RCAA Methodology

The RCAA methodology as already explained in previous chapters is a rapid methodology use to assess climate vulnerability and helps stakeholders to come up with ways of climate proofing water and sanitation services (Doczi, 2014). One of the uniqueness of this methodology is its use in peri –urban and informal areas. Also, because it is designed specifically for the WASH sector, it accounts for the multi- spatial nature of stakeholders involved in achieving the resilience of the WASH services. However, what this methodology failed to capture was the ability of the stakeholders to carry on adaptation plans. At the end of the RCAA methodology, recommendations were made to climate proof the WASH services but these recommendations need to be understood in the context of the local economy and politics as well as power play. This led to the assessment of the adaptive capacity of stakeholders as detailed in chapter 6 of this thesis.

In assessing the adaptive capacity of the WASH sector, top level organizations were used to understand how various dimensions support or hinder adaptations. Unlike the ACW, the RCAA methodology considered the views of the multi-spatial stakeholder groups in the complex WASH systems operated informally. However, after applying the ACW in an informal sector and across a multi spatial sector, the reflections as detailed in the previous section suggests that it can be used alongside the RCAA. At the national and municipal level, the ACW questions (as used in this thesis and attached in the Appendix) can be used to understand the adaptive capacity of these stakeholder groups and how they can take on adaptation plans. Also, the ways of enhancing their adaptive capacity can be recommended to these stakeholders in line with the ACW methodology. However, at lower levels, the RCAA interview schedules and focus group discussion schedules should be used but including questions around adaptation motivation, adaptation belief and learning capacity enhancement. Effectively the adaptive capacity of these local stakeholder groups can also be assessed and improved from the three adaptive capacity social factors (adaptation motivation, adaptation believe and learning capacity enhancement) as explained in the previous section.

To conclude, this research proposes a merger of the two very useful methodologies as shown in Figure 7-3 below. This new methodology is referred to as the Rapid Climate Resilience Enhancement (RCRE). This methodology is a fusion of the RCAA and the ACW aimed at enhancing the resilience of urban WASH services. It assesses the vulnerability, impacts, adaptive capacity and come up with climate proofing recommendations. The climate proofing recommendations will consider ways of improving the stakeholders' capacity as well as recommending workable adaptations to avoid maladaptation in the future.

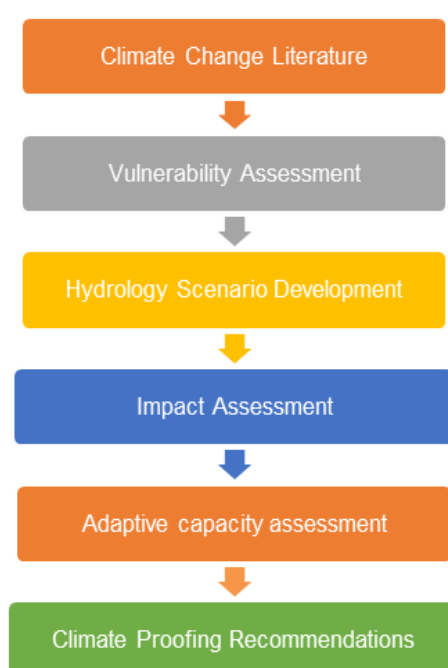


Figure 7-3 Rapid Climate Resilience Enhancement (RCRE).

7.5 Implication of Research

This research even with the crudest of scenarios have proven that Ghana needs to take adaptations in urban poor wash services seriously if they want to achieve the SDGs. Looking beyond Ghana, this section seeks to discuss some lessons that can be improve practice and research in the WASH sector. The goals and targets which this research seeks to contribute to have been listed below and they will be discussed in detail in subsequent paragraphs.

- a) Goal 3: Good health and well-being

- Target 3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.

b) Goal 6: Clean Water and Sanitation

- Target 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all.
- Target 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

From the urban poor communities as reported from this research, the safety of piped water is compromised by the frequent pipe burst and leakages. This is contrary to the general perception that piped water is safe. The challenge therefore lies in securing the robustness of the water service facilities in order to ensure that communities such as those presented in the case studies, have access to safe and equitable drinking water as proposed in Target 6.1 of the SDG-6. The technological transitioning from hand pumps to piped water coupled with the constant repairs and maintenance of the already existing piping systems as well as the effective treatment of drinking water, requires a significant amount of capital cost is required and an increase in operational cost. The story is not different with sanitation as ensuring access to adequate and equitable sanitation has financial implications. In order for governments to meet these financial needs, measures for mobilising funds specifically for such projects will need to be put in place. Norman and Smita (2015) assessed the climate change financing options and concluded that the concept of mobilisation of funds for public projects is still at the elementary stage for most LMICs. This implies that, the affordability of universal, equitable and safe drinking water to all remains a major challenge and the future of the WASH sectors for such communities will significantly depend on agreed terms of joint funding between

the governments and users in the said communities. This is possible with the enhancement of the adaptive capacity of the WASH sector.

Climate extreme conditions are causing serious problems to the already inefficient WASH services in the urban poor communities. Inefficient WASH service delivery also poses a lot of threat to the achievement of most goals. This assertion is also shared by Batty (2015) that achieving the Targets outlined in SDG-6 is a precursor to the success of the other SDGs. According to her, this is because successfully meeting Targets 6.1 and 6.2 will ensure sustained productivity in schools and at work. This will improve education and employment which can then contribute to achieving zero poverty (SDG-1). Evident from this research is how unmanaged solid waste in the urban poor communities contributes to rendering drinking water unsafe and blocking drains to serve as breeding grounds for mosquitos. The contaminated water contributes to water borne diseases whilst choked drains breeding mosquitos increases malaria cases in these areas. This is a hindrance to achieving SDG-3-3.

This research has shown that the problems in WASH cannot be undertaken by only people at the top but rather a collective effort is needed by all stakeholders to achieve the SDGs. This work has discussed the opportunities that can be taken advantage of to ensure that flexible institutions like those in most LIMCs can enhance their adaptive capacity. Even though such institutions lack resources, the adaptation motivation can be built by understanding their adaptive belief and using it to enhance their learning capacity. This will build trust in the institution to allow for a more coordinated adaption measures which will involve all stakeholder groups across different scales working together in harmony to achieve a common goal. With a coordinated and goal oriented sector, seeking of funds to undertake projects will be much easier and this will help achieve SDG-6 faster.

With the Paris agreement come the need for countries to delve into mitigation, adaptation and financing options. Though this agreement is set to kick off in 2020, this research provides an insightful perspective into the type of

adaptations required for climate proofing WASH services. These adaptations were developed to be no regret type of adaptations. This means that even without the presence of extreme climate events, they will still be useful in upgrading the service delivery levels to sustainable service. Even though mitigation measures are outside the scope of this research, developing the adaptive capacity of stakeholders will improve their awareness in deciding on low emission technologies especially at landfill sites.

Away from practice and moving more into theory, this work provides an example of how to apply an integrated vulnerability approach by viewing vulnerability as an outcome and as a context. As an outcome, the RCAA methodology was applied because Kohlitz et al. (2017) explains that the outcome approach is a useful way of understanding in a rapid way the best way to restore the WASH access after an extreme event occurs. As a context this work applied the ACW to understand stakeholder politics and socio-economics by assessing their adaptive capacity assessment. This concept was employed because according to Oates et al. (2011) vulnerability is influenced to a larger extent by socio economic factors.

7.6 How the research could be improved

Despite all that have been discussed above, this research still has room for improvement. These improvements are methodological, protocols or practical. Already in this thesis, the limitations of the two methodologies have been outlined. One limitation of this research is detailed hydrological modelling of the scenario was beyond the scope of this research. The use of conceptual hydrological scenarios made the assessment “broad brush strokes”. The lack of downscaled climate projections for the communities as well as variations in the climate projections meant that the developed hydrological scenarios were just conceptual and not from quantitative data. This makes it difficult to distinguish between general WASH challenges during rainy season versus the impact as a result of climate change. However, the conceptual nature of the developed scenarios helped to maintain the rapid nature of the RCAA.

The research involved a lot of stakeholders in Ghana and they were interviewed or involved in focus group discussions at a point in time. There was not much communication of the recommendations to them as would have been the ideal practice. However, going back to interview some of the stakeholder groups gave an insight of the sector and how it operates. This made the adaptations development situated in their context as it explains the need for recommendation. From a more practical point of view, most institutions involved directly in ensuring that the WASH services function effectively had various perceptions about one another and it would have been good to bring all of them under one roof to have a focused discussion. This could have been insightful in understanding the deeper rules of play within the sector.

8 CONCLUSION

This is the last chapter of this thesis and recounts how the specific research objectives were achieved. It also discusses the knowledge contribution of this thesis and concludes with the discussion of the opportunity for future research which sets the tone for other researchers to build upon this work to improve understanding in this field of research.

8.1 Addressing the research objective

This research was set out with the aim of investigating how to climate proof urban water and sanitation services to achieve resilience. In order to achieve this aim and its specific objectives, various research processes were followed. The table as shown Table 8-1 is a built up from Table 3-1 in the methodology section. This table further gives more attention to the outcome of this research at each process state.

Table 8-1 Summary of research process

| Methodology | Processes | Specific Objective | Key questions | Data source and method | Interviewees | Major highlights |
|---|----------------------------------|--------------------|--|--|--------------|---|
| Rapid Climate Adaptation Assessment (RCAA) | Literature review | 1 | What are the climate predictions for Ghana? | Key climate literature | 96 | Temperature increase but uncertainty in rainfall patterns |
| | Vulnerability assessment | 1 | How, what and who is vulnerable? | Interviews, FGD and observations in 6 communities. | | System breaking points: solid waste management and source contaminations |
| | Hydrology scenario development | 1 | What are the probable scenarios? | Climate projections and fieldwork testing. | | Three scenarios (increased rainfall, decreased rainfall and sea level rise) |
| | Impact assessment | 1 | What are the direct and indirect impacts? | Interviews, FGD, observations and vision 2030 technical report | | Water source contamination, disruption of services due to, accessibility to sanitation facilities |
| | Climate proofing recommendations | 2 | How can WASH services be resilient? | Interviews, FDG and vision 2030 technical report. | | Good water management practices but capacity gap recognised |
| Adaptive Capacity Wheel (ACW) | Adaptive capacity assessment | 3 | How do stakeholder politics, resource distribution and power affect their adaptive capacity? | Interviews- Adaptive Capacity Wheel (Grothmann et al., 2013) | 15 | Low adaptive capacity because of low learning capacity, resources and adaptation motivation |

8.2 Addressing the gaps in literature

This research applied the Rapid Climate Adaptation Assessment (RCAA) methodology (Heath et al., 2010) across different ecological zones and compared the impacts of climate change on urban WASH services. In doing so, the work further developed the RCAA methodology and applied it in Ghana to assess the adaptive capacity of the urban WASH institution. This research argues that the vulnerabilities of the WASH services are similar within and across the ecological zones. These vulnerabilities resulted from intermittent water supply, poorly managed solid waste and lack of spatial planning which are daily problems in WASH management. Though these vulnerabilities were arrived by simple hydrological scenario, they show the need for adaptation measures to be incorporated into urban poor WASH planning. Good management practices are needed to ensure that the WASH service provided for the urban poor is resilient enough to withstand climate related crisis. This work further argues that after applying the RCAA method to climate proof, the methodology needs to incorporate adaptive capacity assessment to ascertain the level of the capacity of the WASH institution. Adaptive capacity supports adaptation to ensure that adaptation becomes a process (Engle, 2011) and not a one-off activity, the capacity of the institution needs to assessed and enhanced. Hence the RCAA has been modified to include adaptive capacity assessment.

In most of the traditional (developed country) literature on adaptive capacity, rigid institutions are primarily seen as hindering factors because they are robust structures that generally resist change. The question here is how to “open up” institutions and make them more flexible. However, this research informs literature on a different type of institution. The story as seen in this research is a more flexible institution understood to have low adaptive capacity because of ineffective and inefficient WASH service delivery. Individuals do not always trust them for protection or look at them as the torch bearers when it comes to adaptations and have their own coping measures aimed which enables them to survive. This therefore led to the question of how to coordinate the individual adaptive capacity in complex informal community setting such as the urban

poor communities. This research answers the question by recommending that Larger-scale institutions can also enable adaptive capacity at the lower- and individual level by providing structures and guidance for collective action which is needed for adaptation.

8.3 Opportunities for further research

This research has assessed and compared the impacts of climate change across various ecological zones. This comparison has set the tone for the possibility of wrapping up all these urban poor WASH services in Ghana with one policy as showed in this research. The question of are all urban poor WASH services in Ghana similar irrespective of the ecological zone they fall within is answered in this research as yes. At least within Ghana, this research shows that the WASH vulnerabilities follow a similar trend. This research has therefore set the debate for future research to explore questions like – do all low-income countries have similar urban poor WASH services vulnerability? This question can be explored more to inform development agencies of the type of problems that are common to all the urban poor communities in lower and middle-income countries. It will help them understand the type of adaptation measures needed and know where to channel their resources to make urban poor WASH services resilient.

This research applied two different methodologies at various stages of this research and proposed the way forward in applying both methodologies to achieve resilience. The combined methodology can be used to access how to enhance the resilience of urban poor WASH and provide useful lessons to improve practice in the urban WASH service delivery. This research recommended that at the local level, the adaptive capacity can be enhanced by improving the motivation, adaption belief and learning capacity of local actors. Future research should explore these dimensions further to develop effective and efficient policy instruments to monitor and enhance them. This will ensure the sector is resilient to climate change.

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APPENDIX

Appendix A Letter to interviewees

Cranfield
UNIVERSITY

Richard Boakye Opoku
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Re: Adaptive Capacity Assessment – Interview Request

To whomever it may concern,

I am Boakye Opoku Richard a PhD student from Cranfield University in the UK. As part of my research into the impacts of climate change on urban WASH services and as a follow up from our assessment of the impacts of climate change on the existing vulnerabilities of water and sanitation services in urban poor areas in Ghana, I am at a stage where I would like to assess the adaptive capacity of your organization in relation to urban WASH services. This will ensure that adaptations developed to ensure that WASH services are resilient to climate change are situated in the right socio political context.

Through interviews I would like to assess the role of this organization, plans and readiness to adapt to climate change. I would like to understand the difficulties and opportunities that your organization hopes to achieve in adapting to climate change.

For this interview we would like to have a conversation on the readiness and willingness of your organization to adapt to climate change. The answers you give will form the basis of this research. The personal information you will share will not be passed to any third party.

Yours sincerely,

Boakye Opoku Richard

Appendix B RCAA Interview schedule

These questions were adopted from (Heath, 2011)

WATER VENDORS

Background

1. Tell me how you get water to finally sell here
 - a) How does the supply vary
 - b) Are there problems with quality/any treatment required
2. What makes up your water supply?
 - a) Do you have expansion plans
 - b) Do you pump your water
3. What is your daily supply quantity and coverage
4.) What is the sanitation situation
 - a) Type/coverage/ability to build/operate/design
5. What are the major problems with your water supply
6. Do you operate any specific tariff structure?
7. What challenges do you normally face?

Climate Change Awareness

8.) Tell me about climate change?
 - a) What are the impacts on abstractions and demand
 - b) How are you taking it into account

Impacts and Adaptations of Events (Droughts/ Floods/ heavy rains)

9. How will your system be impacted by increased rains and change in temperature

10. Are you affected by: flooding/high ground water levels/heavy rainfall /runoff/droughts/low ground water?
11. When did you experience your last flooding/drought and how long did it last for?
12. Describe how it impacted your system?
 - a) Water supply/quality
 - b)) How is demand affected
 - c) Pipes
 - d) Sanitation

Adaptations

13. How do you adapt?
 - a) Maintenance
14. What would solve the problems/ what adaptations do you suggest?
15. How could the utility/council/government adapt

TOILET OPERATORS

Background

1. Tell me how about your facility
 - a) Does the usage vary with season/how does it change
 - c) Do you have plans for expansion
2.) What is the demand for the toilet
3.) What is the sanitation situation
 - a) Type/coverage/ability to build/operate/design

4. What are the main barriers to service provision
5. What tariff structure do you operate?
6. What is your main challenge?

Climate Change Awareness

7.) Tell me about climate change?
 - a) What are the impacts on your facility
 - b) How are you taking it into account

Impacts and Adaptations of Events (Floods/Droughts/heavy rains)

8. Are you affected by: flooding/high ground water levels/heavy rainfall /runoff/droughts/low ground water?
9. When was the last flood/drought, how long did it last/what was the extent?
10. How did it impact your system? (explore each action in detail)
 - a)) How is demand affected
 - b) Septic tank
 - c) Toilet facility
 - d) Sanitation

Adaptations

11. How do you adapt?
 - a) Maintenance
12. What would solve the problems/ what adaptations do you suggest?

UTILITY

Background

1. Tell me how water finally gets to people's homes?
 - a) How does the supply vary
 - b) Are there Multiple supply sources
 - c) Are there problems with quality/any treatment required
2. What are the problems associated with the poor urban
3. What are the main barriers to providing water?
4. Do you operate different tariffs in the urban poor areas?
5. What is your main challenge?

Climate Change Awareness

6. Tell me what climate change is about?
 - a) What changes to climate are expected
 - b)) What will be the impact of climate change
 - c)) What are the impacts on abstractions and demand
 - d) How are you taking it into account as an organization

Impacts of Floods/Droughts/sea level rise

7. Are you affected by: Flooding/high ground water levels/heavy rainfall/runoff/droughts/low ground water levels
8. How does it impact the Local provider?
 - a) Water supply/quality
 - b) How is demand affected
 - c) Pipes

d) Sanitation

9. What other problems are there?

Adaptations

10. How do you adapt?

11. What support do you get?

MUNICIPALITY/COUNCIL

Climate Change Awareness

1. Can you explain what you understand by climate change?

a) What climate changes are you expecting?

b) Will these expected changes have any impacts

c) As an organization, are you taking these changes into considerations?

Impacts of Floods/Droughts/sea level rise

2. How are the urban poor areas affected by floods/droughts/seasonal changes?

3. When was the last/ how long did it last/ what was the extent?

a) How does it affect water supply/ sanitation/ hygiene

b)) How does it affect drainage/waste collection

4. Do you face other problems

Adaptations

5. How do you adapt?

6. What studies and research are being done on water resources, water balances or

7. Key contacts, who else should I talk to?

GOVERNMENT

Expected Changes to climate

1. What changes are you expecting
2. What will be the impact of changes to temperature/rainfall and sea level rise?

Climate Change Awareness

3. How aware of climate change is the government?
4. How is the government preparing for climate change
5. How much has climate change been incorporated into policy?
6. Who are main institutions researching on Climate change

Impact of Climate change on indirect aspects

7. How will electricity generation be impacted
8. What studies and research are being done on climate change
9. Who are the key contacts, who else should I talk to?

NGOS / RESEARCHERS

Climate Change Awareness

1. How is climate awareness incorporated into policy?
2. Who are main institutions researching in climate change
3. How are you taking climate change into account as an organization?
4. What are the impacts of climate change

Expected Changes to climate

5. What are the changes expected to climate
6. How is Temperature / rainfall and extreme expected to change

Impacts of Events (Floods, sea level rise and droughts)

7. How do floods, droughts and seasonal changes affect the urban poor areas?
8. How does it impact the community?
 - a) How are your water supply, sanitation and hygiene affected
 - b) How is drainage/waste collection affected?

Adaptations

9. How do you adapt?
10. How are you as organization adapting

Appendix C Adaptive capacity interview schedule

Introductory

1. Can you tell me something about yourself? What do you do? And in general, what is your role in local water management?

Variety:

2. Are there different solutions you can use to perform your role in local water management? How did you learn about those solutions?
3. What are the most important problems in local water management in your opinion, and do people agree on those problems?
4. Can you say something about the role of others in local water management?

Learning

5. Have there been changes in local water management in your region? What was at the cause of those changes?
6. Have you yourself adjusted your behaviour in local water management in recent years? Why?
7. When you have questions about your role and responsibility in local water management, is there an organization you can go to for answers?

Room for autonomous change:

8. Do you know what to do at times of crisis, for example in case of extreme rainfall or dryness? Do you know what others should do at times of such a crisis?
9. Did a (water or dryness) crisis occur in recent years, and how do you think this was resolved/ managed?

Leadership:

10. Are you collaborating with anyone else to perform your role in local water management? With who and how did this collaboration start?
11. In your opinion, is there any person or organization in charge of local water management? How would you characterize this leadership?

Resources

12. In your opinion, do you have sufficient resources (financial, knowledge) available to perform your role in local water management?

Fair governance

Do you think the division of responsibilities in local water management is fair?
Why?

End of interviews and thank you for your cooperation

Appendix D Focus group discussion schedule

Background

- 1) Have you experienced heavy rains/drought/sea level rise
 - a. When was the last heavy rainfall/drought/sea level rise event?
 - b. How often does flooding occur (per year; during the rainy season)?
 - c. For how long did heavy rainfall/drought/sea level rise last for?
 - d. Have you seen a change in the frequency/nature of heavy rainfall/drought/sea level rise
 - e. Do you think flooding/drought/sea-level rise will impact you in the future?

Climate Change Awareness

- 2) Tell me about climate change?
 - a. What is climate change?
 - b. How does it affect you?
- 3) Do you observe changes in rainfall/temperature/shore lines?

Impacts

- 4) How do they impact water supply (location, reliability, use)?
- 5) How do they impact toilets?
- 6) Is coastal erosion affecting you?
- 7) Is saline intrusion affecting your groundwater? (Is the taste affected)

Adaptations

- 8) What is the best way to tackle each of the impact of flood/drought/sea-level discussed?
- 9) Who is responsible for solving flood/drought/sea-level rise related impacts?
- 10) What should (local) government, CSOs, NGOs do to solve the problem?
 - a. What are they already doing?
- 11) What capacity do you have?
- 12) Do you expect of support from the municipal government/government?

Appendix E Thematic analysis

These themes capture important information about the interviewee's responses in relation to how they interpret their vulnerability, their climate change awareness and how they are affected by climate variability. The two broad umbrellas that each theme will fit under are management and technology. This is because the WASH services consist of these two components and they form both the biophysical and socio-economic components of the WASH services as reviewed in the literature review section. The various analytical themes and what they capture from the data have been explained below. In the OSOP analysis, these analytical themes were combined to form major themes for the write up.

Affiliation

This theme captured whether participants belonged organized body and the type of benefits they gain from such a body.

"I have heard of an association but I don't know what they do"

"I am a driller so I belong to the drillers association"

Cleaning

The purpose of this theme was to capture how service providers maintained good hygiene in and around their facilities. This theme captured the various cleaning problems that face seasonally.

"The floor tiles get dirty a lot during the rainy season hence there is frequent cleaning"

"We clean with parazone, Dettol and Omo"

Dust

This theme came up a lot when various service providers described the problems they face especially during the dry season.

"During the dry season, the dust is too much"

“I have to sprinkle water around the kiosk frequently to reduce the dust”

“Since I am at the road side, there is always dust from moving cars”

Effect on demand

This theme captured what participants deemed as the contributing factor to the demand of their services and how it varies daily, weekly or annually.

“During the raining season my sales decreases because people harvest rain”

“People mostly buy my water just for drinking because they do not drink the rain harvested water”

Effect on distribution

The purpose of this theme was to understand what the possible effect of climate variability could be on the whole water distribution system.

“My borehole is deep hence won't be affected by flooding”

“We record a lot of pipe burst and leakages during dry season”

Electricity

Electricity seemed to be one major concern of service providers and it was patterns that run through the whole data.

"We don't get water when there is 'lights out' but when there is light, water flows."

“'Lights out' outages damaged my pump”

Flushing

For most toilet operators, their major concern was how people left the toilets unflushed and this issue kept coming up in most of the discussions.

“People (customers) don't flush after use”

“Our cistern uses spring so it takes a lot of time to fill up”

Maintenance

“Changes tap about four times a year but not changed pump ever”

“We do maintenance as and when it comes”.

I tell Ghana water about major problems but the minor repairs are done by a local plumber

Perceptions

This theme captured how participants interpreted climate change in their daily lives.

"More buildings, more people because things are advancing"

"If we don't take care of our environment properly, definitely it will have an effect on us"

“In God's own wisdom, that is how he has created the world for us and we are only at the receiving end of what God gives us”.

Quality

This theme explains the quality of water served to customers and whether water vendors treat the water before selling it. This theme also captures how treatment pattern changes seasonally.

“I treat water every 4 months but I have forgotten the name of the chemical I use”

“We send samples of the water for testing upon complaints of unusual taste from customers”

Source of water

The source of water determined problems that these water vendors faced and hence it was right to acknowledge that with a theme.

“Drilled for domestic use but got extended for commercial purposes”.

"We have 6 standpipes, fed by a central pumping system"

Uses

This theme highlights the problems the service providers encounter as a result of how their facilities are used by customers.

"Women dispose of pad and papers into the bowl as well"

"People stand on the pot and it damaged the pots not long after they were installed"

Appendix F Ghana climate brief

GHANA CLIMATE CHANGE BRIEFING

Richard Boakye PhD researcher - o.boakye@cranfield.ac.uk



A PhD research project assessing the impacts of climate change on urban WASH services.



Overview of current climate in Ghana

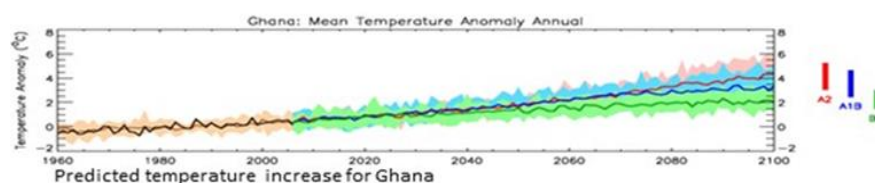
Ghana's rainfall seasons are controlled by the oscillation of the tropical rain belt between the northern and southern tropics¹. Generally rainfall in Ghana decreases from south to north. The wettest area is the extreme south-west with annual rainfall of 2000mm. In the extreme north, the annual rainfall is less than 1100mm. The driest area records an annual rainfall of 750mm. The dry conditions in the south eastern coastal strip are out of the ordinary and causes important differences in ecology and land use from the rest of the country². Daily Temperature also varies from 30 degrees in the northern part of Ghana during the dry season (April to June) to as low as 22 degrees in the southern part of Ghana during the rainy season (January to March)¹.

Climate Change

Climate change is evident in West Africa and Ghana is no exception as observed data from 1960 to 2006 depicts an increase in the mean annual temperature by 1.0 °C. The rate of increase has been most rapid in April, May, and June and more rapid in the northern regions of the country than in the south. The frequency of 'hot' days and nights has increased significantly while the frequency of cold days and nights has decreased. Rainfall over Ghana was particularly high in the 1960s, and decreased to particularly low levels in the late 1970s and early 1980s, which causes an overall decreasing trend in the period 1960 to 2006, of an average 2.3mm per month (2.4%) per decade¹.

Annual rainfall is projected to decrease in all regions and the percentage decrease tends to increase from north (Sudan Savannah zone) to south (Coastal Savannah). All values shown in the graph below are anomalies, relative to the 1970-1999 mean climate. Mean annual Temperature is projected to increase as shown in the graph below. Temperature at each projection period (2020,2050,2080) tend to decrease from north to south³.

The Sea level in the Gulf of Guinea is projected to rise by 1m by 2100 and could lead to loss of over 1000km² of land, with 132,000 people likely to be affected. The east coast especially the Dansoman suburban is particularly vulnerable to flooding and shoreline recession².



Prediction highlights

| Temperature | Rainfall | Extreme Events |
|---|---|--|
| Ghana's mean annual temperature is predicted to increase. The frequency of days and nights that are considered 'hot' in current climate is predicted to increase. | Annual rainfall is projected to decrease in all ecological zones. Seasonal rainfall will decrease in January through June and increase in July through December | The frequency and intensity of Extreme events is expected to increase. Droughts and floods are projected to increase due to rainfall intensity and temperatures. |

1. McSweeney et al., (2010). The UNDP Climate Change Country Profiles
2. Environmental Protection Agency (EPA) (2008) Ghana climate change impact, vulnerability and adaptation assessment
3. Minia, Z. 2008. Climate change scenario development.

Main Impacts of climate change in Ghana

| | INCREASED TEMPERATURE | DROUGHTS | FLOODS | SEA LEVEL RISE |
|--------------|---|--|---|---|
| WATER | <ul style="list-style-type: none"> Reduction in hydropower potential (eg. Akosombo Dam) Rivers drain in dry season (eg. Nsawam)¹ Struggle for water available and Agriculture suffers Increase in irrigation water demand | <ul style="list-style-type: none"> Water scarcity³ Lower groundwater Reduced hydropower production Saline intrusion Rivers Dry up | <ul style="list-style-type: none"> Contamination of drinking water Sedimentation and infiltration of water into pipes. | <ul style="list-style-type: none"> Increase in extreme weather and flooding⁴ Salt water intrusion in coastal areas Rise in coastal water table |
| HEALTH | <ul style="list-style-type: none"> Food shortage Cerebrospinal meningitis (CSM) Malaria Risk increases | <ul style="list-style-type: none"> Starvation and malnutrition Increase in water-washed diseases Increase in water-borne diseases through deterioration of drinking water quality | <ul style="list-style-type: none"> Outbreak of Cholera and diarrhoea Food shortages and Loss of life Increase in water-borne diseases Damage to health infrastructure and inaccessible health facilities. | <ul style="list-style-type: none"> Loss of life Damage to shelter along coastline (eg. Dansoman)² |
| LIVELIHOOD | <ul style="list-style-type: none"> Crop failure and food insecurity Change in livestock productivity Lower maize yields Reduced production of Cocoa⁶ Crop pests more common Wildlife extinction Decline in fish stocks | <ul style="list-style-type: none"> Death of livestock Human-wildlife conflict Conflict between pastoralists and famers Erosion of top soil and grass seed Decline in vegetable production Damage to tourist attractions/ wildlife Reduction in aquaculture production and food prices increase at rural markets | <ul style="list-style-type: none"> Loss of infrastructure (houses, roads, bridges, etc.) Redistribution of washed up Nutrients Daily activities are disrupted. Damage to Flora and Fauna | <ul style="list-style-type: none"> Land submerged resulting in loss of communities Erosion of shoreline and infrastructure Loss of Flora and Fauna |
| BIODIVERSITY | <ul style="list-style-type: none"> Increased deforestation Reduction in growth and regeneration Reduced biodiversity and desertification⁵ Forest land degradation and invasive species More frequent forest fires Extended range of pests Species range shift extinction of species | <ul style="list-style-type: none"> Forest loss rapid and conspicuous Forest fires (bush fire) Land degradation | <ul style="list-style-type: none"> Sedimentation Loss of habitats Soil erosion | <ul style="list-style-type: none"> Food shortages Mangroves submerged Displacement of coastal wetlands Bleaching of coral reefs Increase of earthquake hazards |

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