PERCEPTIONS OF CLIMATE VARIABILITY EFFECTS ON HOUSEHOLD WATER AVAILABILITY AND HEALTH:
A CASE STUDY OF FOUR RURAL COMMUNITIES IN GHANA.

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ABSTRACT

Globally, one of the major contributors to diseases burden and mortality are waterborne diseases and sanitation-related infections. The study sought to investigate the implications of climate variability on water availability and its implications for public health. Cross tabulations, Chi-square statistic and a logit model were used to identify determinants of water availability and the determinants of water borne diseases. Data for the study was collected via survey of women in households within the villages of Tsetsekpo, Totope, Sayikope and Klukope. A questionnaire instrument, direct observation and focus group discussions were employed to collect data from respondents. Generally, the outcome of the study showed that there was an association between socio-economic factors of the household head such as education ($\chi^2 = 10.4$, df=8, $p=0.002$), occupation of household head ($\chi^2 = 21.1$, df=10, $p=0.02$), household income ($R= -0.27$, $p=0.00$) and the choice of a water source used by the household. Likewise, focus group discussions revealed that the cost of water from a particular source also influenced household choice. Also, respondents had a perception that climatic variability could have an impact on the availability of water. The probability of contracting water borne disease was dependent on age, income, education and duration of stay in the community. Furthermore, water borne diseases were found to have a significant impact on household welfare in terms of time lost in taking care of sick persons. Socio-economic status of household heads could also influence water and sanitation choices of household and in turn influence public health. It is recommended that policies geared towards poverty alleviation for small scale farmers and fisher folk must be implemented as this is a prerequisite for successful adaptation to the impacts of climate change.
DECLARATION

This is to certify that this thesis is the result of research work undertaken by KARYN EWURAMA ASMAH towards the award of the Master of Philosophy in Climate Change and Sustainable Development from the Department of Geography and Resource Development, University of Ghana.

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DEDICATION

I dedicate this thesis to all women in the field of science.
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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

One of the basic needs of all living things is water. Water is abundant on the planet as 71 percent of the earth’s surface is covered by water (Liebmann & Marengo, 2001). However fresh potable water is not always available for human or ecosystem use as the vast majority of the Earth's water resources are salt water, with only 2.5% being fresh water. Seventy percent of this amount of fresh water available on the planet is frozen in the icecaps of Antarctica and Greenland leaving the remaining 30% (equal to only 0.7% of total water resources worldwide) available for human consumption (Corcoran, 2010; Solomon et al., 2007). Water cannot be used up; however, factors such as pollution and salt water intrusion can threaten its human use. These factors in association with increasing demand and climate variability, can compromise the availability of water (Webersik, 2010). The geographical location coupled with the high dependency on climate sensitive economics, makes developing countries more susceptible to variations in water availability (Webersik, 2010). Water is a source of economic activity and crops cannot thrive without it (Webersik, 2010). In sub-Saharan Africa, about 70 percent of the population work in subsistence agriculture, highlighting the importance of sufficient and clean water supplies (Allen & Thomas 2002).

Water supply that is easily accessible, reliable, affordable and safe is essentially a key determinant of population and health, particularly in developing countries. Humans need about five litres of water for daily survival either by drinking or ingestion through food (Gleick, 1998). Further research posits that at least 50 litres per person per day is needed...
to ensure all personal hygiene, food hygiene, domestic cleaning, and laundry needs (Hunter *et al.*, 2010).

1.1.1 Water and the Millennium Development Goals

The Millennium Development Goals (MDGs) are eight international development goals that were set by the United Nations following the Millennium Summit in 2000 (Bourguignon *et al.*, 2010). Millennium Development Goal (MDG) 7 aims to ensure environmental sustainability. Specifically, target 7C aims at halving the proportion of people without sustainable access to safe drinking water and basic sanitation by the year 2015 (UN Economic, 2008). The MDG target 7C implies a commitment to raise the global drinking water coverage of 77% per cent in 1990 to 88.5% in 2015. This water supply target has strong interconnections with several other MDGs such as those relating to poverty (MDG1), education (MDG2), gender equality (MDG3) and health (MDG 4, 5 and 6) (WHO, 2005).

Generally, water-related infectious diseases also create more poverty and slow economic growth (McGarvey *et al.*, 2008). Diarrhoeal diseases (including cholera) are attributable to unsafe safe drinking water and lack of access to basic sanitation. Diarrhoea kills 2,195 children every day—more than those killed by AIDS, malaria, and measles combined (Liu *et al.*, 2012) especially in developing countries. Hence, it particularly corroborates MDG4, the reduction of child mortality, since lack of safe water is a major risk factor for diarrhoeal disease in this age group (Hunter *et al.*, 2010).

Globally, even though the MDG target for drinking water was met in 2010, with a coverage of 88%, 748 million people still lack ready access to improved sources of
drinking water; with 325 million (43%), nearly half of this number living in sub-Saharan Africa (WHO & UNICEF, 2014). Most of the people who still lack access to an improved water source are either poor, marginalized or both and are dependent on untreated surface water. According to the 2014 progress report of the WHO/UNICEF Joint Monitoring Program (JMP) on sanitation and drinking-water, 173 million people have no access to improved sources of drinking water and over 90% are rural inhabitants. Also in the area of sanitation, Asia and sub-Saharan Africa continue to have the lowest levels of sanitation coverage (WHO & UNICEF, 2014).

1.1.2 Water and Climate change

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) (Bernstein et al., 2007) as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Natural and anthropogenic substances and processes alter the Earth’s energy budget and are known as are drivers of climate change (Solomon et al., 2007). These include atmospheric concentrations of greenhouse gases (GHGs) and aerosols, land cover and solar radiation. Drivers of climate change are responsible for altering the absorption, scattering and emission of radiation both at the Earth’s surface and within the atmosphere. This results in changes in the energy balance, which may be either positive or negative and is expressed as radiative forcing. Warming or cooling influences on global climate can then be compared using radiative forcing (Solomon et al., 2007; Stocker et al., 2013)
The IPCC in its fifth assessment predicts diverse effects of climate change both on natural and human ecosystems (Stocker et al., 2013). Many challenges such as sea level rise, atmospheric alteration, changes in weather systems, shifts in rainfall patterns and seasonality are predicted by climate scientists. Forecasts of more frequent and extreme weather events are further predicted (Bates et al., 2008b).

Climate drivers such as changes in the hydrological cycle and non-climatic drivers such as population increase, economic development, urbanization, and land-use or natural geomorphic change, can independently or in synergy lead to a reduction of the sustainability of water resources by decreasing water supply or increasing demand. Hence reliability of water supply, which is expected to suffer from increased variability of surface water availability, will be further compromised (Arnell et al., 2014).

Water is essential not only in quantity, but also in quality. A reduction in raw water quality has been predicted as an impact of climate change. Risk factors include increased temperature, increases in sediment, nutrient and pollutant loadings due to heavy rainfall, reduced dilution of pollutants during droughts, and disruption of treatment facilities during floods (Bates et al., 2008b). These factors tend to negatively influence drinking water quality even with conventional treatment (Campbell-Lendrum et al., 2014). Many adverse direct and indirect impacts on health, especially relating to water quantity and quality, may hence result due to climate change (Greenough et al., 2001; Costello et al., 2011; McMichael, et al., 2012).

In Sub-Saharan Africa, several human lives are endangered daily by the consumption of unsafe water, inhaling polluted air and living in inadequate sanitary conditions
(Mabugonje, 1995; Matthews, 2012). Compounding these lifelong risks and in addition to the HIV/AIDS and malaria pandemics, emerges a pervasive public health risk: a changing climate (Matthews, 2012).

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) predicts the health of human populations will be sensitive to changes in climatic parameters and weather pattern shifts (Stocker et al., 2013). Predictions of the negative human health impacts due to climate change include significant increases in deaths, illnesses, and hardship due to direct exposures as a result of changes in temperature, precipitation, and extreme weather events. In the same vein, indirect exposures, due to changes in ecology may also extend the range of infectious diseases and vectors, create food and water shortages or modify social responses to climate change. The environment, pathogenic agents and host are factors whose interplay can frequently result in ill health or disease (Eisenberg et al., 2007). Clean air, safe and adequate water, nutrition and secure shelter are the central prerequisites for health.

1.2 Theoretical framework

Human health is altered by climate change mostly in indirect, complicated and long pathways that may agglomerate uncertainties (Costello et al., 2009). Behavioural factors, socio-economic characteristics such as level of economic development, the state of public health systems and education, in addition to climatic factors can strongly influence the majority of health impacts (Füssel, 2007). However, since climate is but one of the many factors that determine the status of population health, assessing the role of climate in disease occurrence requires careful analyses since data acquisition is often more difficult in human health than in other impact domains. This is because it is usually dependent on
human co-operation and there is limited scope for controlled experiments (Füssel & Klein, 2006).

Not only is human health distinct from other climate-sensitive domains, but anthropogenic climate change is also distinct from other environmental threats to human health. The most important differences are the large spatial scale of the problem, the very long time horizon to be considered, the uncertainty related to future scenarios of climatic hazards, and the complexity of the relationship between climatic factors and health outcomes (Patz & Balbus, 1996). Several authors who have investigated the applicability of classical risk assessment approaches to the health effects of anthropogenic climate change (McMichael, 1993; Patz & Balbus, 1996; McMichael & Haines, 1997; Bernard & Ebi, 2001) are of the view that the prevailing toxicological model of environmental health (where a defined exposure to a specific agent causes an adverse health outcome to identifiable exposed populations) is often not applicable to climate-sensitive health issues, particularly for indirect effects of climate stimuli on human health. Also, quantitative assessments of the future health risks posed by anthropogenic climate change are often not possible because appropriate models or data are not available at all, or not at the appropriate scale (Bernard & Ebi, 2001). Therefore, standard procedures for quantitative risk assessment are often less relevant for assessing climate-health associations than expert judgement, analogue studies, process-based and empirical modelling, and other integrated assessment methods (Füssel & Klein, 2004).

Vulnerability assessments on the other hand, incorporate both the natural and the social sciences with the addition of integrating non-scientific knowledge by involving relevant stakeholders (Füssel & Klein, 2004; Füssel, 2007). However, its main focus is still a
descriptive one, that is to assess the magnitude and likelihood of adverse consequences of climate change, and potentially other aspects of global change, on a system or society (Füssel, 2007). In this work therefore, a vulnerability assessment is being used in some part as an alternative to traditional quantitative risk assessment as well as incorporating some elements of an eco-social framework for epidemiology (Bernard & Ebi, 2001).
1.2.1 Conceptual framework

Figure 1: The conceptual framework of the interaction between climatic factors, socio-economic factors and the implications on public health

Source: Author’s own construct
1.3 Problem Statement
The health of any population – if it is to be sustained – requires clean air, safe water, adequate food, tolerable temperatures, protection from the elements and high levels of biodiversity. Globally, one of the major contributors to diseases burden and mortality are water-related diseases and sanitation-related infections (Howard & Bartram, 2003; Adams, 2009). These are mostly viral, bacterial and parasitic diseases associated with water-related transmission (Hunter, 2003). Vulnerabilities such as food insecurities, inadequate access to safe water and sanitation, limited access to health care and low socio-economic standing currently exist especially in developing countries. These vulnerabilities will likely be exacerbated by climate change and may lead to an increase in the proliferation of water related diseases (Figure 1). Currently there are few studies that focus on the link between climate change, water availability and climate sensitive diseases (The Draft Ghana Climate Change Policy, 2013). There is therefore a need for directed research towards better understanding the role climatic variables, socio-economic and behavioural factors may play on the incidence of water-borne diseases (Netherlands Climate Assistance Programme (NCAP) Report, 2006); since isolating the impact of climate change on health from other influencing and interrelated socio-economic factors that complicate the relationship is difficult (Parry, 2007).

1.4 Objectives

1.4.1 Main objective
The main objective of the research was to investigate the effect of changing climatic factors on public health and the incidence of water borne diseases
1.4.2 Specific objectives

i. To ascertain a relationship between the socio-economic factors and water availability by exploring the interactions between the effect of climate variability and socio-economic factors on water availability.

ii. To examine the effect of socio-economic characteristics of respondents on the incidence of water-borne diseases.

iii. To investigate the implications of water-borne diseases on household livelihood and finances of the inhabitants of the study communities.
1.5 Justification of study

To date, significant gaps still exist in our understanding of the health impacts of climate change and this clouds our ability to understand and address the issues properly (Patz et al., 2000; Costello et al., 2009). Understanding the impact that climate change could have on water borne diseases, and consequently human health, is important for future disease control and health infrastructure planning in Ghana. Currently, few studies have focused on the link between climate change and climate sensitive diseases (The Draft Ghana Climate Change Policy 2013). Public health can be impacted by climate change not only by climatic factors, but also by socio-economic changes that may come about as a result of climate change (Parry, 2007). It is therefore imperative that these inter-relationships be investigated to know how they affect public health. Thus the study aims to contribute relevant knowledge regarding the impact that climate change could have on water-related diseases and consequently human health in Ghana, while identifying potential adaptation measures that can be employed to extenuate the potential impact of climate change on water security and health.
CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents the literature reviewed on the relevant themes of this thesis. The literature review was guided by the themes of the research and works towards the hypotheses on the relationships between climate change, water availability and water-related diseases. The chapter is organized into eight sections.

2.1 Women and Water Availability

The management of household water supply, sanitation and health in most rural societies in the developing world is the woman’s responsibility. This responsibility rests almost exclusively on women because men seldom engage in household chores (Devas & Korboe, 2000; Ngorima et al., 2008). In the household, water is essential for all activities including cleaning, washing, food preparation, personal hygiene, waste disposal and drinking. This reliance on water resources makes women more susceptible to changes in water availability (UN Water, 2006). The impact of inadequate water supply is mostly felt by women particularly girls due to the time spent collecting water. Hence the provision of safe, affordable, accessible and reliable sources of water is key to reducing this vulnerability. It also allows for the allocation of more time and energy in the pursuit of education and income generation activities (Green & Baden, 1995; Water, 2006). Furthermore, it helps in the empowerment of women, reduction of child mortality and thereby the fulfilment of MDGs 3 (Promote gender equality and empower women), 4 (Reduce child mortality rates) and 7C (Halve, by 2015, the proportion of the population
without sustainable access to safe drinking water and basic sanitation) (Bourguignon et al., 2010; UN, 2010).

2.2 Water Availability and Health

The choice of a water source is dependent on various factors (Figure 1). Poor reliability, cost and distance between a water source and the home may make reduce the availability of water. These factors may cause households to depend on less safe sources and reduce the volume of water used for hygiene purposes (Lloyd & Bartram, 1991; Cairncross & Kinnear, 1992; Howard, 2002). When water is freely available at close range, personal hygiene practices such as hand-washing becomes more frequent (Curtis et al., 2000). This can lead to a reduction in the incidence of water borne and water related diseases. Water-borne diseases are more likely to affect women because their gender roles involve handling, using and working with water (UN Water, 2006). However, safe, affordable and accessible water, adequate sanitation, and proper hygiene education (Water Sanitation and Hygiene (WASH)) can prevent illness and death, leading to improved health, poverty reduction, and socio-economic development (UN Water, 2006; Webersik, 2010). Fresh water availability invariably has direct links to health and indirect links to gender. Therefore, with predicted decreases in fresh water availability as a result of climate change, climate change will have links with gender especially in the area of health even if not at the individual level, certainly at the community and household levels (Figure 1).

2.3 Climate change: causes and characteristics

A drastic rise in global temperatures has become evident within the last twenty years (Müller-Kuckelberg, 2012). Global warming is a human-caused phenomenon due to an
increase in carbon dioxide (CO\textsubscript{2}) emissions and other greenhouse gases (GHG) into the earth’s atmosphere. These gases are produced both naturally and industrially and include water vapour with three atoms (H\textsubscript{2}O), ozone (O\textsubscript{3}), carbon dioxide (CO\textsubscript{2}), and methane (CH\textsubscript{4}) and also trace quantities of chloro-fluoro-carbons (CFCs). The first evidence of global warming was discovered in 1824 by the French scientist Jean Baptiste Joseph Fourier and currently an overwhelming body of scientific evidence supports this interrelation (Müller-Kuckelberg, 2012). Greenhouse gases according to the Encyclopaedia of Global Warming and Climate Change (Philander, 2008) are gas molecules in the Earth's atmosphere with three or more atoms that are relatively transparent to solar radiation and relatively opaque to thermal radiation (Philander, 2008). They have the ability to capture outgoing long wave infrared energy from the Earth, thereby warming the planet. Carbon dioxide and other GHGs in the atmosphere entrap part of the outgoing solar radiation, thereby raising the earth’s temperature. This natural “greenhouse effect” ensures that our planet (earth) remains habitable and maintains a balanced temperature. Currently however, a rise in CO\textsubscript{2} concentration in the atmosphere has increased warming rapidly, exceeding the natural range of the last several thousand years. The process of global warming was accelerated by the industrial revolution that started in the nineteenth (19th) and twentieth (20th) centuries (Müller-Kuckelberg, 2012). This led to a surge in productivity and changes to different sources of energy such as fossil fuels specifically, coal and oil. This change in energy has no doubt transformed human societies by providing significant development; however, it has also fuelled climate change due to the burning of fossil fuels and natural gases leading to an increase of GHGs. Emissions of four greenhouse gases (GHGs) namely CO\textsubscript{2}, methane (CH\textsubscript{4}),
nitrous oxide ($N_2O$) and halocarbons (a group of gases containing fluorine, chlorine or bromine) are as a result of human activities. According to the Intergovernmental Panel on Climate Change (IPCC), global atmospheric concentrations of $CO_2$, $CH_4$ and $N_2O$ have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values as determined from ice cores spanning many thousands of years (Sundquist, 1993). Brown et al. (2008) also indicate that extreme daily maximum and minimum temperatures have warmed up for most regions of the world since 1950 and that the total area exhibiting positive trends is significantly greater than that which can be attributed to natural variability.

The energy balance of the climate system is altered by changes in the atmospheric concentrations of GHGs and aerosols, land cover and solar radiation and hence are drivers of climate change. They affect the absorption, scattering and emission of radiation within the atmosphere and at the Earth’s surface (Solomon et al., 2007b). The resulting positive or negative changes in energy balance due to these factors are expressed as radiative forcing. Radiative forcing is used to compare warming or cooling influences on global climate. Hence, the changing concentrations of radiatively important GHGs are key indicators and significant drivers of global climate change (Huber & Knutti, 2012; Stocker et al., 2013). Globally, increases in concentrations of $CO_2$ are primarily as a result of fossil fuel use and even though land use change provides another source of $CO_2$, its contribution is significantly smaller and secondary in nature (Stocker et al, 2013). Fossil fuel use and agriculture are also likely to be the cause of observed increases in $CH_4$ concentrations. However, increases in $N_2O$ concentrations are primarily due to agriculture. Global climate change is occurring at a rapid rate and a further increase in
global temperature is irreversible until approximately 2030, regardless of present CO$_2$-emissions. Climate change is a problem resulting from long-term accumulation of CO$_2$-emissions in the earth’s atmosphere and predicting the timing and magnitude of future consequences is a difficult and uncertain task.

In 1988, the IPCC was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide the world with a clear scientific view on the current state of knowledge on climate change and its potential environmental and socio-economic impacts (Griggs & Noguer, 2002). The IPCC which is a scientific body under the auspices of the United Nations (UN), reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. The ability of the IPCC to provide rigorous and balanced scientific information to climate scientists, the general public and decision makers makes it the leading international body for the assessment of climate change. In the last thirty-one (31) years, the IPCC has published five monitoring reports. Climate change is defined by the IPCC in its fifth assessment report as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties that persists for an extended period, typically decades or longer (Cubasch et al., 2013). It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

The fifth assessment report just like its predecessor, the fourth assessment report, both arrive at the consensus that unequivocal evidence from in situ observations and ice core records show that the atmospheric concentrations of important greenhouse gases such as carbon dioxide, methane and nitrous oxide have increased over the last few centuries.
(Stocker et al., 2013) and are responsible for most of the observed increase in globally averaged temperatures since the mid-twentieth century (Hegerl et al., 2007; Huber & Knutti, 2012).

### 2.4 Impacts of Climate Change

Climate change impacts every aspect of human life (Grover, 2012). The impacts of climate change and variability will vary across regions and populations being dependent on a myriad factors (Stocker et al., 2013). Climate change could present a multitude of impacts in various sectors. Climate change impacts economies as a result of changes in natural systems and resources availability thereby influencing long term prosperity (Grover, 2012). These factors include non-climate stressors and the extent of mitigation and adaptation. The least developed countries will have the least capacity to adapt.

#### 2.4.1 Impacts of Climate Change on Freshwater Availability

Water is part of all components of the climate system namely the atmosphere, cryosphere, hydrosphere, land surface and biosphere. Essentially, this means that any change in climate impacts the water cycle through different means (Bates et al., 2008b). Climate change has been linked with changes in hydrological systems such as: change in precipitation patterns, melting of snow and ice, increased evaporation, increased atmospheric water vapour and changes in soil moisture and run off (Bates et al., 2008b). Since most of the solar energy received by the Earth is used by the hydrological cycle, higher levels of solar energy trapped in the atmosphere will lead to an intensification of this cycle, resulting in changes in precipitation patterns. These changes will result in increased floods and droughts, which will have significant impact on the availability of freshwater. These impacts on freshwater will be further compounded by rising sea levels,
and melting glaciers. Freshwater is particularly vulnerable because the quantity or quality of water is exacerbated by climate change (Bates et al., 2008b; Grover, 2012). Climate change poses a threat to water security because changes in precipitation and other climatic variables may lead to significant changes in water supply in many regions (Charlton & Arnell, 2014). Climate change is predicted to increase the number of people facing water scarcity around the world by 1.8 billion by 2080 (Arnell, 2004; Webersik, 2010; Hagemann et al., 2012). Drought will not only lead to decreased water availability but also a decrease in water quality in water scarce regions, such as southern and northern Africa, Central America and central Asia (Webersik, 2010). Another crucial risk factor, especially for many African societies, is the existing conditions of high human vulnerability. Societal well-being and development are currently encumbered by freshwater scarcity (Oki et al., 2001; Rijsberman & de Silva, 2006). This situation will be further aggravated as a result of the compounding issues of the expected growth of global population over the coming decades, flourishing economic prosperity and increased water demand (Vörösmarty et al., 2000; Arnell, 2004; Alcamo et al., 2007).

2.4.2 Climate Change Impact on Agrarian Livelihoods

Changing global weather patterns will threaten people’s livelihoods, especially where they depend on climate-sensitive economies. Rising mean temperatures are set to have socio-economic consequences. Battisti and Naylor (2009) posit that rising temperatures will reduce the overall productivity of agricultural crops. In sub-Saharan Africa, this scenario is set to affect one of the most common cereal staples, maize, because it is less receptive to carbon fertilization (when CO₂ concentration increases) (Müller-Kuckelberg, 2012). This has implications for both food security and farmers’ income.
Currently, majority of the world’s population dependent on agriculture for their survival, officially live in poverty (that is less than US$ 1 per day) (Müller-Kuckelberg, 2012). Climate change scenarios predict substantial losses in the production of food staples linked to drought and rainfall variation, especially in areas of sub-Saharan Africa. Likewise projected revenue losses due to loss of arable land are expected to amount to 26 percent of Gross Domestic Product (GDP) of most sub-Saharan African countries by 2060 (Müller-Kuckelberg, 2012). Such an impact on agricultural production would directly influence food security, leaving 600 million people to face malnutrition by 2080 (Müller-Kuckelberg, 2012).

Many African communities will be at risk, particularly subsistence farmers with low incomes. This is because most farmers because are solely dependent on rain fed agriculture (Battisti & Naylor 2009). In addition, fragile infrastructure and reduced capacity to respond to emergencies plus the heavy reliance on small-scale farming makes them even more vulnerable. Moreover, a large part of the gross domestic product and the employment of up to 70 percent of workforce in subsistence agriculture occurs in most sub-Saharan African countries (Watkins, 2007). It is therefore safe to assume that changes in precipitation or temperature will have an impact on economic performance (Grover, 2012). This will essentially affect the income of these small scale farmers, as increased droughts may exacerbate poverty levels and increase vulnerability to climate change (Figure 2). Even in such cases, women will be disproportionally affected as poor rural female farmers have very little or no access to resources that may enable them utilise irrigation facilities and hence are entirely dependent on rainfall ( Water, 2006;
Watkins, 2007; Grover, 2012). Without appropriate adaptation measures, this will lead to widespread negative effects.

From the socio-economic point of view, household welfare is also affected through impacts on agrarian livelihoods (Figure 2). Rural livelihoods are affected by changes in the environment through impacts on agricultural production and income, as weather elements may directly affect farm yields (Karfakis et al., 2012).

**Figure 2:** The channels of impact of climatic variability on different dimensions of household welfare. Source: Karfakis et al., (2012).

Impacts on income may also lead to the reallocation of resources within the household where the most pressing needs but not necessarily the most important needs, take precedence. The relative impacts of climate change on household welfare are also influenced by socio-economic characteristics such as gender, age, income and the position of human capital (Adubofour et al., 2013; Koskei et al., 2013; McGarvey et al.,
Health-related effects may also occur, directly if the prevalence of diseases is affected by changes in weather elements or indirectly if food or other resources are downsized (Figure 2).

### 2.4.3 Impact of Climate change On Women

Women make up the majority of the world's poor and are more dependent than men on natural resources for their livelihoods and survival (UNFPA, 2009). Climate variability increases the scarcity of basic household resources, such as water, fuel, and fodder (UN Water, 2006). This in turn may increase the workloads of women in terms of the time and the energy required to source, collect, and carry these resources to meet household needs. In times of drought and erratic rainfall, women and girls must walk farther and spend more of their time collecting water and fuel. Girls may even have to drop out of school to help their mothers with these tasks, thereby continuing the cycle of poverty and inequity. The additional time devoted to this single activity is also likely to have negative impacts on the longer term health and well-being of women and girls, and can erode their economic opportunities to participate in education, training, and income-earning activities (UNFPA, 2009).

The immediate impact of climate-related disasters such as hurricanes and floods on individuals is determined by their ability to evacuate to safety in time. Studies have shown that women disproportionately suffer the impacts of disasters, severe weather events, and climate change because of cultural norms and the inequitable distribution of roles, resources, and power, especially in developing countries (Grover, 2012; Behrman et al., 2014). Sociocultural factors, such as social norms that prevent women from moving freely in the community or learning to swim, and access to information, such as
early warning systems, determine the survival rate of women during natural disasters (Quisumbing et al., 2014). Women tend to be more vulnerable and have less access to resources, assistance, and support than do men in the aftermath of extreme climate events. For example, during the 2000 floods in Mozambique, many women had to settle with using floodwater for domestic chores when clean water was in short supply, thereby increasing the risk of disease outbreak (UN Water, 2006).

In terms of agricultural production, increasing climate variability tends to lower agricultural production and has different impacts on women’s and men’s well-being and assets, including land, livestock, financial, and social capital (Quisumbing et al., 2014). Increasing climate variability causes both women and men to invest more time and labor in agricultural production (UNFPA, 2009). However, women’s workloads tend to be heavier because of their additional domestic commitments. Women, who are also often responsible for producing the food eaten at home, must therefore work harder for less food and in instances where this still might not be enough, women often reduce their own food intake or sell assets, such as jewelry or livestock, to ensure their household’s food security. Sadly though, women, have less access to information, agricultural technologies, inputs and requisite climate change adaptation know-how all of which put them at a disadvantage in adapting to climate change impacts (WHO, 2011).

2.5 Water and sanitation

Water is crucial for good sanitation and hygiene in any society. The Millennium Development Goal (MDG) 7, which aimed at halving the proportion of the global population without access to sustainable safe drinking water and basic sanitation was achieved in 2010, five years ahead of schedule (Bourguignon et al., 2010). This marks
substantial progress in water availability since the programme commenced in 1990. These results however conceal major regional and national differences, especially the difference between developed and developing countries. Since 1990, over a quarter of the world’s population has gained access to improved sanitation, yet one billion people still resort to open defecation (Bourguignon et al., 2010). Middle income countries account for majority of people who practice open defecation (82%) (Hutton, 2013). The global estimate for the annual cost of inadequate water supply and sanitation is about US$260 billion (Hutton, 2013). Inadequate water services have far-reaching health consequences with the possibility of poor sanitation systems causing environmental contamination (Katukiza et al., 2014; Nayebare et al., 2014; Prüss-Ustün et al., 2014). Bates et al. (2008 a and b) predicted that water will be the main channel through which climate change will affect people and economies. Even though climate change may be gradual, the cumulative effect it has on water security makes it more costly over time for governments to adjust (Rojas et al., 2013; Stern, 2013).

2.6 Waterborne Diseases

Environmental factors, which include the climate, are drivers of waterborne diseases. Climatic variables have seen significant changes and are projected to shift further in the future (Easterling et al., 2000). Semenza and Menne (2009) showed that indirect exposure routes of waterborne diseases are responsive to climatic conditions and can subsequently have negative effects on health because elevated ambient temperatures tend to favour the replication cycles of most waterborne pathogens. These occurring and projected shifts in climatic variables could modify the exposure pathways of waterborne diseases and pose different health risks to future generations (Boxall et al., 2008; Fawell,
However, the specific role of climate change in the spread of waterborne diseases is confounded by the simultaneous impact of factors like migration of human populations, drug and pesticide resistance, increased population density and availability of health services (Semenza & Menne, 2009).

A high number of naturally occurring microorganisms, consisting of viruses, bacteria and parasitic protozoa can cause waterborne diseases in humans. Microorganisms which are of human and animal faecal origin enter surface water primarily through the discharge of raw untreated wastewater and runoff from the land (Moe et al., 2007). Pathogens like *Vibrio cholerae* and *Schistosoma* species are constrained to tropical areas, while others like *Cryptosporidium* species and *Campylobacter* species are more evenly distributed (Hunter, 2003). An increase in intensity of rainfall can cause over-flooding of sewage and runoff of animal waste. This would result in high concentrations of pathogens in natural water bodies and in turn result in a poor quality of drinking water and water for general household (Nagels et al., 2002; Muirhead et al., 2004; Nie et al., 2009).

A major problem could result from the increased presence of diverse strains of enteric viruses in water bodies, since these are resistant to treatment in sewage treatment plants (Maalouf et al., 2010). There are several examples of waterborne diseases outbreaks associated with excessive rainfall (Curriero et al., 2001; Howe et al., 2002; Auld et al., 2004; Tryland et al., 2011; Funari et al., 2012). The largest reported waterborne disease outbreak in the United States was due to the presence of *Cryptosporidium* cysts in drinking water, and it resulted in the deaths of 54 people and leaving more than 403,000 sick (Howe et al., 2002). Curriero et al. (2001) reported a statistically significant
association between excess rainfall and waterborne disease outbreaks over a long period of time and on a national scale in the USA.

Floods, destroying the water distribution system and mixing drinking and waste waters, can have a significant bearing on the dispersion of cholera, which is caused *V. cholerae*. The disease is one of the most severe forms of waterborne diarrheal diseases. It usually causes the most damage in developing countries associated with poverty and use of poor sanitation and unsafe water (Miller *et al.*, 1985). Ghana has recorded several cholera pandemics with the outbreak between January and June 2006 having the highest fatality rate of 4.2% (de Magny *et al.*, 2006; Thompson *et al.*, 2011). In these cases, heavy rains preceded the onset of the cholera outbreak (de Magny *et al.*, 2006).

Even though there is well documented and projected increment in temperature, there is scarcely any data on the effects of this increment on microbial pathogens and infectious diseases (Semenza *et al.*, 2012). Increasing temperatures are however expected to expand the range and increase the incidence of *V. cholerae* if public health measures are not properly implemented (Lipp *et al.*, 2002). Greater saltwater intrusion on land due to sea level rise will lead to an increased level of estuarine bacteria, which include *V. cholerae* (Lipp *et al.*, 2002). It is anticipated that a disease like cholera will threaten water quality with an increase in temperature, especially in places like Africa, Asia and South America (Hunter, 2003).

### 2.7 Climate change impacts on water and sanitation

Freshwater is indispensable for all forms of life and is needed, in large quantities, in almost all human activities. Climate, freshwater, biophysical and socio-economic systems are interconnected in complex ways, so a change in any one of these induces a change in
another. Anthropogenic climate change adds a major pressure to nations that are already confronting the issue of sustainable freshwater use. Water is predicted to be the main channel through which the impacts of climate change will be felt by people, ecosystems and economies (Bates et al., 2008b). Globally, the negative impacts of future climate change on freshwater systems are expected to outweigh the advantages (Bates et al., 2008b). Even though in some areas, increased annual runoff is projected to lead to increased total water supply, this gain is likely to be neutralised in many parts by the negative effects of increased precipitation variability (Haines et al., 2006). Also seasonal runoff shifts in water supply, water quality and flooding hazards can occur. Flooding can lead to both infrastructure damage and contamination of surface and groundwater supplies especially in rural areas where surface water is mostly utilised. This can hamper both access to water and cause contamination and health risks. Likewise, sanitation may be affected as open defecation and pit latrines, both widely used in rural areas, are vulnerable to flooding and can cause serious environmental contamination and public health problems (Oates et al., 2014)

2.8 Vulnerability to Climate Change

Social stressors and bio-physical factors interact with climate-related risks to make people vulnerable. In the third assessment report (TAR) of the IPCC, McCarthy (2001) defines vulnerability is defined in terms of susceptibility and as a “function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity”. In the fifth assessment report (AR5) of the IPCC, the meaning of vulnerability has evolved and is defined simply as the tendency or predisposition to be adversely affected and such vulnerabilities can occur through societal
risks, particularly in low-income economies (Field et al., 2014). Adaptation and resilience to climate change are influenced by multiple stressors. Poor people are less able to cope with and adapt to natural hazards. Poverty, unemployment or lack of access to potable water, poor sanitation, health care, and education interact with land degradation, water stress, or biodiversity loss to restrict adaptive capacity. Recent studies suggest that climate impacts could slow down or reverse past developmental achievements resulting in increased environmental and human insecurity, and impeding poverty reduction efforts worldwide (Jerneck & Olsson, 2008; Boyd et al., 2009; Barnett & O’Neill, 2010; Ogallo, 2010).

2.8.1 Vulnerability of water and health

The impact of health on the domestic economy is particularly relevant for developing countries. With climate-sensitive economies facing multiple stresses, including gender inequality, poverty, and civil warfare, developing countries are highly vulnerable to changes in the climate system. Moreover, with low incomes, the capacity to adapt to predicted changes is low. Securing access to safe drinking water is the key to limit outbreaks (Webersik, 2010; Grover, 2012; Field et al., 2014).

2.8.2 Vulnerability of Africa

Africa has contributed the least to anthropogenic factors causing climate change; however, Africa will be the continent worst hit by the effects of climate change (Collier, Conway, & Venables 2008). This level of vulnerability of African societies is mostly as a result of several factors (Müller-Kuckelberg, 2012). Firstly, the large fraction of economic productivity occurring in climate-sensitive sectors; Secondly, low economic,
political and institutional capacities coupled with warmer baseline climates all contribute to Africa’s vulnerability (Watkins, 2007; Müller-Kuckelberg, 2012; Field et al., 2014).

According to Hulme et al., (2001) and Nicholson et al., (2013) near surface temperatures have increased by 0.5°C or more during the last 50-100 years with minimum temperatures warming more rapidly than maximum temperatures over most parts of Africa. This is set to further increase as research by Christensen et al (2007) predicts temperatures in Africa will rise and rise faster than the global average increase during the 21st Century. Likewise, precipitation is predicted to become more variable with changes in the timing and intensity of rainfall as a result of climate change (Niang et al., 2014).

Many major African rivers cross several national boundaries (Ashton 2002, De Wit and Jacek 2006) and sources of water that are reliable and regular are greatly valued in many African regions. Changes in the timing and intensity of rainfall as a result of climate change could lead to increasing water scarcity and stress with a subsequent increased risk of potential conflicts over water resources (De Wit & Stankiewicz, 2006).

Changes in the timing and intensity of rainfall as a result of climate change can also lead to widespread drought and food insecurity. In 2011 severe droughts in the Horn of Africa and in the Sahel region in 2012 all go to show how vulnerable Africa is (Boyd et al., 2013). Higher temperatures will directly change crop yields through a decrease in yield potential and the duration for growing seasons (Boko et al., 2007). Arid and semi-arid lands are also expected to increase in proportion by about 5–8 per cent by the 2080s (Boko et al., 2007). Widespread drought and food insecurity resulting in food price volatility can also create the socio-economic conditions that act as triggers to violent
insurgency (Bain et al., 2014). Nigeria and Egypt are prime examples of countries where this has occurred. With one in four people still undernourished in sub-Saharan Africa (Bain et al., 2014), climate change impacts will likely make it even more difficult for governments across the region to ameliorate food security and aid in the diminishing of strained political relationships.

According to Siegfried (1989), about one-fifth of all known species of plants, mammals, and birds in the world and one-sixth of amphibians and reptiles. Emerging evidence shows that climate change will have an effect on Africa's biodiversity (Boko et al., 2007). Ecosystems, habitats and species are already susceptible as a result of land use change, habitation destruction, introduction of invasive species among other stressors. Climate change is an added stress will that augment this vulnerability. Boko et al., (2007) Reduced water sources, elevated temperature and variable precipitation patterns will lead to shifting ranges of some species, habitat loss and loss of ecosystem services.

Finally, existing health vulnerabilities that exist will be multiplied by climate change. Malaria, tuberculosis, diarrhoea and meningococcal meningitis are climate sensitive diseases and have strong seasonal trends and associations with weather and climate variability (Guernier et al. 2004). These strong seasonal trends and associations suggest the disease burden could be affected negatively by climate change (Guernier et al. 2004, Niang et al., 2014). Climate variability in the future will also interact with other stresses like conflict, food and water insecurity (Harrus and Baneth 2005), thereby leading to increased risk to infectious diseases (e.g. cholera and diarrhoea) and malnutrition for adults and children with the highest toll expected in children (WHO 2004, Niang et al., 2014). Limited access to health care and education, insufficient access to safe water, lack
of improved sanitation and food insecurity are all climate-relevant health outcomes whose current burden might increase as a result of climate change. However this detection and attribution of trends is difficult as disease transmission is complex, with several interacting drivers apart from weather and climate, and lapses in datasets.

2.9 Adaptation to climate change

The scientific community has wide consensus on the link between emissions and warming but much less is agreed on about the possible manifestations of the warming through changes in rainfall, groundwater discharge and climate extremes (Kirshen, 2002; Groisman et al., 2004; Dore, 2005; Conway et al., 2009). This has led to the questioning of the usefulness of climate models for adaptation decisions (Dessai & Hulme, 2007; Stainforth et al., 2007; Knutti, 2010). There is very little scientific understanding of the African climatic system as a whole. With the exclusion of South Africa, there has been no coordinated climate change research programme supported by either government or other bodies (Conway et al., 2009). Effective adaptation projects would hinge on a holistic assessment of the current vulnerabilities of a country and the subsequent possible complications presented by climate change.
CHAPTER THREE

METHODOLOGY

3.0 Introduction

The central premise of this study was that changing climatic factors play a critical role in shaping household water availability and consequently public health, an idea that has support in the literature see Chapter 2, but requires further empirical validation. Therefore, this chapter establishes how the study was organised and carried out. It established the research design employed, the target population, the sampling methods and data collection instruments used as well as the reliability and validity of the data collected and how collected data was analysed.

3.1 Research design

The positioning of the study’s operating paradigm suggests a research methodology that combined both the perspectives such as quantitative and qualitative, known as Mixed Methodology. For this study there are three primary reasons for choosing a mixed methodical design:

1. The research purpose and research questions mentioned in Chapter 1 require a combination of qualitative and quantitative methods.

2. Research questions prepared in this study require the exploration and integration of perceptions and understanding of climatic factors in relations to water availability and public health (qualitative) and their empirical validation (quantitative).
3. There are gaps in literature regarding the role of changing climatic factors on rural household water availability and public health. Therefore a detailed understanding of this, requires the mixing of qualitative and quantitative methods.

Further justifying the use of a mixed method design approach in the study, Denzin and Lincoln (2000), indicated that in order to overcome the limitations of a single design and achieve a more centralized form of targeted research a mixed method is appropriate especially when the study’s research questions cannot be completely answered through qualitative or quantitative research alone.

In this study, the approach of mixing is more valid and robust, because rather than inferring and conceptualizing the perception and relational dimensions of household water use and availability from the qualitative data alone (in-depth interviews), rich empirical data provided a context for quantitative interpretation and support and triangulation (Creswell, 2003).

3.2 Study Area

The study was conducted at four different sites. Three of the sites are located in the Volta region of Ghana and the fourth site, which served as a control community was found in the Greater-Accra region of Ghana (Figure 3). All study sites were selected based on particular characteristics, such as the availability of a health facility, rural inhabitants, and people with an agrarian based source of income and the presence or absence of potable drinking water. The four selected project sites are Site 1: Totope, Site 2: Tsetseko, Site 3: Sayikope and Site 4: Klukope
Figure 3: Map of study communities
3.2.1 Study Area characteristics

3.2.1.1 Tsetsekpo, Sayikope and Klukope

Tsetsekpo, Sayikope and Klukope are located in the Central Tongu district of the Volta region of Ghana. The district is fairly new and was created in 2012 out of the then North Tongu district. It lies within latitudes 5°47N to 6°N and longitude 0°25 E to 0°45E. The district is a relatively rural one with 89.4% of the population being rural.

The climate is tropical and is greatly influenced by the South-West Monsoons from the south Atlantic sea and the dry Harmattan winds from the Sahara. There are two rainy seasons, the major rainy season from mid-April to early July and the minor rainy season from September to November. Average annual rainfall, mean temperature and average relative humidity is 900 mm -1100 mm, 27ºC and 80 percent respectively. Geologically, the area is characterised by clay, nepheline, gneiss, sand, granite and oyster shell deposits.

3.2.1.2 Totope

Totope is located in the Ada East district which is in the Eastern part of the Greater Accra Region. Its coordinates are Latitudes 5°45 South and 6°00 North and from Longitude 0°20 West to 0°35 East. The topography of the area is generally gently undulating with the highest peak being about 240 metres (800ft) above sea level. The major water bodies situated close to the study site are the Songor lagoon, Volta River and the Gulf of Guinea. However, none of the water bodies are used for either drinking or drinking due to the saline content of the water. Major occupations of the inhabitants include farming, fishing, fish processing and livestock rearing. Temperatures are high throughout the year and
range between 23°C-28°C; however a maximum of 33°C is attainable during the dry season. Average rainfall is about 750mm. Humidity is relatively high at about 80% due to the proximity of the sea, the Volta River and other water bodies.

3.3 Ethical considerations

After explaining the rationale for the study to the respondents, participants were verbally asked if they were willing to participate in the study. A verbal informed consent was obtained from each respondent and was sufficient to give the interviewer authorisation to proceed with the administration of the questionnaire. Furthermore, permission was also obtained from the heads of communities selected to take part in the study before the study commenced.

3.3.1 Confidentiality

At the start of an interview, participants were assured of confidentiality of responses given. They were assured that any information given would not be used to identify them. Furthermore, they were also informed that any information obtained during this study was going to be used solely for academic purposes.

3.3.2 Freedom to Withdraw

It was explained to the participants that participation in this study was voluntary and could therefore refuse to participate or withdraw at any time without repercussions.

3.4 Data collection

In accordance with the mixed method research design, both quantitative and qualitative data were collected. The main instrument used for the collection of quantitative data in the study was a pretested structured interviewer-administered questionnaire. The
questionnaire consisted of both close-ended and open ended questions and sought information on the socio-demographic (background) characteristics of the respondents, knowledge, attitude towards water and water-related diseases. It also collected data on their knowledge of climate change and environmental sanitation. The questionnaire survey was conducted by trained research assistants who could also speak the local language.

Qualitative data was also collected through direct visual observation coupled with casual questions. As most of the questions asked had to deal with attitudinal practices relating to sanitation and health, answers given during questionnaire administration might have been false. Direct observation was done to observe first-hand the water usage and sanitation practices and also to ascertain the validity of answers provided on the administered questionnaires (Kraan, 2009; Adubofour et al., 2013; Johnson et al., 2007) and also through the use of focus group discussions (FGDs).

This was considered necessary to give some contextual meaning to the quantitative findings in the study (Bhattacherjee, 2012). The FGDs were conducted with carefully developed FGD/ in-depth interview guide, which contained diagnostic questions on some of the issues raised in the questionnaire study. This provided in-depth understanding on the socio-cultural and economic issues with respect to issues of climate change, water, sanitation and health. Focus group discussions were conducted with 8 to 20 persons in a group. The discussions were held with adult females. A total of three FGDs, were conducted in all. This allowed the collection of collaborative information. The participants in the FGDs were purposively selected from all women available within the community and may or may not have been interviewed in the questionnaire study.
Important non-verbal expressions and reactions to issues raised by the facilitators of the FGDs as well as general observations were recorded by a note-taker on hand. In addition to that, for all sessions, notes were taken and discussions were tape recorded (Onyeneho et al., 2010).

3.5 Target population

The target population for the study comprised the number of households within the study communities. Therefore based on the 2010 population census figures (GSS, 2010), Six hundred and fifty one (651) households were present in the study communities. And since the primary objective of this study is to direct data gathering efforts toward getting information about the rural household availability and health related issues, women formed the bedrock of the study. This is because women normally have the primary obligation of managing the households’ water and this usually includes location, quality, collection, storage and usage of water (Aureli, 2004; UN Water, 2006). This therefore makes them generally more knowledgeable about issues pertaining to household water practices (Peletz, 2006). In addition, women in most communities play a crucial role in areas of health and sanitation and mostly have a role as caregivers (UN Water, 2006). Women were also chosen solely as participants in order to minimize the differences in responses in the survey.

3.6 Sample Size Selection

The sample size used in this study followed similar studies by West and Roche (2014). According to the author, a sample size between 300-500 provides a necessary guide for determining a statistically significant representation of the population of interest. For this
study Three hundred and one (301) women however were interviewed as representatives of households.

3.7 Study Phase 1- Pilot testing

A pilot testing of the questionnaire was done at the beginning of the study. In the pilot test, the questionnaire was administered to ten respondents using the simple random sampling method at Dodowa; an area bearing similar characteristics to the study area. This was intended to test for clarity and understandability of the questionnaire by the participants. It was also to test the procedures for selection of the sample and an application of the statistical procedures to be used in the data analysis stage (Monette et al., 2005).

Analysis of data collected from the participants and consultations helped frame and guide the design of the final questionnaire on the problem of attaining safe and clean water, the incidence of water-related diseases and climate change.

3.8 Study Phase 2- Field work

3.8.1 Sampling method

A simple random technique was employed to select the respondents at the household level for the survey. This type of sampling was chosen for this study in order for each respondent to have an equal probability of being selected for the household questionnaire interviews and also to reduce potential sampling bias (Whittington, 1998; Strina et al., 2003; Lagardere, 2007; Adubofour et al., 2013; Neumann et al., 2014). A total of 301 respondents were interviewed for the study. One hundred and fifty (150) respondents were interviewed in Totope, 64 in Tsetsekpo, 37 in Sayikope and 50 respondents in
Klukope. Total number of households surveyed (301) was limited by available funds and time constraints while still ensuring responses were a representative sample of households across the selected communities (Neumann et al., 2014). The survey was carried out between June and August 2014 in the four selected communities.

3.8.2 Recruitment Procedures

Participants were approached by interviewers who introduced themselves as research project personnel collecting data on climate change, water, sanitation and incidence of water related diseases. If a participant agreed to participate, then she was interviewed. Since majority of the respondents were rural inhabitants with little or no formal education, questions were translated and asked in the local dialect and a questionnaire filled out on their behalf. No inducements were given for participating in the study. However, compensation was given to respondents to compensate them for their time.

3.8.3 Distribution of survey

The surveys were conducted by 4 local interviewers who were recruited and trained as interviewers. The interviewers were trained on interviewing skills including, but not limited to self-introduction, explanation of the purpose of their visit, and the study. They were made to understand every detail of the survey to enable them explain it to the participants who may have difficulties in answering questions. They then administered the questionnaires door to door and carried out face-to-face interviews under the supervision of the principal investigator.
3.8.4 **Survey Instrument 1 (Questionnaire)**

The questionnaire consisted of both multiple choice as well as open-ended questions. The topics covered in the questionnaires included: socio-economic and demographic factors that influence access to water and sanitation; household water, sanitation and waste practices; water-related diseases incidence in households; climate change perception and adaptation practices. Some basic information was also collected on the characteristics of the respondents who participated in the survey including gender, age, and level of education, marital status, and number of people in the household. The questionnaire also collected information on characteristics of the household’s dwelling unit, such as the source of water, and type of toilet and waste disposal facilities. It also collected information on knowledge and experiences of water related diseases. In addition information was also collected on knowledge, perceptions, and attitudes about the causes and effects of climate change and climate change adaptation practices. A copy of the questionnaire can be found in Appendix 1.

3.8.5 **Survey Instrument 2 (Observation Schedule/Guide)**

There are two techniques that can be employed during observation. These include direct observation, where the researcher is a neutral and passive external observer and is not involved in the phenomenon of interest (as in case research), and participant observation, where the researcher is an active participant in the phenomenon and her inputs or mere presence influence the phenomenon being studied (as in action research) (Bhattacherjee, 2012). In this study, the direct observation technique was employed to observe the household water and sanitation practices and the environment in the study communities. This provided the opportunity for photographs to be taken to validate the observations.
Direct observation was also to ensure that conclusions drawn were verified and reflect the true situation to ensure appropriate recommendations were put forward.

3.8.6 Survey Instrument 3 (Focus Group Discussion)

A focus group is a method for collecting qualitative research data through carefully planned group discussions with the purpose of obtaining perceptions of participants in a permissive and non-threatening environment (Morgan, 1988). Women in the villages were informed of the time and venue of the scheduled meeting by the village announcer (gong-gong beater). After general introductions and stating the purpose of the meeting, participants were informed of the audio recording of the session after which the discussions took place. The discussions were guided by a skilled moderator fluent in the local language, who worked from a predetermined set of questions (Appendix 2). The notes, audio recordings and pictures of the FGDs were reviewed and transcribed within a week after the sessions.

3.9 Validation and reliability of data

In every research, it is important to ascertain the veracity and consistency of data collected. It is therefore essential to put in place measures that ensure that the data obtained was consistent and accurate (Bhattacherjee, 2012). In this thesis, multiple indicators and different methods of data collection namely structured interviews, focus group discussions and direct observation were employed. Also in this research work, maximum effort was put into ensuring the minimisation or elimination of confounders. In research work, confounding factors generally introduce error and must be avoided or reduced to ensure accurate analysis. Confounders may be minimized through adopting prudent study design and analysis. One method of reducing confounders is by the
randomization of the selection of participants of the study. Randomisation disseminates the known and unknown confounders evenly throughout the study population to prevent skewed results. In this study, though communities were chosen based on characteristics and location, households were randomly selected within the communities.

Another method of limiting confounders is restriction. Restriction limits the study to one category or level of confounder. In this study, the participants were limited to the woman of the household to minimize the differences in responses. In addition, matching which is another method to limit confounders was employed in this study. Matching restricts the selection of a comparison group according to the confounder. In this work, communities without a potable source of drinking water were matched to similar communities with potable water, to minimize the general differences between the households in order to make a suitable comparison. These measures employed in this study, helped increase the validity and reliability of data collected.

3.10 Data Processing and Analysis

The data processing of the questionnaire results began following the completion of the fieldwork. Completed questionnaires were edited manually and then entered onto a spreadsheet. SPSS software version 21 (IBM, Armonk, NY, USA) was used for analysis of data. For the analysis of the quantitative data, independent variables used in the analysis include gender, age, level of education, source of drinking water, and knowledge of climate change and waterborne diseases. In the data analysis process, socio-demographic variables and respondent responses were summarized and presented using frequency tables. Differences between variables of interest were also presented using cross tabulation tables. Evidence of association between socio-demographic variables and
attitudes was explored by cross-tabulation and measured using the $\chi^2$ statistic and ordinal correlation analyses.

The binary logit model was employed in examining the effect of climate variability on water availability (Table 3.9.1). This model was adapted from Peng et al., (2002) and used because it has the advantage of predicting the probability if climatic variables would or would not affect water availability. The model is specified as:

$$Logit(Y_i) = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum \beta_i X_i + \mu_i$$ \hspace{1cm} (1)

where $Y_i = \text{dummy for water availability}$ which is equal to one (1) if water is available in the community throughout the year and zero (0) if water is not available throughout the whole year, $X_i = \text{independent variables affecting water availability}$, $\beta_i = \text{regression coefficients to be estimated}$,

$\beta_0 = \text{intercept regression coefficient}$,

$P_i = \text{the probability of water being available throughout the whole year and}$

$\mu_i = \text{error term}$

Equation (1) can be further written as:

$$Logit(Y_i) = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 TEMP_i + \beta_2 RAIN_i + \beta_3 DURA_i + \mu$$ \hspace{1cm} (2)
The binary logit model was also employed in examining the effect of socio-economic characteristics of respondents on the incidence of water borne diseases (Table 3.9.2). According to Gujarati (2004), the advantage of this logit model, lies in its ability to predict if the socio-economic characteristics of respondents can or cannot influence the incidence of water borne disease. The model is specified as:

\[
\text{Logit}(Y_i) = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum \beta_i X_i + \mu_i \tag{1}
\]

where \(Y_i\) = dummy for incidence of water borne disease which is equal to one (1) if there is the prevalence of water borne diseases is available in the community and zero (0) if there is no prevalence of water disease, \(X_i\) = independent variables influencing the incidence of water borne disease, \(\beta_i\) = regression coefficients to be estimated, \(\beta_0\) = intercept regression coefficient,

\(P_i\) = the probability of the prevalence water borne disease and \(\mu_i\) = error term

Equation (1) can be further written as:

\[
\text{Logit}(Y_i) = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 FAM_i + \beta_2 INC_i + \beta_3 EDU_i + \beta_4 AGE_i + \beta_5 TREAT_i + \beta_7 PER_i + \mu \tag{2}
\]
Table 3.10:1 Summary of explanatory variables employed in the climate variability and water availability logit regression analysis.

The table below shows the various variables that were used in the logit regression model, their descriptions and the modes of measurement and the expected signs employed in the logit regression analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mode of measurement</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_i$</td>
<td>Water availability</td>
<td>Dummied: Yes =1, No = 0</td>
<td></td>
</tr>
<tr>
<td>$TEMP_i$</td>
<td>Temperature perception</td>
<td>Dummied: 1 = Increased, 2 = Decreased, 3 = Remained the same</td>
<td>-</td>
</tr>
<tr>
<td>$RAIN_i$</td>
<td>Rainfall perception</td>
<td>Dummied: 1 = Increased</td>
<td>+</td>
</tr>
<tr>
<td>$DURA_i$</td>
<td>Duration of variability</td>
<td>Dummied: 1 = Less than a year, 2 = 1 to 2 years, 3 = 2 to 5 years, 4 = 5 to 10 years, 5 = More than 10 years</td>
<td>+/-</td>
</tr>
</tbody>
</table>
Table 3.10: Summary of explanatory variables employed in the socio-economic characteristics and incidence of water-borne disease logit regression analysis

The table below shows the various variables that were used in the logit regression model, their descriptions and the modes of measurement and the expected signs employed in the logit regression analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mode of measurement</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_i$</td>
<td>Incidence of water borne disease</td>
<td>Dummied: Yes =1 No = 0</td>
<td>-</td>
</tr>
</tbody>
</table>
| $INC_i$    | Income category              | Dummied: 1 = Very poor 2 = poor 3 = middle income 4 = wealthy 5 = very wealthy Dummied: 1 = Primary 2 = Junior high 3 = Secondary 4 = Tertiary 5 = Never attended school | - |)
| $EDU_i$    | Education level              | Dummied: 1 = 20 and below 2 = 21 to 30 years | +/- |
| $AGE_i$    | Age                          | Dummied: 3 = 31 to 40 years 4 = 41 to 50 years 5 = 51 to 60 years 6 = Above 61 years | - |
| $TREAT_i$  | Treatment of stored water    | Dummied: 1 = Yes 0 = No    |               |
3.10.1 Explanation of independent variables

Temperature perception

The study hypothesized a negative relationship between perception of temperature and water availability. This is due to the perception that an increase in temperature results in evaporation of water bodies on which the respondents depend. Likewise, a reduction in temperature also results in the reduction of evaporation which makes water readily available for the inhabitants of the community.

Rainfall perception

The study hypothesized a positive relationship between rainfall perception and water availability. This is due to the perception that rainfall increases in amount and intensity result in an increase of the availability of water in streams and rivers on which the respondents depend whereas a decrease in rainfall amounts and intensity reduction results in the reduction of water in the water bodies.
Duration of the changes in the weather

This study hypothesized an ambiguous relationship between duration of the changes in the weather and water availability. This may be that as changes in weather variables such as rainfall and temperature persist for a long time in a geographical location, it may lead to an increase or decrease in water availability as a result of increased evaporation, increased rainfall amount or both.

Income category

The study hypothesized a negative relationship between income category and the incidence of water borne diseases such as skin rashes, diarrhoea and worm infestation. As household income increases, other sources of treated water will be utilized. Also better water treatment methods may be adopted which may prevent the contraction of water borne diseases.

Educational level

The study hypothesized a negative relationship between educational level and the incidence of water borne diseases. As the education of an individual increases, there is increased knowledge about the repercussions of using untreated water and so better ways of treating water are adopted. Alternatively, a higher income bracket may enable individuals resort to other sources of water.
**Age**

The study hypothesized a positive or negative relationship between age and the incidence of water borne diseases. As the age of an individual increases, one is more likely to either adopt a better water treatment method or resort to other sources of treated water.

**Treatment of stored water**

The study hypothesized a negative relationship between treatment of stored water and the incidence of water borne disease. When stored water is treated before use, there is a very low probability of contracting water-borne diseases as the microorganisms which cause diseases may be rendered inactive.

**Family head**

The study hypothesized an ambiguous relationship between position as a family head and the incidence of water borne diseases. Usually, decisions in the family are spearheaded by the head of the family and so he/she can make a decision as to which water source a family utilizes.

**Period of staying in the community**

The study hypothesized an ambiguous relationship between the period of staying in the community and the incidence of water borne diseases. The duration an individual stays in a community may influence the incidence of water-borne diseases since it is likely immunity against water borne diseases may result from continuous drinking of a particular water source.
3.10.2 Marginal Effect Estimation

The marginal effect is a measure of the change in the probability of an event occurring as a result of a unit change in the value of the explanatory variable *ceteris paribus* (Gujarati, 2004). In a linear regression model, the regression coefficients can be interpreted as a marginal effect. However, in non-linear regression models such as probit, tobit and logit models, coefficients cannot be interpreted as a marginal effect. This is because marginal effects are non-linear functions of regression coefficients (Gujarati, 2004). Also according to Peng (2002), the marginal effect in the logit model is given by

\[ \beta_i P_i (1 - P_i), \]

where \( \beta_i \) is the regression coefficient of the \( i^{th} \) explanatory variable and \( P_i \) is the probability of the event \( Y_i \) occurring.

A qualitative method of analysis was also used to describe and interpret data from the focus group discussions. The notes and audio recordings from the meetings were reviewed and transcribed and important key words, quotes and ideas were selected and grouped into categories or central themes based on the objectives of the study.

3.11 Study limitation

This study was carried out in a rural adult population therefore results generated can be generalized only to rural populations. Also, sex bias of the results is also a possibility since all the respondents were female.
CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the results of interviews, observations and focus group discussions which were undertaken in the four rural communities of Klukope, Sayikope, Tsetsekpo and Totope in order to answer the research questions of this work.

4.1 General Findings

4.1.1 Household Demographics and Socio-economic Status

A total of 301 respondents were interviewed in the four communities. Forty-nine point eight (49.8%) were from Totope, with 21.3%, 12.3% and 16.61% being from Tsetsekpo, Sayikope and Klukope respectively (Table 4.1:1). The average household size was 8 persons per household with 3 children on average per every household; with a modal age range of respondents in all the communities being 31-40 years constituting 21.9% of the study population. Fifty-seven percent of all respondents had electricity and almost 99% used a solid fuel source that was firewood, charcoal or both for cooking. None used liquefied petroleum gas or other sources of fuel for cooking.

Almost half (47%) of all respondents had no form of formal education. However 24.3% had obtained primary level education, 19.9% had junior secondary level education, 7.3% had secondary level education and 1.3% tertiary level education. Most of the respondents worked in the informal sector (89%) with only 3% having white-collar jobs or pursuing an education (8%). The most common occupation among respondents was farming.
(30.9%) followed by fish processing (27.9%) with the least common occupation among respondents being tailoring (1.3%). All four communities together had a monthly household expenditure of GHC 334.93 (96 US dollars). The results are summarised in Table 4.1.1 below.

**Table 4.1:1**: The table below shows the percentages of households surveyed per community, the general socio-demographic characteristics of the households, their sources of water, water storage and their general perception of water quality (N=301).

<table>
<thead>
<tr>
<th>Communities surveyed</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Totope</td>
<td>150/301=49.8%</td>
<td></td>
</tr>
<tr>
<td>Tsetsekpo</td>
<td>64/301=21.3%</td>
<td></td>
</tr>
<tr>
<td>Sayikope</td>
<td>37/301=12.3%</td>
<td></td>
</tr>
<tr>
<td>Klukope</td>
<td>50/301=16.61%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household Information</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of people in household</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Average number of children in household</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Modal level of education</td>
<td>No formal education</td>
<td></td>
</tr>
<tr>
<td>Average monthly household expenses</td>
<td>GHC 334.93</td>
<td></td>
</tr>
<tr>
<td>Most common Occupation(s)</td>
<td>Farmer</td>
<td></td>
</tr>
<tr>
<td>Public standpipe</td>
<td>177/301=58.8</td>
<td></td>
</tr>
<tr>
<td>Public standpipe and River Volta</td>
<td>24/301=8.0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Source</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>River Volta only</td>
<td>63/301=20.9</td>
<td></td>
</tr>
<tr>
<td>Stream Aklakpa</td>
<td>37/301=12.3</td>
<td></td>
</tr>
<tr>
<td>Jerry can</td>
<td>3/301=1.0%</td>
<td></td>
</tr>
<tr>
<td>Jerry can and Ceramic pot</td>
<td>9/301=3.0%</td>
<td></td>
</tr>
<tr>
<td>Ceramic pot</td>
<td>162/301=53.8%</td>
<td></td>
</tr>
</tbody>
</table>
### Water Storage

<table>
<thead>
<tr>
<th>Storage Method</th>
<th>Usage Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic pot and Plastic barrel</td>
<td>34/301=11.3%</td>
</tr>
<tr>
<td>Plastic barrel</td>
<td>5/301=1.7%</td>
</tr>
<tr>
<td>Wash basin</td>
<td>44/301=14.6%</td>
</tr>
<tr>
<td>Plastic bucket</td>
<td>44/301=14.6%</td>
</tr>
</tbody>
</table>

### Water Quality Perception and Treatment

- Yes: 64/301=21.3%
- No: 237/301=78.7%

#### 4.1.2 Household Water Supply

There were three main sources of drinking water in all four study communities. These were public standpipes, rivers and streams (Figure 4). Both the Volta River and Aklakpa stream serve three of the four communities. Fifty nine percent of respondents used the public standpipe solely as their main source of drinking water (Figure 4B). All inhabitants of Totope use the public standpipe as their sole source of water. The public standpipe water was provided as a result of the recent provision of pipe borne water for rural communities by the Community Water and Sanitation Agency (CWSA). Others, (8%) used both the public standpipe and Volta River as a drinking water source due to financial reasons. Some families (20%) used the public standpipe on an as can be afforded basis. The Volta River served as the alternative source of water in periods of financial constraints. However, 20.9% and 12.3% respectively that used only the Volta River and Stream Aklakpa as a drinking water source did so because they were the only available sources of water. Even though some of the communities (Totope and Tsetsekpo) used a pipe-borne water drinking source, all communities apart from Totope
used the Volta River (Figure 4A) and the Aklakpa stream (Figure 4C) for all other household activities. Over 60% of all sources of drinking water in the four communities fell under the WHO classification of unimproved sources of drinking water. According to WHO, an "improved" drinking-water source is one that, by the nature of its construction and when properly used, adequately protects the source from outside contamination, particularly faecal matter. Surface water utilized by respondents provides an example.

Responsibility for the fetching of water for the household in all four communities was mostly that of the mothers (40%) (Figure 5). The most common receptacle for the storage of water was ceramic pots (54% usage). Other water storage means were wash basins and plastic buckets, both constituting a total of (14.6% use). Even though in Totope and Tsetsekpo, water was from a pipe-borne source, some of the storage receptacles may likely compromise the quality of the water as direct observation revealed some of the storage receptacles were dirty and even mouldy. Likewise the lack of covering for storage containers (50%) in all study communities may have also compromised water quality. Respondents that were interviewed in all study communities (98.7%), claimed to cover their storage receptacles, even so direct observation proved otherwise since (50%) of all water storage receptacles that were observed in respondents homes were found to be uncovered.

A large proportion of respondents (55%) thought the water source was unfit for drinking without treatment. Although 35% of respondents had no idea why it was unfit for drinking without treatment, 27% classified the water source as turbid, and 17% said it caused Bilharziasis. Other respondents also reported the water source had some form of microbial contamination (9.6%) or had a smell (7.3%). The least reasons given for prior
treatment of the water source were the presence of worms/larvae (5%), the ability to cause diarrhoea (1.3%) and the ability to cause malaria (1.0%).

Despite the perception that the water available to the respondents was generally unfit for drinking without treatment, only 21% treated their drinking water source. The various forms of water treatment included the use of chlorine (7.6%), alum (1%), camphor (0.7%), filtering (7.3%), kerosene droplets (3%), boiling of water (2%) and the use of a treatment plant (0.3%) (Table 4.1.2).
Figure 4: Depiction of the various water sources utilized by the four study communities. All residents in Tsetsekpo and Klukope use the River Volta (A) to some extent. Respondents from Klukope use the river Volta for all their water needs, whereas respondents from Tsetsekpo use it primarily for household chores. Some residents in Tsetsekpo also buy pipe-borne water when it can be afforded for drinking. In Totope, the sole source of water in the community for all residents is a public stand pipe (B). Stream Aklakpa (C) is used by the inhabitants of Sayikope for all their water needs as it is also the only water source currently available to the community.
Figure 5: A graph showing the percentage distribution of household member responsible for fetching water in the four study communities. In all four communities, the mother was most responsible for fetching water (40%) followed by female child only fetching water (22%). Both male and female children (20%) fetching water was the third most common practice followed by mother and children (male and female) fetching water together (11%). Mother and female fetching water together also had 6% percent. In all four communities, male children only had the least percentage of fetching water (0.8%).
Table 4.1:2 Household Water Treatment Practices

The table below shows the various treatment methods used within the four study communities. The most common form of water treatment was chlorination whereas the least common form of water treatment was the use of a treatment plant.

<table>
<thead>
<tr>
<th>Treatment Method</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling</td>
<td>6/301 = 2.0%</td>
</tr>
<tr>
<td>Filtering</td>
<td>22/301 = 7.3%</td>
</tr>
<tr>
<td>Alum</td>
<td>3/301 = 1.0%</td>
</tr>
<tr>
<td>Chlorine</td>
<td>23/301 = 7.6%</td>
</tr>
<tr>
<td>Camphor</td>
<td>2/301 = 0.7%</td>
</tr>
<tr>
<td>Drop of Kerosene</td>
<td>9/301 = 3.0%</td>
</tr>
<tr>
<td>Treatment plant</td>
<td>1/301 = 0.3%</td>
</tr>
<tr>
<td>No form of treatment</td>
<td>235/301 = 78.1%</td>
</tr>
</tbody>
</table>

4.1.3 Household Sanitation

Open defecation constituted the most common means of defecation (45.5%) in all four communities due to the absence of good sanitation infrastructure. (Table 4.1.3) Pit latrines situated very close to the households were the next most common used facility for defecation (34.2%). Even though some respondents claimed to use a Kumasi Ventilated Improved Pit (KVIP) (18.9%), all KVIPs in the study communities (Tsetsekpo
and Totope) were found to be out of order during direct observation. Less than 2% of all respondents used an improved sanitation facility. Only 1.3% of respondents possessed water closets (WC) as a means of disposing off human faecal waste. These were affluent residents with holiday homes in the coastal village of Totope. Similarly, only the same percentage (1.3%) had access to a hand washing facility after defecation.

The absence of drainage systems in the communities meant liquid waste was disposed of indiscriminately in all four communities. Solid waste was in a similar manner likewise disposed of indiscriminately in the Songor lagoon (48.5%) (Figure 6A). Rubbish was also dumped behind the household dwelling (33.6%) (Figure 6B) in all the four study communities. Some respondents disposed of solid waste in the bush (16.6%), and also in the sea (1.3%).
Table 4.1.3 Household Sanitation Practices of Communities

The table below shows the various sanitation practices employed within households in the four study communities. The most common type of toilet facility was the free range (open defecation). Likewise, the most common site for solid waste disposal was also the Songor lagoon. Hand washing facilities were also not present.

<table>
<thead>
<tr>
<th>Sanitation – Type of Toilet Facility</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>KVIP</td>
<td>57/301=18.9%</td>
</tr>
<tr>
<td>Pit Latrine</td>
<td>103/301=34.2%</td>
</tr>
<tr>
<td>Free Range (Open defecation)</td>
<td>137/301=45.5%</td>
</tr>
<tr>
<td>Flush Toilet (WC)</td>
<td>4/301=1.3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sanitation- Hand washing Facility</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>278/301=92.4%</td>
</tr>
<tr>
<td>Yes</td>
<td>23/301=7.6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sanitation- Waste disposal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Songor Lagoon</td>
<td>146/301=48.5%</td>
</tr>
<tr>
<td>Sea</td>
<td>4/301=1.3%</td>
</tr>
<tr>
<td>Bush</td>
<td>50/301=16.6%</td>
</tr>
<tr>
<td>Behind the House</td>
<td>101/301=33.6%</td>
</tr>
</tbody>
</table>
A. Songor Lagoon

B. Behind a household dwelling
Figure 6: The waste disposal of solid waste by the residents of the study communities. Indiscriminate dumping of solid waste was the only form of waste disposal in all four study communities. A shows the indiscriminate dumping of refuse in the Songor Lagoon by the residents of Totope. B shows the indiscriminate dumping of solid waste behind a house by residents of the Tsetsekpo, Sayikope and Klukope.

4.1.4 Household Expenditure

Household expenditure considered such as monthly expenses on energy, water, health, transportation, education and miscellaneous expenses and their effects on household water availability and use is herein reported.

4.1.5 Household Water Expenditure

Generally, water made up 8% of the average monthly household expenditure (Figure 6). This figure however varied from community to community dependent on the usage of pipe borne water. Totope and Tsetsekpo both spent 12% and 4% of their monthly household expenditure. However, both Sayikope and Klukope spent zero percent (0%) of their monthly expenditure on water. The level of community dependence on the pipe-borne water differed between the study sites with Totope being the most affected by the pricing of pipe-borne water which they solely depended on. It is evident in that 12% of their household monthly expenditure is spent on household water acquisition.

In Totope and Tsetsekpo where pipe-borne is the water source, GH5p was the price for a 34cm$^3$ bucket of pipe-borne water that was three-quarters full (Figure 7). This cost was however only applicable when the taps were running. In the absence of the taps flowing,
the cost escalated from GH5p to GH10p in Totope and GH20p in Tsetsekpo for the same quantity of water. From the focus group discussions (FGDs) held, there was a general consensus that should the price of pipe-borne increase further, its use will become unsustainable since most respondents could not afford it.

![Figure 7: A graph showing the mean monthly spending (GHC ± 1 SD) for all households in the four study communities. Miscellaneous expenditure which comprises savings, cost of food, clothing expenditure and minor household expenses had the highest average household monthly expenditure (GH120.11). Transport had the second highest average (GH 66.68) followed by education (GH 52.96), health (GH 36.70), energy (GH 30.39) and water (GH 28.09).](image-url)
**Figure 8:** A bucket showing the quantity of pipe-borne water purchased at a cost of GH5p. The figure above shows the water level shown in a 34cm$^3$ bucket. The bucket is only three-quarters full but costs GH5p when taps were flowing. The cost further increases to as much as GH10p when taps were not flowing.

**4.1.6 Household Water Expenditure versus Other Expenses**

Since all communities were predominately rural, energy consumption was relatively quite low. Over 99% (299/301) of all respondents used charcoal, firewood or both as a source of cooking energy. In addition, only 57% (172/301) had access to electricity for which they spent little on due to the non-existence of sophisticated appliances. In some cases, respondents spent no amount on electricity since the Electricity Company of Ghana
(ECG) had recently connected them to the national grid or they had never been billed (Figure 6).

4.1.7 Perception of Water-Borne and Water Related Diseases in the study communities

Malaria was perceived by respondents (183/301) as the most common disease in all four communities (60.8%). Skin rashes were considered the second most common ailment among respondents (13.6%) (41/301). Diarrhoea was also considered as the third most common medical condition in the communities (11.6%) (35/301) followed by malaria combined with skin rashes (11.3%) (34/301). Even though 1.7% (5/301) of respondents were unsure about the most common water-borne or related disease in the community, 1.3% (3/301) of all respondents thought eye problems, worm infestation and Bilharziasis were the most common ailments. The main point of call for respondents who were ill was the health centre or hospital probably because of their close proximity to the communities.
4.2 Specific Findings

4.2.1 Socio-economic factors and household choice of a water source

The results indicate that there was generally an association between socio-economic factors of the household head and type of water source used by households in the research communities. There was significant association between household head’s education and type of water source used by households in the research communities ($\chi^2 = 10.4$, df=8, $p=0.002$). Similarly, the type of water source used by households was significantly influenced by the occupation of household head ($\chi^2 = 21.1$, df=10, $p=0.02$). There was a significant association between household income and type of water source used by households in the research communities even though there was a weak inverse relationship between household income and the choice of a water source ($R= -0.27$, $p<0.01$). However, the type of water source used by households was not influenced by the age of the household head ($\chi^2 = 37.7$, df=16, $p=0.24$). Likewise, the type of water source used by households was not influenced by whether or not the household head was a mother of a child less than five years of age ($\chi^2 = 2.7$, df=2, $p=0.26$). A summary of the results of the association between socio-economic factors and the choice of a water source by households are presented in Table 4.2:1.
Table 4.2:1 Chi-square analysis between socio-economic factors of household head and the choice of a water source.

Cross tabulations were run between the choice of a water source (independent variable) used by the households and the socio-economic factors (dependent variable) that may influence this choice. Chi-square tests ($\chi^2$) were run to determine if a significant association existed between socioeconomic factors and the choice of water sources at $p < 0.05$ significant level. The socio economic factors that had significant association with the choice of a water source included education level, occupation, household income with $p$ values of 0.002, 0.02 and 0.001 respectively.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Occupation</td>
</tr>
<tr>
<td>Type of water source used</td>
<td>Chi-square</td>
</tr>
<tr>
<td></td>
<td>$Df$</td>
</tr>
<tr>
<td></td>
<td>Significance (2-tailed)</td>
</tr>
</tbody>
</table>

*Significant at $p$ value of 0.05, $N=301$
4.2.2 Socio-economic factors and household sanitation choices

Household income had a significant correlation with both the type of toilet facility (R=0.20, p<0.01) and solid waste disposal (R= -0.39, p<0.01) used by households. Also, even though a statistically significant correlation was found between respondents’ status as a mother of a child less than five years of age and the type of toilet facility (R=0.22, p<0.01), no significant correlation was found between the respondents’ status as a mother of a child less than five years of age and type of solid waste disposal (R= -0.10, p=0.09) utilized by households. Likewise, no significant correlation was found between the educational status of the household heads and type of toilet facility and solid waste disposal at values of (R=0.01, p=0.87) and (R= -0.05, p=0.41) respectively. Similarly, the age of household head had no significant correlation with the kind of toilet facility in use by the household (R= -0.02, p=0.73). Conversely, there was a significant correlation between the type of waste disposal used by households and the age of household head (R=0.2, p<0.01). A summary of the results of the relationship between socio-economic factors and household sanitation choices are presented in Table 4.2:2

Table 4.2:2 Bi-variate correlation analyses between socio-economic factors and household sanitation choices.

Bivariate correlation analyses (Pearson’s R^2) were run between the choice of sanitation facilities (independent variable) used by the households and the socio-economic factors (dependent variable) at p < 0.01 significant level. This was to determine if a correlational relationship existed between socioeconomic factors and the choice of sanitation facilities used by the households. Age and household income had a significant correlation with the choice of solid waste disposal at p values of 0.00 and 0.00 respectively. Equally,
household income and whether or not respondent had a child aged five years and below also had a significant correlation with the choice of solid waste disposal at p values of 0.00 and 0.00 respectively.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of waste disposal used</td>
<td>Occupation</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.03</td>
</tr>
<tr>
<td>Sig.(2-tailed)</td>
<td>0.60</td>
</tr>
</tbody>
</table>

| Type of toilet facility used | Pearson Correlation | -0.09 | -0.02 | 0.01 | 0.20 | 0.22 |
|Sig.(2-tailed) | 0.14 | 0.73 | 0.87 | 0.00* | 0.00* |

*Significant at a p value of 0.01, N=301
4.2.3 Perception of climatic parameters and the incidence of water-borne and water-related diseases.

The respondents’ perception that rainfall could influence the incidence of water borne and water-related diseases from the logit analysis was statistically significant (p= 0.002) with the coefficient of change in the dependent variable being 1.039. Likewise, temperature perception by respondents was statistically significant (p= 0.003) with a coefficient of -1.446. Conversely, the duration of the changes in weather was also found to be statistically significant (p<0.01) and a coefficient of 0.473. A summary of the results are presented in Table 4.2:3
Table 4.2:3 Logit analyses between respondents’ perception of climatic parameters and the incidence of water-borne and water-related diseases in the four study communities

The table below shows the logit analyses carried out between respondents’ perception of climatic factors (independent variable) and the incidence of water-borne and water-related diseases (dependent variable) in the community. Rainfall and temperature were found to be statistically significant at p values of 0.002 and 0.003 respectively.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>Rainfall perception</th>
<th>Temperature perception</th>
<th>Duration of changes in the weather</th>
<th>Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of Water-Borne and Water-Related Diseases</td>
<td>Coefficient</td>
<td>1.039</td>
<td>-1.446</td>
<td>0.473</td>
<td>-2.732</td>
</tr>
<tr>
<td></td>
<td>Standard Error</td>
<td>-0.342</td>
<td>0.485</td>
<td>0.132</td>
<td>0.891</td>
</tr>
<tr>
<td></td>
<td>Significance</td>
<td>0.002*</td>
<td>0.003*</td>
<td>0.000*</td>
<td>0.002*</td>
</tr>
</tbody>
</table>

* Significant at p value of 0.01, F-statistic= 2.681, Prob> F 0.000, R² = 0.111, Adjusted R² = 0.153, N=301, - 2 Log likelihood = 294.840
4.2.4 Socio economic characteristics and the incidence of water-borne and water-related diseases.

The income level and age and of the head of the household were found to be statistically significant in influencing the incidence of water-borne and water-related diseases in the four communities with p values of 0.00 and 0.05 at p<0.01 and p<0.1 levels of significance respectively (Table 4.2.2) As well, both had analysis coefficients of -0.314 and 0.311 respectively. Educational level of the household head conversely was significant (p=0.014) and with an analysis coefficient of -0.232. The duration of a household head’s stay in the community was found to have an analysis coefficient of 0.293 and be statistically significant (p=0.030) (Table 4.2.4).
Table 4.2:4 Logit analyses of socio-economic characteristics of household heads and the incidence of water-borne diseases (WBD) and water-related diseases in the four communities

The table below shows the logit analyses carried out between respondents’ socio-economic factors (independent variable) and the incidence of water-borne and water-related diseases (dependent variable) in the community. Age, educational status, the income category of the households and the duration of stay in the community were found to be statistically significant at p values of 0.05, 0.014, 0.00 and 0.03 at significance levels of 0.1, 0.05, 0.01 and 0.5 respectively

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>Age</th>
<th>Income</th>
<th>Education</th>
<th>Duration of community stay</th>
<th>Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of WBD</td>
<td>Coefficient</td>
<td>0.195</td>
<td>-0.314</td>
<td>-0.232</td>
<td>0.293</td>
<td>-0.377</td>
</tr>
<tr>
<td>and Water-Related</td>
<td>Standard Error</td>
<td>0.101</td>
<td>0.088</td>
<td>0.094</td>
<td>0.135</td>
<td>0.618</td>
</tr>
<tr>
<td>Diseases</td>
<td>Significance</td>
<td>0.05*</td>
<td>0.00***</td>
<td>0.014**</td>
<td>0.03**</td>
<td>0.542</td>
</tr>
</tbody>
</table>

*, **, *** Significant at p value of 0.1, 0.05 and 0.01 respectively,
F-statistic =2.571, Prob> F 0.000, \( R^2 = 0.161 \), Adjusted \( R^2 = 0.223 \), \( N= 301 \), - 2 Log likelihood = 331.313
CHAPTER FIVE

DISCUSSION OF RESULTS

5.0 Socio-Economic Characteristics and Effect on Household Water And Sanitation Choices

The results indicate moderate to low access to sanitary infrastructure and good quality water sources in the study communities. This is similar to what others have reported for other communities in the developing world (McGarvey et al., 2008; Ghana Statistical Service, 2010). The use of tap water for water consumption characterized 59% of all households interviewed. This may be because of the recent provision of pipe borne water for rural communities by the Community Water and Sanitation Agency (CWSA) combined with the fact that all inhabitants of Totope (150/301) used the public standpipe as their sole source of water probably leading to a higher figure than the 40% reported in a study in the Accra metropolitan area in 2005 (Boadi & Kuitunen, 2005a) or the 32% estimated from a child health study of Accra households in the same year (Boadi & Kuitunen, 2005b). However, it was 10% lower than the estimation of 60% from a study in the Central Region of Ghana in 2008 (McGarvey et al., 2008). Less than 2% of the respondents also had access to a flush toilet and that, as many as 46% practised open defecation. This may be because of a lack of provision of toilet facilities in the study communities. Globally, nearly one in five people (1.1 billion individuals) habitually defecates in the open and households rely on filthy, risky latrines or shared toilet facilities (Bartram & Cairncross, 2010). High levels of under nutrition as well as the highest numbers of deaths of children under the age of five, high levels of poverty and large disparities between the rich and poor occur where open defecation is most widely
practised (Bartram & Cairncross, 2010). Also the lack of safe, private toilets also has serious gender impacts as women and girls may be more vulnerable to violence whilst attending to nature’s call. This can be an impediment to girls’ education and the elevating of socio-economic status of females in the developing world (WHO & UNICEF, 2013).

All respondents interviewed, disposed of waste in public dumps or open spaces compared with about 86% in a study in 2005 of urban Accra by Boadi & Kuitunen (2005c). Types of toilet facility and waste disposal pattern are associated with household social and economic variables, which in turn directly affect water quality and water-borne diseases (Wright et al., 2004; Cronin et al., 2006). Water-borne infectious diseases in turn, create more poverty and slow economic growth.

A significant but weak correlation was revealed between household income and the type of toilet facility (R=0.20, p=0.00) and waste disposal (R= -0.39, p=0.00) used by households. This is not surprising, as households with more income tend to have more disposable income and are more likely to have access to or own a flush toilet (Trevett et al., 2004). This confirms our findings as respondents from the study that had access to a flush toilet and hand washing facilities after defecation were affluent residents with holiday homes in the coastal village of Totope; affirming that wealthier households tend to have more sanitary methods of waste disposal.

The type of water source used by households was significantly influenced by the level of education of household head (χ² = 10.4, df=8, p=0.002). This is in agreement with what McGarvey et al (2008) discovered in their study in Central Ghana where socio-economic status had a clear relationship with the quality of the water source used by respondents (Manun'Ebo et al., 1994; Shier et al., 1996; McGarvey et al., 2008; Nyati, 2010).
Although none of the respondents with tertiary education used poor quality water sources (River Volta and Stream Aklakpa), most of the households in which the respondent had acquired only primary education or no education at all (71%), used poor quality water sources. Likewise, from the results, it showed that as the education of the respondent increased the probability of the respondent contracting water borne disease could reduce by 0.232 since an increase in the level of the education tends to make one more knowledgeable about the repercussions of using unsafe sources of water and hence prevent the incidence of water-borne and water-related diseases. This is similar to research conducted by Koskei et al. (2013) in Kenya in which they found out that education influenced an individual’s choice of a water source.

5.1 Effect of Socio-Economic Characteristics of Respondents on The Incidence Of Water Borne-Diseases

As all the study sites were pre-dominantly rural, a large majority of the respondents were employed in the agricultural sector as subsistent farmers which is mostly informal. Informal sector employees seldom attract substantial income to cater for the needs of their family; the low incomes of these households are closely linked with the affordability of services such as access to potable water due to their inability to pursue higher education that could possibly lead to higher earnings (International Labour Organization, 2004; Adubofour et al., 2013; Koskei et al., 2013). Research demonstrates a clear link between education and income. This is in agreement with our findings as only 8.6% of respondents had gone past the junior high school mark and only 3% had white-collar jobs and hence found the cost of pipe-borne water to be high thereby their choice of poor quality sources of water.
There was a significant association between occupation of households and type of water source used by households in the research communities ($\chi^2 = 21.1$, df=10, p=0.02); and from the logit analysis, the probability of the respondent contracting water borne disease could reduce by 0.314 as the household income category of the respondent increased. Income is directly predicted by the occupation of an individual and is as a result of education attained. The low level of education in all four study communities may indicate the high level of subsistence farmers and hence the low levels of income as the average household monthly spending for all four communities was GHC 334.93 (96 dollars). This agrees with what was reported by Koskei et al. (2013) in their research that occupation influences the households’ income and hence the amount of funds available to spend on water.

Economic status of households is closely linked with the affordability of services such as water (Kimenyi & Mbaku, 1995). Thus households with no reliable source of income are likely to use water from unimproved sources and therefore stand a greater risk of contracting waterborne and water-related diseases. Household expenditure (proxy of household welfare) is the principal factor, which makes households rely on unimproved sources of water as water can easily be compromised for immediate pressing needs such as health, food or rent (Kimenyi & Mbaku, 1995). Income levels are inherently influenced by types of occupation. Majority of the respondents (68%) were either peasant farmers or fisher folk. One area of agricultural production particularly vulnerable in Ghana to climatic variability especially with inadequate tools and water management practices is crop production (Müller-Kuckelberg, 2012). One respondent from the focus group discussion in Sayikope restated this view when she said “Without rain, all the
crops wither and die. Without the rain to water our crops, we cannot get money to trade or even go to school to improve ourselves and get money. We really need irrigation machines to help us on our farms”. Farm yields are directly impacted as a result of weather elements impacts on agricultural production and financial gain and thereby affecting the consumption of rural livelihoods (Karfakis et al., 2012).

Given the income risk or shock, some reallocation of resources within the household is also likely to take place. The indirect (through income and resource availability and reallocation) or direct interplay between environment, on the one hand, and health and consumption, on the other, eventually determines the final welfare impact of climate change on a household at any point in time. Consequently, it is worth noting that environmental shocks may have negative direct impact on health (Karfakis et al., 2012). It is therefore imperative that economic policies that favour small scale farmers and fishermen and alleviate rural poverty be implemented especially in the face of climate change; this will likely improve household incomes (Nonvignon et al., 2010). As it is likely that improved water sources might be provided but that people may be remain “water poor” not because there is no safe water in their area, but because they are “income poor” (Lawrence et al., 2002). This reiterates the view of some of the respondents from the focus group discussions held in Tsetsekpo who said that “River Volta is the source of water that is used the most. This is because without money or funds, the pipe-borne water cannot be bought. This also explains why we use the pipe-borne water for drinking and water from the River Volta for everything else. At the moment, water in a 34cm³ bucket, costs 5Ghp and 10Ghp for plastic basin. We wish it could stay the same price otherwise; we would be unable to pay for pipe-borne water. If the price
should increase, it would be extremely difficult to continue using pipe-borne water. Even now at 5Ghp, it is extremely expensive and it makes it impossible for some people in Tsetsekpo to use pipe-borne water”. Another respondent also said “To be frank, if the price should go any higher, I will, in fact we will all go back to using the River Volta. After all, it’s free and even since time memorial, that’s what we have been using”. An essential requirement for health is an available, safe and continuous supply of water for drinking, cooking, and personal hygiene (Hunter et al., 2010). According to Hunter et al. (2010) substantial health hazards such as endemic diarrhoea, intestinal helminthiases, giardiasis, schistosomiasis, trachoma, and several other globally important infections are associated with an inadequate water supply—whether as a result of reduced access or quality, low reliability, immense cost, or difficulty of management. These health risks are experienced most strongly by the poorest households within nations who lack the necessary capital to afford safe water (Hunter et al., 2010)

5.2 Implications of Water Borne Diseases on Socio-Economic Livelihood

Water borne diseases tend to have an impact on households. To investigate this possible relationship, correlation analysis was performed between household spending on water and household spending on health. The results show that there was no statistically significant relationship between household spending on water and household spending on health. This may be as a result of the mass registration of respondents into the national health insurance scheme (NHIS) (Ghana Statistical Service, 2010). The NHIS covers most medical and pharmaceutical expenses and hence may explain the low spending on health and the lack of a significant relationship. However, cost of health is not necessarily
always financial but can be in other forms such as time lost, physical pain and suffering and low cognitive development.

Sick family members have to be cared for. The burden of caring for family members who are ill with waterborne diseases often falls disproportionately on female members of the household (Kenya National Bureau of Statistics, 2010; Koskei et al., 2013) hence limiting available their time for other activities such as education, income generating and food-related and care activities, such as preparing food and feeding young children (Bergeron & Esrey, 1993). Again, water-borne and water-related diseases force children to absent themselves from school and can have lasting consequences for impaired fitness, growth, cognitive development and performance at school many years later (Guerrant et al., 2002). Well documented health data on the specific sample areas over a number of years could have also been used to determine possible relationships between the occurrence of waterborne diseases and the source of water used. Health data available, however, was riddled with gaps and was organised at the district level, making it inappropriate for analysis at the community level.

5.3 Effect of Climate Variability on Water Availability

R-squared and adjusted R-squared values of 0.111 and 0.153 respectively from the logit analyses imply that from respondents’ perception, rainfall intensity increase would likely increase by 1mm the log of odds as water availability increases by 1.039. This agrees with prior research by (Bates, Bryson et al., 2008b; Oates et al., 2014; Stocker et al., 2013) that increase or decrease in rainfall amount and intensity could result in an increase or decrease in the availability of water on which respondents depended on and may therefore influence the incidence of water-borne and water-related diseases. In the same
vein, temperature increases by 1°C may lead to a reduction of by 1.446 of the log of odd of the water availability. This suggests that increase or decrease in temperature may result in the increase or decrease of evaporation of water bodies on which the respondents depended. This in turn agrees with research by (Hagemann et al., 2012; Charlton & Arnell, 2014).
CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Conclusion

In spite of the general patterns of poor sanitation, and the use of unimproved water sources, significant relationships between the socio-economic status of households and the choice of water sources that were observed in this study were rather very few. This suggests that social and economic factors exert their influence indirectly on water availability and sanitation variables, which in turn impact on the perception of water borne and water related disease prevalence. These factors may also interact to affect the prevalence of water-borne and water-related diseases. It would be thus worthwhile for future research studies to focus on understanding the more complex indirect and direct associations between the prevalence of water borne or water related diseases and water availability, socio-economic factors and their interactive effects. A few correlational relationships between water availability and socio-economic variables, an increase or decrease in perception of prevalence of water borne and water-related diseases was revealed in this work, it may likely be linked to socio-economic factors (McGarvey et al., 2008).

Given that water borne and water-related diseases have far reaching consequences not only economically but for all facets of household socio-economic livelihood, urgent attention is needed to extend safe and affordable water systems, provision of sanitation infrastructure and embarking on health education campaigns about the interplay between climate change, water availability, sanitation and the outbreak or prevalence of water-borne and water-related diseases (Soares et al., 2002; McGarvey et al., 2008).
In the interest of providing rural and urban poor people in developing countries a better opportunity at adapting to the potential threats posed by climate change, education on causes and impacts of climate change, poverty alleviation strategies, improving water stress and sanitation challenges, improving health infrastructure is a major prerequisite that would not only be but essential to the very survival of such populations (Anstey, 2013).

6.1 Recommendations

Because the greatest need for clean and safe water is within the rural communities, but affordability of pipe-borne water is a problem, alternative ways of providing potable water must be explored such as the use of tube wells, boreholes and other groundwater resources must be explored.

Likewise, the use of solar stills for the disinfection of unsafe sources of water to kill pathogenic bacteria and make them safe for use could be a cheaper but alternative to pipe-borne water. Further research is needed on the efficacy of this technology for rural areas in Ghana since it has proved to be beneficial and relatively cheap elsewhere in the world.

The Central government in partnership with the Community Water and Sanitation Agency (CWSA) must also look into ways of further subsidizing the cost of pipe-borne water for rural communities to make it more affordable for rural inhabitants.

Policies geared towards poverty alleviation and the improvement of the standards of living must be implemented for small-scale farmers and fishermen. This is important for farmers to successfully adapt to the impacts of climate change.
Education of farmers on simple but effective climate-smart farming techniques will also help to increase farm productivity and incomes, and make agriculture more resilient to climate change. In addition, the distribution of improved varieties of various seeds such as drought and temperature resistant varieties for planting by the Ministry of Food and Agriculture may help farmers to adapt to the impacts of climate change.

The provision of sanitation infrastructure by the district assemblies in the communities will be a major step towards ensuring sanitation. The construction of composting latrines and garbage disposal sites by local authorities could be also explored as it may provide the dual advantages of adequate sanitation and fertilizer for agriculture.

Local authorities and health personnel should embark on routine health education campaigns on the benefits that are derived from good sanitation and hygienic practices.
REFERENCES


Fischer G, Mahendra S, and Harrij van V. (2002). Climate Change and Agricultural Variability, A special report, on Climate Change and Agricultural Vulnerability, Contribution to the World Summit on Sustainable Development. Johannesburg 2002 (Global, agriculture)


West, M., & Roche, K. B. (2014). *Statistical Methods in Public Health*


World Health Organization (WHO), Gender, Climate Change and Health (Geneva: World Health Organization, 2011).


**APPENDIX 1**

**QUESTIONNAIRE**

Hello, my name is Ewurama Asmah and I am a student from the University of Ghana. I am conducting a household survey on water, sanitation, water borne diseases and climate change in Ghana. I would like to talk with a woman in this household for about 30 minutes. All information given will be kept confidential and is strictly for academic purposes only.

**Date:**                                             **Start Time:**                                    **End Time:**

**Interview background**

<table>
<thead>
<tr>
<th>i) Survey Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>ii) Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>iii) District:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>iv) Community:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**SECTION A: BACKGROUND/ HOUSEHOLD INFORMATION**


4. How many members are in this household? ......................

5. How many are children? ..............................

6. How many are less than 5 years? ......................


SECTION B: WATER USE PRACTICES

9. Where do you get your drinking water from? .............................................


<table>
<thead>
<tr>
<th>Improved Source</th>
<th>Always</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Unimproved Sources</th>
<th>Always</th>
<th>Sometimes</th>
<th>Rarely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household tap</td>
<td></td>
<td></td>
<td></td>
<td>Surface(lake/river)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protected well</td>
<td></td>
<td></td>
<td></td>
<td>Unprotected well</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protected spring</td>
<td></td>
<td></td>
<td></td>
<td>Unprotected spring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borehole</td>
<td></td>
<td></td>
<td></td>
<td>Tanker truck water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainwater collection</td>
<td>Water vendor: bottled (cost)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public standpipe</td>
<td>Water vendor: sachet (cost)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify):</td>
<td>Other (specify):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IF WATER IS FROM A HOUSEHOLD TAP MOVE TO QUESTION 13**

11. Who goes to fetch the water? …………………

12. How many times in the a. dry season .......... b. rainy season .....................

13. How many times a week does water flow from the tap? ................

**WATER STORAGE**


19. What do you treat your stored water with? ..................

WATER QUALITY PERCEPTION


SECTION C: HEALTH

22. Rank these diseases based on how common they are in the community? Malaria [ ] Diarrhoea [ ] Worm infestation [ ] Skin rashes [ ] Acute respiratory tract infestation (ARTI) [ ]

24. If not then what? ..............................................

25. Where is the nearest health facility? ................. How far is it? (time)


27. Can you give the number of people, their ages and the number of days they had it for?


............................

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HOUSEHOLD SANITATION AND HYGIENE


34. How far is the toilet facility from your home? ..............................


36. Where do you dispose of your solid waste/ refuge? ..............................

37. How far is it from your home? ..............................

SECTION D: INFORMATION AND PERCEPTION ABOUT CLIMATE CHANGE


39. Which changes have you noticed in the environment/ weather? ..............................


43. What in your view accounts for the observed changes in temperature and rainfall?


If yes, how? ..............................................................................................................................


ADAPTATION

47. What have you done or are you doing to cope with the effects of the changes in rainfall?

48. What have you done or are you doing to cope with the effects of the changes in temperature?

49. When did you start doing this to cope with the effects of the changes in rainfall?

50. How about temperature?....................................................................................................
51. What changes or effects have you noticed since you started using this action to cope?

52. What are others also doing in the community to cope with the effects of the changes in rainfall and temperature?

53. Are their methods effective? Y/N How?

54. Are there other methods/means you can use to cope?

55. Why are you not using those methods instead?

56. What can be done by the authorities to help you cope with the effects in rainfall and temperature?

SECTION E: PERSONAL INFORMATION


59. What is your occupation?

OBSERVATIONS (Socioeconomic)

60. How much do you spend on each of the following each month in (GHC)?
61. Which of the following needs of the community should be met urgently?

...........................................................................................................

Thank you so much for your time.
APPENDIX 2

Focus Group Discussion Questions: FACILITATOR SHEET

Estimated time: 60-90 minutes

Participants: women in the villages of Tsetsekpo, Sayikope, Avadiwe (Central Tongu district), Totope (Ada east district)

Central Tongu district and Ada East District

Date and Location___________________

1. Purpose of the FGD

Introduction

Good afternoon and welcome to our focus group session on water, sanitation, health and climate change. Thank you for taking the time to come here. My name is Ewurama Asmah and I am a student at the University of Ghana. With us here are ……….. (Mention names of co-facilitators). We would like to understand your views on water, sanitation, health problems and climate change in this village as part of my research work but the information gathered will also go to the relevant authorities so the issues raised can be addressed and solved. As we are aware, water is an expensive resource and fishing, fish processing, farming and well as healthy living depends much on water.

In this discussion, there are no right or wrong answers but rather various points of view. Please feel free to share your point of view even if it differs from what others have said. Before we begin, let me remind you to please talk one at a time. Please keep in mind also
that we’re just as interested in negative comments as positive comments, and at times the negative comments are the most helpful. Our session will last about an hour to an hour and a half. But before we ask the first question, let’s find out some more about each other. Tell us your name, how long you’ve lived in this community and your occupation.

2. Introduction of Participants and Facilitators

**Opening questions**

1. Please tell me about all the sources of water available?
2. Of these sources of water which one is readily available?
3. Which one do you use the most? Why?
4. Are you happy with your current water source? Why?
5. Does the community plan on building alternative sources of water? (if yes, ask what the options are. If not ask about Q6 &7 i.e. well and rainwater harvesting)
6. Is rainwater harvesting an option? Why yes or no?
7. Is digging wells an option? Why yes or no?
8. Does the quality of the water source change with the seasons? If it does, does it significantly affect you? How?

**Intermediate Questions**

9. Do you treat your water source to improve the quality? If yes, what are you using? If no, why do you not use any treatment method?
10. What treatment option in your opinion to improve the quality of your current source of water?
11. At present, which treatment option is most affordable to you? Please explain
12. At what price will you be willing to pay for a bucket of water?
13. If the price you stated should increase, will you still be willing to use it as a water source?
   Can you explain further?
14. What could possibly lead to an increase in the price of a bucket of water? Please explain.
15. Have you heard of climate change? Please explain.
16. Where did you hear about it for the first time?
17. What is climate change?
18. What can be done to help you do your work and make money even if there is climate change? Please explain further
19. Why haven’t wells been dug in the farms for use instead of rain fed agriculture?
   **For Totope only**
20. Why is farming not an option in this community?
21. Why do you dump of refuse in the lagoon?
22. Does it help to reclaim the land?
23. Even though it helps reclaim the land, it decreases the size of the lagoon and the amount of fish caught. Are there any other alternatives you can use instead?

   Thank participants for co-operation and ask if there are any suggestions or comments.