CLIMATE CHANGE AND CITY DWELLERS ADAPTIVE CAPACITY: THE CASE OF FLOODING IN THE KUMASI METROPOLIS

By

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DECLARATION

I declare that this submission is my own work towards the MPhil and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

To God be the glory for the strength provided, the grace bestowed and mercies abundant.

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ABSTRACT

Climate Change is a reality, evidenced by changing and unpredictability of climatic factors such as increasing temperature, evapo-transpiration, rainfall, disruption in climatic patterns; and increasing frequencies and intensities of extreme event. According to Ghana‟s country report to the UNFCCC in 2000, the mean daily temperatures in Ghana will increase by about 2.5° C to 3.2°C, if the mid-range atmospheric sensitivity of 2.5°C is assumed, over the 1961 to 1990 baseline temperatures by the year 2100. This is higher than the global average of about 2°C in the same period. In the rainforest and moist semi-equatorial zones, increases are expected in the rainfall pattern.

Clearly, the above shows that Ghana is being affected by climate change with some negative effects recorded for some decades now. Of all the effects of climate change, flooding presents danger to cities than the other effects, with significant number of disasters happening in the last decades being flood were in areas considered urban. In spite of the overwhelming evidence suggesting that climate change is responsible for flooding in cities in the world, there are reasons to suggest that Kumasi‟s flooding incidence is otherwise. Therefore, the study sought out whether climate change is happening in Kumasi and if so, is it responsible for the flooding incidence experienced of late in the Metropolis.

Information for the study was collected utilizing the case study approach, which enhanced the use of multiple evidences for the conclusion drawn at the end of the study. In all data was collected from households in seven suburbs of the city including Bremang, Dichemso, Aboabo,

Oforikrom, Atonsu, Asafo and Adiembra. These were augmented by data from the Ghana Meteorological Department, National Disaster Management Organization (NADMO), the Engineering Department and Town and Country Planning Department of KMA.

Available meteorological data on temperature and precipitation for Kumasi from the Ghana Meteorological Agency evidently shows increasing temperature and rainfall patterns since 1961 with variations for temperature of about 0.2°C above the mean for the last ten years (1990-2009), evidently an increment of about 0.4°C for the decade. It therefore suggests that Kumasi is experiencing climate change as experienced by the whole country, though on a moderate scale. Other evidence pointed out in the thesis suggest strongly that Kumasi‟s flooding is as a result of human factors such as sanitation, poor planning and ineffective and blatant disregard for physical development laws in the city. Just as the research sought to identify causes, it also proposed a number of policy options to mitigate this developing phenomenon. It proposed both short and long term options in mitigating this flooding phenomenon so as to make Kumasi a more resilient and sustainable city.

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INTRODUCTION

1.0 Research Background

Scientific evidence confirms that climate change is taking place and human activities have been linked to most of the increasing earth‟s temperature over the past 50 years (Intergovernmental Panel Climate Change, 2007). Millions of people around the world are already, or will be, affected by climate change. In the South of the Sahara, climate change projections from World Meteorological Organization suggest increased variability in rainfall, more frequent extremes events, and increased temperatures (Hewitson et al, 2006). It further suggests these events will still occur even if global emissions were to be reduced in accordance with Kyoto Protocol.

Increasing evidence suggests that climatic variability is adversely affecting Ghana‟s natural resources such as land, water, forests and vegetation, as well as human capital (Masahudu, 2012). Food security is under threat from unpredictable changes in rainfall and more frequent extreme weather. The severe floods and drought of 2007, coupled with rise in global food and fuel prices have cumulatively increased the already existing vulnerabilities among people and communities in the country, especially, the three Northern regions. Small farms, which employs about 60% of the farming workforce (Ministry of Food and Agriculture, 2005) and is expected to feed a nation of 24 million is heavily dependent on climate and in the face of changing climatic patterns, the question is whether Ghana will be able to feed its population or rely on imported food. Aside agriculture, other sectors of the country such as health and environment are reeling under the impact of climate change from flooding.

Climatic change impacts are cross cutting and not exclusively limited to one sector of human activities. There are many examples of effects of climate change such as a rise in sea level during the past century from four to eight inches, an increase in precipitation by approximately one percent, changes in the ecosystem altering the amount of snow in the north, a rise from five to ten percent in rainfall, and summers becoming increasingly dry while ice in the Arctic Ocean decreases, drought conditions and floods, with the last two killing more people than the rest combined (WMO, 2010). Climate change can bring positive changes, such as its effect on extending the growing season in areas with short seasons, but when change comes quickly, living systems don‟t have time to adapt.

Of all the effects outlined, flooding presents more danger to cities than the other effects, with significant number of disasters happening in the last decades being flood and in urban areas. Urban centres in developing economies, which houses more than one third of the world‟s population, have a large proportion of their population and economic activities, hence being mostly at risk from extreme weather events (Satterthwaite, 2007). In these same areas of the world, they contain most of the economic activities and most of the new jobs created over last few decades (United Nations Environmental Programme, 2007).

In Ghana, a significant number of past disasters and events have been associated with weather conditions and the concern is that these may occur more frequently in the future. There is a clear upward trend in the frequency of disasters arising from natural events. There is also an increase in economic and insured losses due entirely to weather related disasters. A large proportion of disasters recorded were in urban areas and they are mostly floods and storms (Borger, 2007). In effect, most people at risk of flooding in areas of human settlements in Ghana are the urban centres. These areas concentrate a large proportion of population most at risk from climate change effects and businesses that generate most of the products used in the world (GDP, etc.).

Most physical development and economic growth in developing and undeveloped countries takes place outside any official plan and official regulation and rules. It is the situation for most new housing development. This is because most of the population cannot afford a house that meet official standard, which always are unrealistic (a relic of colonialism). In other ways, it is the result of a mismatch between the growth of urban centres‟ economic base and population and the incompetence, inadequacy and unaccountability of local government institutions (Bicknell et al, 2009).

In urban centres of developing and undeveloped countries in Africa, Asia, the Caribbean and Latin America, millions of people live in shelters that are of poor quality, overcrowded, insecure tenure and little provision for infrastructure including water and sanitation (Hardoy et al, 2001). In such areas of the world, it is normal for high proportion of the urban population to live in illegal settlements because they cannot afford to buy, rent or build legal shelters. The poor often live in most unsafe and hazardous environments in the urban centres.
They build their homes on marginal lands (marshy areas), steep hillsides and unstable hills that are susceptible to disasters, of which has been compounded by climate change.

The problems of climate change has brought in, a new dimension to the existing challenges in Africa. Though it affects large areas of the world, climate change effects such as flood impact the poor in developing countries the most, in terms of lost and disrupted livelihoods. The management of disasters requires technical preventive actions to reduce the impacts before and after they occur. Such approach should consider the reduction of human vulnerability and one key to addressing the issue of the effects of climate change is planning. However, "disasters" do not feature in many conventional urban researches as "unusual events" (natural events) are not understood to be caused by urban development.

By their very nature, cities contain more people and their homes, impervious surfaces, physical capital, industries and waste, making them dangerous place to live and work at the same time thus making their population very vulnerable to extreme weather events or events that have the potential to be disasters.

1.1 Problem Statement

In Ghana, the issue of climate change and weather variability is given the attention when extreme weather events such as floods, droughts, heavy rains and storms and extreme temperatures are experienced. It gets the headlines because they are considered unusual and unexpected, with the media full of publications detailing how many people were killed, injured or displaced and the worth of properties destroyed. Authorities, experts and the general public comment on the situation, probable causes and the measures to prevent its reoccurrence, but it is forgotten in few days and those affected continue to struggle with their predicament.

More often than not, urban managers do not understand why urbanization is taking place, what drives the people to concentrate in specific urban locations and what particular processes make the population of each urban centre vulnerable to environmental hazards. With a few honourable exceptions, literature suggests that they have a simplistic, often stereotyped „urban population explosion" or „rural-push/urban-pull" view of urban change" (Satterthwaite et al, 2007). It is the aim of this research to provide more analytical view of the problem of climate change, flooding and the effects on the urban poor. It is the concern of this research to provide a better understanding of what makes a city and its population at risk from climate change.

1.2 Research Questions

Based on the problem statement, the study seeks to find answers to the following questions:

i. What are the nature, type, causes and effects of the incidence of flooding in the city of Kumasi?
ii. What is the relationship between the incidence of flooding and climate change in the city of Kumasi?
iii. What are the characteristics of City Dwellers affected by the incidence of flooding in the Kumasi Metropolis?
iv. What are the adaptation measures and the capacity of city dwellers in dealing with the incidence of flooding in the Kumasi Metropolis? and
v. What policy measures are needed to mitigate the adverse impact of climate change and flooding in Kumasi?

1.3 Study Objectives

The general objective of the study is to examine the relationship between climate change and flooding and its effects on the urban poor. Specifically, the research addressed the following:

i. To identify the frequency of flood occurrence in the Kumasi Metropolis
ii. To determine the nature, types, frequency, causes and effects of flooding in the Kumasi Metropolis; iii. To assess the relationship between the incidence flooding and climate change in the city of Kumasi;
iv. To assess the characteristics of City Dwellers affected by the incidence of flooding in the Kumasi Metropolis;
v. To assess the adaptation measures and capacities of communities and city authorities in dealing with flooding; and
vi. To recommend policies to mitigate the adverse impact of climate change and flooding in Kumasi.

1.4 Study Hypotheses

In other to answer the research questions and study objectives, the following hypotheses were tested:

i. Flooding in Kumasi is because of localised factors;

ii. Flooding in Kumasi is due to Climate Change; and
iii. Increasing urbanization contributes to flooding

1.5 Scope of study

Geographically, the research was carried out in the city of Kumasi with special emphasis on suburbs of the city that has been and continue to be affected by the perennial flooding of the city. Conceptually, the research was confined to climate change, flooding, vulnerability assessment and adaptation methods and techniques of those affected by climate change. The research also recommended ways to effectively plan with changing climatic condition in mind.

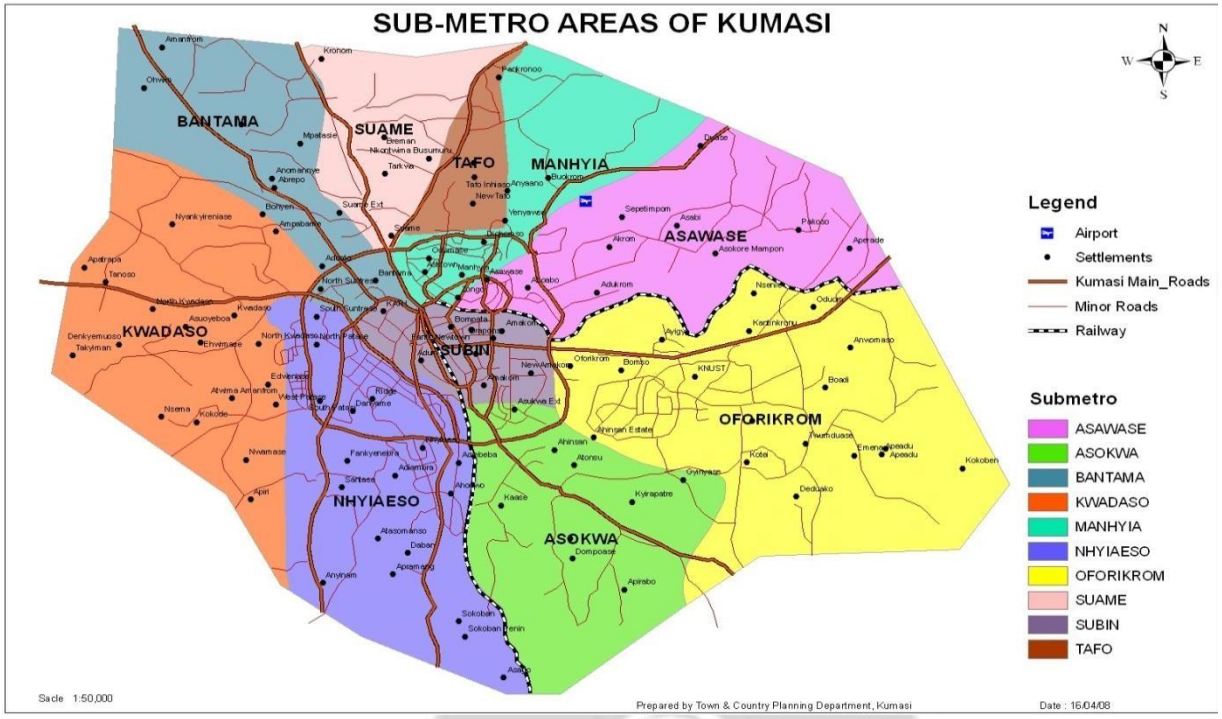
1.5.1 Overview of Study Area

The Kumasi Metropolitan Area is centrally located in the Ashanti Region with Kumasi as its capital. Kumasi is also the second largest city in Ghana after the national capital, Accra. It is the capital of the Ashanti Region and the seat of the Ashanti Kingdom. The Metropolis lies 270kilometres north of the national capital. It is between latitude 6.35º – 6.40º and longitude 1.30º – 1.35º, an elevation that ranges between 250 – 300 metres above sea level with an area of about 254 square kilometres. It is located in the transitional forest zone, a zone characterised by heavy and intense rainfall in the months‟ of June and September (Double Maxima Regime).

Kumasi Metropolis has a population of about 1.6 million with a growth rate of 5.47%. It has an additional daytime population of about 500,000 people in view of its strategic location and the administrative and commercial functions it performs. The metropolis is 48% urban, 46% peri-urban and 6% rural.

Kumasi has the single largest traditional market in West Africa and due to its location, it has vibrant private sector involvement in trading which dates back to the pre-colonial days.
Employment level is high taking about 86% mostly in the informal sector. In terms of composition, the services/commerce sector accounts for about 71%, while the industry sector employs about 24% with agriculture accounting for only 5% of the active labour force.

Figure 1: Administrative Map of Kumasi, Showing Sub-Metros



Source: Town and Country Planning Department, 2009.

1.6 Justification

Recurring disasters from extreme weather events can undermine community‟s resilience and capacity to make investment needed to protects themselves against larger disasters. Urban contexts inevitably increase the risk of "concentrated hazards" (Levell, 2003), "as primary hazards leads to secondary hazards". High proportion of lower income groups may settle on a marginal land (e.g. Site susceptible to flooding) as such sites are cheaper and they may not have access to safer land. At the same time, such groups do not have the capacity to reduce their vulnerability. Issues of disasters are costly when not mitigated and when they happen, identifying a workable solution sometimes is a marathon for policy makers as they are not understood properly. It is the aim of this research to provide that critical link. Such detailed local studies are needed in urban centres, not only to show the health and other costs from extreme weather events (including „small‟ disasters whose aggregate impact may be larger than events classified as „disasters‟) but also because of the following:

i. The number, territorial spread and impact of disasters or small disasters may be increasing rapidly;

ii. Risk from these may graduate in time to larger events, as populations and their vulnerabilities increase in the areas close to the hazard sources and as hazards grow in size and potential intensity; and

iii. Developing an ability to intervene to prevent „small" disasters or limit their damaging impacts can also serve to develop a capacity for doing so for larger events.

This research also provided data and insight that will broaden the understanding of the unfolding process and how the problems associated with it can be effectively addressed. It has at the end, added to literature and serve as a reference for further research.

CHAPTER TWO CLIMATE CHANGE, FLOODING AND ADAPTATION STRATEGIES

2.0 Introduction

The earlier chapter set the framework of the study by outlining the purpose of the study and the general arrangement of the research work. This chapter present reviewed related literature on climate change, adaptation, vulnerability, and flooding, all in the urban context. The review contributes to the dialogue on the linkages between climate change and planning. Specific issues considered in the literature review include the assessment of the incidence of Climate change in Kumasi, the relationship between the incidence of Climate change and flooding in Kumasi, the level of Kumasi to climate change-induced flooding if any and the consequences of climate change on planning in Kumasi.

2.1 Climate Change: Theoretical Perspective

Climate change is now a scientifically established fact. The exact impact of greenhouse gas emission is not easy to forecast and there is a lot of uncertainty in the science when it comes to predictive capability, but we now know enough to recognize that there are large risks and in fact potentially catastrophic ones. Therefore, climate change demands urgent action now in order to address a threat to at least two constituencies with a weak political voice: the world‟s poor and future generations.

The term „climate change‟ is used with different meanings and perspectives. In some cases, it may refer to all environmental change or include natural variability. It is most useful to think of climate change as one of several symptoms of human-induced environmental change with both global and local perspectives. A global perspective is appropriate in recognition of the global interactions involving the component physical systems fundamental to climate change, whiles the local perspective is essential because it is the local impacts, which are of significance to individuals and communities. Again, it is at the local level where measurements must be obtained from all parts of the world in order to properly describe climate and predict its changes.

Climate is generally defined as the average state of the atmosphere for a given time scale (hour, day, month, season, year, decade and so forth), usually observed over thirty (30) years (World Meteorological Organization, 2010), and generally for a specified geographical region. The average-state statistics for a given time scale including all deviations from the mean are obtained from the ensemble of conditions recorded for many occurrences for the specified period. Thus, the mean temperature for the month of May in Kumasi, is obtained from measurements considered representative for Kumasi, averaged over the month of May from a record of many years.

IPCC (2007) states that "climate change is a change in the state of the climate that can be identified by changes in the mean and or the variability of its properties and that persists for an extended period, typically decades or longer". Okali (2004) defines climate change by first of all defining climate as the "average weather" together with the variability from the average; it is the synthesis of the weather in a given place over a period of at least 30 years". He listed the main elements of weather to include temperature, rainfall, dew, humidity, wind, sunshine, mist, haze and cloud. It is the collective pattern of expressions of these elements overtime that is described as the climate of the place. Climate change is thus a change in these collective patterns of expression, not a change in one of the element of weather. It is the permanent departure of climatic patterns from mean values of observed climate indices (Obioh, 2002). For the purpose of this study, of all the afore-mentioned definitions, that of IPCC is used.

Climate change has been and continues to be one of the most engaging environmental subjects of debate in recent times. The 2011 Durban Conference in South Africa on Climate Change has further heightened the debate. Indeed, the environmental problems associated with the potential impact of expected climate change may prove to be among the major environmental problems facing many countries. Climate change and variability is already affecting Ghana‟s water resources, and often attributed to global warming caused by increased greenhouse gas emissions for several decades.

A review of literature shows much interest and attention has been given to climate change. Arguments and counter arguments have been raised, all in support or against climate change. Because of the attention given to this phenomenon, care must be taken in order not to be caught in the politics of climate research. However, in all the review, there are two competing theories for the recent global warming trend.

- The first is based on a theory which followed the warming trend that occurred between 1975 and 1998; and
- The second theory is based on highly correlated data going back thousands of years.

In spite of the varying differences, most agree that temperature has increased by about 0.6 - 0.7 Centigrade over the last century and that the level of CO^2 or Carbon Dioxide, a greenhouse gas, has been increased in the atmosphere by 25-30% from pre-industrial values.

- The first theory, which is the generally accepted one, is that the release of greenhouse gases from the burning of fossil fuel and from land use is responsible for the recent temperature increase.
- The second theory is that the sun's magnetic field and the solar wind modulate the amount of high energy cosmic radiation that the earth receives. This in turn affects low altitude cloud cover and how much water vapour there is in the atmosphere and thus regulates the climate.

For the purpose of this research, the first theory which explains climate change as a result of CO^2 emissions and land use change is adopted. It presents a simplistic explanation to both experts and non-experts alike and represents a most accurate explanation of the phenomenon, thereby its wide acceptance.

2.2 Climate Change and Millennium Development Goals Interrelationships

Since climate change effects represent a setback to human development, it is worth to explore the Millennium Development Goals. These goals represent a major attempt at speeding development around the world for human prosperity. Broadly defined under eight (8) thematic areas, the goals are looked at in terms of its relationship with climate change and how the issue of climate change affects the achievement of the MDG‟s by 2015, which is set by the UN as a timeline for most countries to achieve them.

MDG 1: Eradicate extreme Poverty and Hunger: The first goal seeks to eradicate all extreme form of poverty and hunger in the world. Poverty plagues more than half of the world‟s population, mostly in third world countries. Hunger is responsible for more death than HIV/AIDS and concerns are that with increasing world population, mostly in third world

countries, this is going to be exacerbated. Continuous degradation of natural resources such as food, medicinal plants, fuel wood etc. and land degradation might lead to poverty.

MDG 2: Achieve Universal Basic Education: With education viewed as the bedrock of development as many countries vie for rapid development, educational agenda is seen as important investment by many governments that have ruled the country. This led the country to adopt the FCUBE program, with the aim of making basic education free for all Ghanaians. With the economic barrier to education removed, it is expected that enrolment levels will improve and consequently educational levels in the country. However, with increasing weather variability, children, especially females spend much time in foraging for fuel wood (an energy source predominantly used in rural Ghana) and water, which is getting scarcer even in urban areas (Afeku, 2005). This inadvertently affects their availability and ability to attend school, with these resources, particularly in the Northern regions of the country, where weather variability is commonly felt.

MDG 3: Promote Gender Equality and Empower Women: With females constituting more than half of Ghana‟s population in the just ended census, inability to empower women can spells doom for the country‟s economic future. It is also established that women contribute significantly in workforce to agriculture, which is a top earner for the country. However, with natural resource base reducing (forest and arable land) due to climate change and women‟s vulnerability in a male property-owning traditional system of the country, their contribution to national development will logically wane. Poor women exposed to indoor air pollution, burden of collecting fuel wood and water, and unequal access to land and natural resources does not promote national development.

MDG 4: Reduce Child Mortality: Climate change brings in its wake change in weather conditions that favour the spread of certain diseases. Unexpected rainfall and its attended effects may help in the breeding of mosquitoes. It is no wonder that the World Health Organization considers malaria as the number one killer of children in Africa.

MDG 5: Improve Maternal Health: The physical stresses associated with the gathering of environmental resources such as firewood, good drinking water all have toll on the health of people, especially women who are involved in its exploitation. Food availability, water quality, poor sanitation etc. caused by environmental degradation tends to affect maternal health.

MDG 6: Combat HIV/AIDS, Malaria and other Diseases: Climate change has critical health implications. Changes in rainfall will affect the presence and absence of vector- and water-borne pathogens (IPCC 2001). For example, it can be expected that small changes in temperature and precipitation will boost the population of disease-carrying mosquitoes and result in increased malaria epidemics (Lindsay and Martens 1998). Increased flooding could facilitate the breeding of these malaria carriers in formerly arid areas (Warsame et al. 1995). Climate change currently contributes to the global burden of disease and premature deaths. Adverse health impacts are greatest in low-income countries, including from heat stroke, malaria, dengue and diarrhoea.

MDG 7: Ensuring Environmental Sustainability: Resource use is intrinsically part of development. Ghana‟s economy largely depends on resource exploitation for foreign exchange. Increasing population and growing global economic hardship call for more resource exploitation. As these resources are exploited, the needs for sustainably replacing them are considered. However, for resources that are renewable, which largely depends on the weather, may become non-renewable because of the extreme variation happening in the country. According to the Adaptation report submitted to UNFCCC by Ghana, the boundaries of ecological zones in the country are changing with savannah pushing southward and invading the semi-moist deciduous forest zone. With this trend, environmental sustainability espoused in the seventh goal of the MDG will not be feasible.

MDG 8: Global Partnership for Growth and Development: Developments in technologies have made the world a „global village‟ with its advantages and disadvantages. Countries that have positioned themselves and created alliances are developing faster than their counterparts who have closed their economies to the world. This surge in demand for goods not produced originally from the country of destination has created a demand for earth‟s resources, leading to exploitation and pollution of the environment. The problem created as a result of this same demand required a global effort to tackle them. Climate change is not only felt at the local level but is an issue of global proportion. Since the three Kyoto Protocols on Climate Change and the formation of the IPCC, various charters and treaties have been signed but there is less commitment from some countries whose contribution to global carbon emission is huge. This and the failure of the recent Durban Conference on Climate change to make any concrete

decision but to re-ratify the Kyoto Protocol (which expires in 2012) paints a gloomy picture of the world‟s effort at combatting the effect of climate change.

2.3 Incidence of Climate change in Kumasi: Reality or Myth

Vulnerability and adaptation assessments carried out by the Environmental Protection Agency under the Netherlands Climate Assistance Programme have clearly demonstrated that Ghana‟s economy will be adversely affected by climate change since it depends on sectors that are predominantly susceptible to the impacts of climate change.

According to Ahmad and Ahmed (2000), IPCC (2001a), NEST (2003), Hengeveld et al. (2005), the indicators for measuring evidence of climate change in a region are:

i. Increasing Temperature;
ii. Increasing Evapo-transpiration;
iii. Increasing Rainfall; iv. Increasing Disruption in Climatic Patterns; and
v. Increasing frequencies and Intensities of Extreme Event.

Chapter Five of the IPCC‟s 1990 report shows the following variations in elements of climate. For temperature, the lower atmosphere and earth warms, the stratosphere cools, and near the earth‟s surface the global average warming lies between +1.5^{o}C and +4.5^{o}C. For precipitation, the global average increases, the larger the warming the larger the increase (IPCC, 1990). Again, according the IPCC, scientific evidence of climate change (so far from scientific studies and observation) are that the earth‟s surface temperature is rising faster now than it has done for 1,000 years. The general mean temperature of 15^{o}C has risen by 0.30.6^{o}C since 1900 and over 0.7^{o}C over Africa during the 20th Century. It is reported that the 1990s are the warmest decades on record, with 1998 as the hottest year (IPCC, 2000). General predictions from the IPCC are that, over the next 100 years, the global average temperature will rise between 1.4^{o}C and 5.8^{o}C.

According to Ghana‟s country report to the UNFCCC (2000), the mean daily temperatures in Ghana will increase by about 2.5° C to 3.2°C, if the mid-range atmospheric sensitivity of 2.5°C is assumed, over the 1961 to 1990 baseline temperatures by the year 2100. This is higher than the global average of about 2°C in the same period. These changes could, however, be

lower or higher depending on the way the atmosphere will respond to increases in the concentrations of greenhouse gases. The range of uncertainty in these projections is about 1°C to 3.5°C due mainly to oceanic inertia. It should, however, be noted that even if a 1°C rise in temperature is attained by 2100 above current mean temperatures, it would be larger than any century-time-scale trend for the past 10,000 years. The rate of climate warming in Ghana during the baseline period is about 0.2°C per decade which is comparable to the projected decadal rate of increase of about 0.25°C to 0.32°C between the years 2000 and 2100. The differences might be attributed to the increased effect of greenhouse gas concentrations in the past and current periods on global climate between 2000 and 2100.

Annual totals rainfall amount will decrease throughout the country except in areas in the Rainforest and moist semi-equatorial zones where very slight increases are expected. On monthly basis, however, there will be some slight increases during the dry months, which are from November to March again over the entire country except the Rainforest and moist semiequatorial zones. In the two zones decreases are projected during the months of December to May while June to November show increases causing a net effect of very little increase in annual totals. The predicted trend in rainfall in all zones is similar to the observed trend during the baseline period. For Ghana as a whole, however, the observed rate of decrease in rainfall of about 5.4% per decade during the period 1961 to 1990 is larger than the average predicted rate of decrease of about 4% per decade between 2000 and 2100. Projected changes in rainfall are also subject to uncertainty mainly due to the uncertainty in the way the atmosphere will respond to increased concentrations of greenhouse gases.

For sea level rise, the global averages based on the IS92a as amended for the IPCC 1995 report was used. Using an atmospheric sensitivity of 2.5°C the projected rise in sea level will range from 2cm in the year 2000 to about 48.9cm by 2100. There is a wide range of uncertainty in sea level rise projections due to atmospheric sensitivity. For example under the same emission scenario but with an atmospheric sensitivity of 4.5°C, the sea level could change by as much as 85.9cm by 2100.

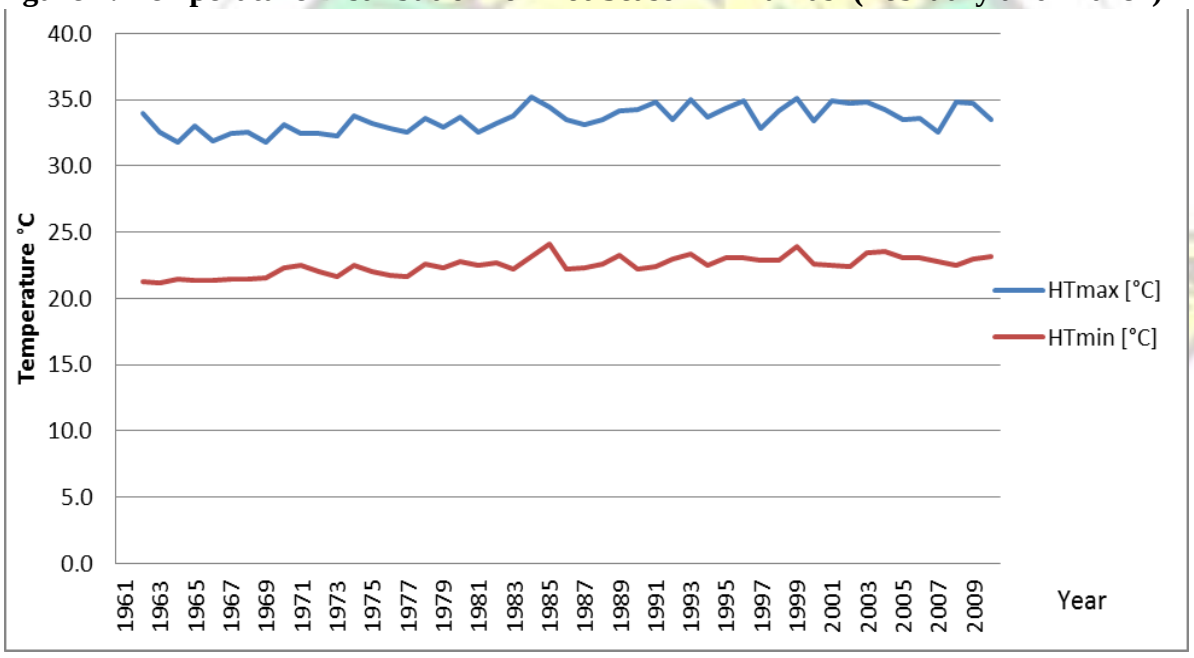
Kumasi features a tropical wet and dry climate, with relatively constant temperatures throughout the course of the year. Kumasi is noticeably wetter than Accra, averaging around 1400 mm of rain per year. The city almost features two different rainy seasons, a longer rainy season from March through July and a shorter rainy season from September to November. In

actuality, the months of February through to November are one long wet season, with a relative lull in precipitation in August. Similar to the rest of West Africa, Kumasi experiences the harmattan during the "low sun" months. Lasting from December to February, the harmattan is the primary source of the city"s dry season.

Available meteorological data on temperature and precipitation for Kumasi from the Ghana Meteorological Agency evidently shows increasing temperature and rainfall patterns since 1961 with variations for temperature of about 0.2°C above the mean for the last ten years (1990-2009), evidently an increment of about 0.4°C for the decade (See Table 3 in appendix). Analysis shows average temperature of about 30.9°C for both cold and hot days. Though the temperature pattern plotted on the line graph shows irregular pattern for the years presented, it has increased at a rate of about 0.035°C per annum, a 133 percent increment, which is higher than the national and global warming rate of about 0.015°C per annum.

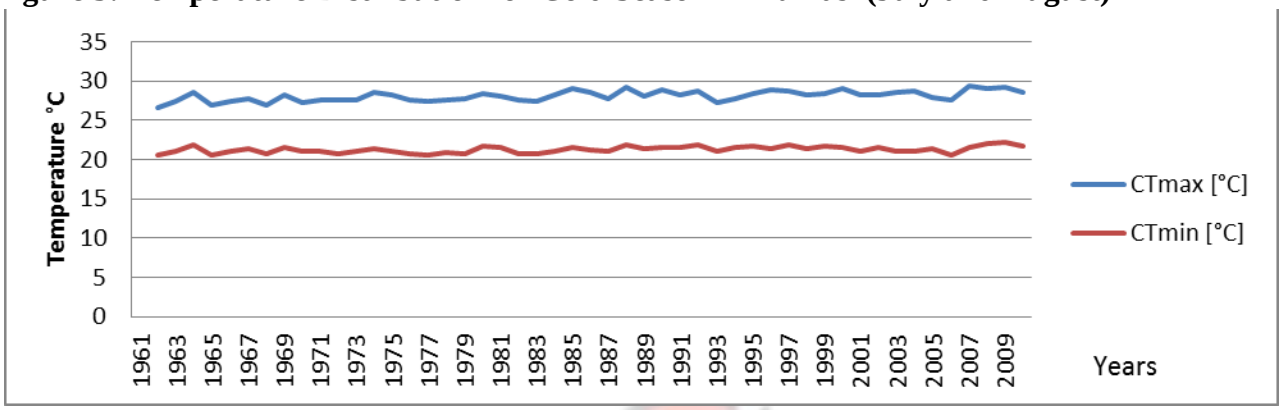
Other climate variables such as precipitation have averaged about 1379.99mm between 1961 and 2009. The annual mean precipitation is shown in Figure 3. The results presented suggest that, all things being equal, Kumasi is definitely experiencing climate change on a moderate scale compared to Accra (Kizito, 2005; Karley, 2008; Rain et al, 2011) and the Northern Regions of Ghana (Global Facility for Disaster Reduction and Recovery, 2011).

Figure 2: Temperature Distribution for Hot Season in Kumasi (February and March)



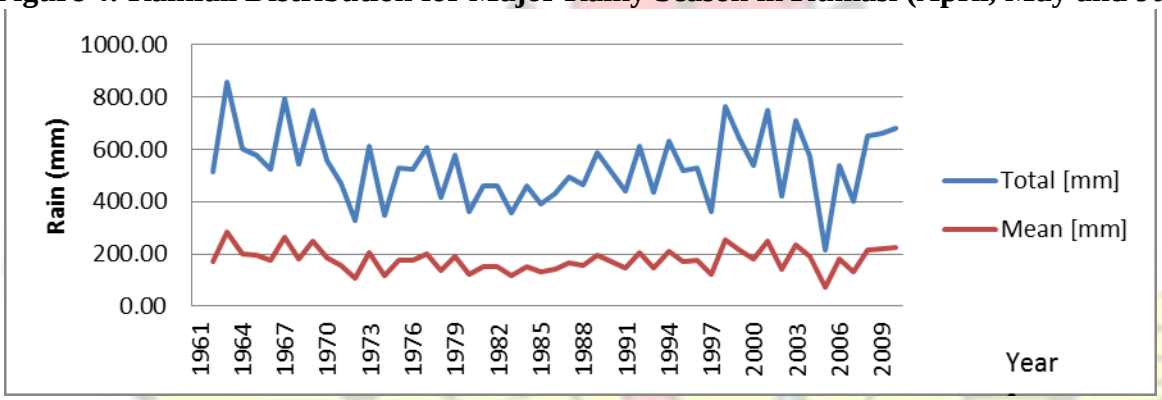
Source: Ghana Meteorological Agency, 2011.

Figure 3: Temperature Distribution for Cold Season in Kumasi (July and August)



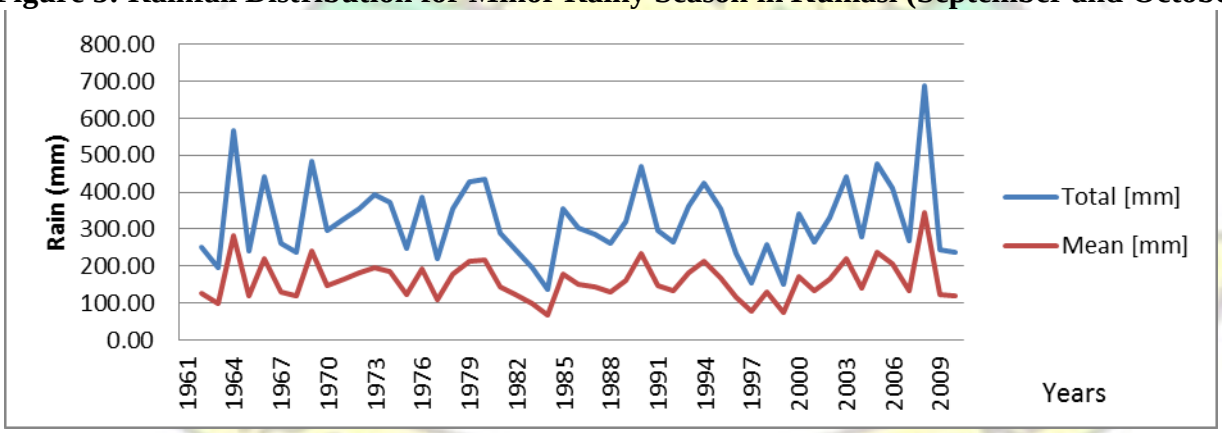
Source: Ghana Meteorological Agency, 2011

Figure 4: Rainfall Distribution for Major Rainy Season in Kumasi (April, May and June)



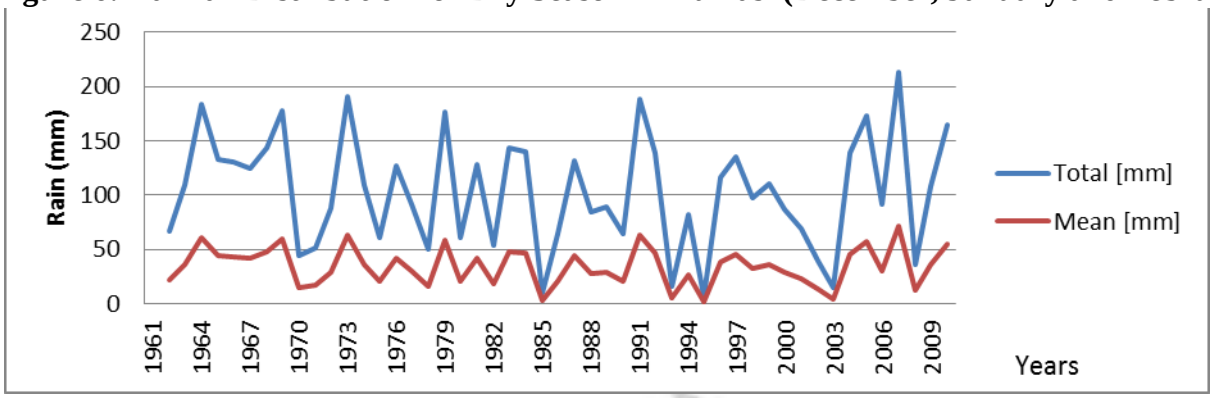
Source: Ghana Meteorological Agency, 2011.

Figure 5: Rainfall Distribution for Minor Rainy Season in Kumasi (September and October)



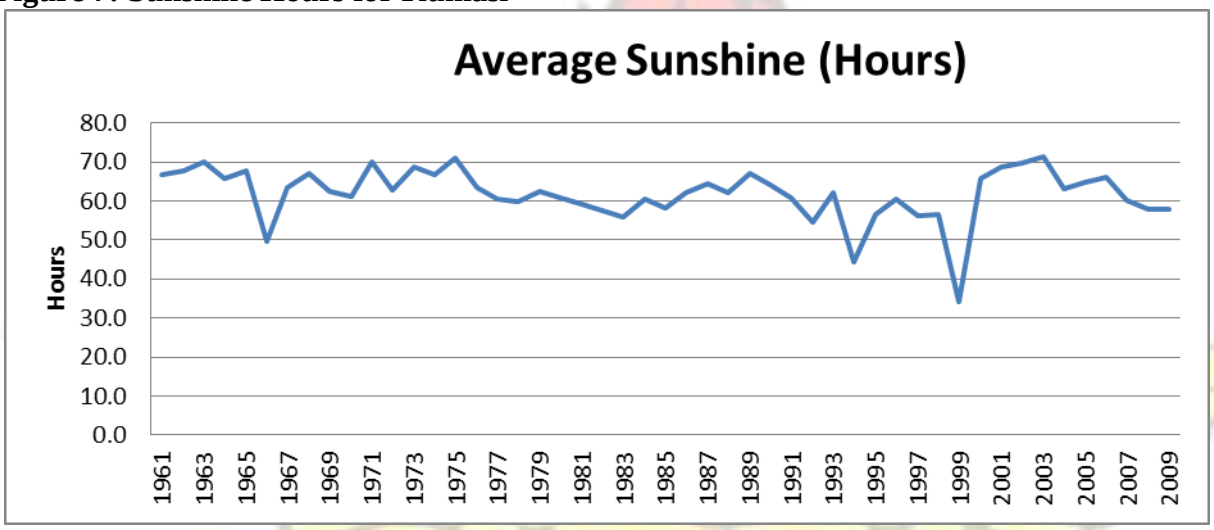
Source: Ghana Meteorological Agency, 2011

Figure 6: Rainfall Distribution for Dry Season in Kumasi (December, January and February)



Source: Ghana Meteorological Agency, 2011

Figure 7: Sunshine Hours for Kumasi



Source: Ghana Meteorological Agency, 2011

2.4 Climate Change and Flooding

The IPCC (2007) concluded that warming of the climate is unequivocal. There is a growing scientific consensus that these changes are expected to increase flood risk. Flooding is a natural process that happens anytime. Flooding from the sea and the rivers are the best known cause of flooding but protracted, intense and localized rainfall (probably from climate change) can cause sewer flooding, overland flow and groundwater flooding. The frequency, pattern and severity of flooding are expected to increase as a result of climate change. Development can also exacerbate the problems of flooding by accelerating and increasing surface water run-off, altering water courses and removing floodplain storage.

Climate change is disturbing the delicate balancing act that people have with water. Water is critical to life - for drinking and irrigation, and as a source of food, transportation and

recreation. Too much water or water that comes at an unexpected time or in unexpected places can be a big problem. As global temperatures rise, many places are threatened by flooding.

Climate change is making the weather less predictable, rains more uncertain and heavy storm rainfalls more likely. Heavy thunderstorm and rains appear to have increased in frequency. Urban areas help to increase thunderstorm activity because their built-up surfaces attain higher temperatures than surrounding areas and create a local air circulation that produces an "urban heat island". Dust particles caught up in that circulation act as nuclei on which moisture in clouds condenses, forming rain droplets that eventually may develop into the large rain drops of a major thunderstorm. Though flooding is a natural process, which little can be done about it, climate change magnifies the frequency and volume of such events.

2.4.1 Impact of Urban Flooding

Flooding has significant impacts on human activities. It can threaten human lives, their property and the environment. Property risk can include housing, transport and public service infrastructure and commercial, industrial and agriculture enterprises. The social, economic, environmental and health risk of flooding can be significant and have wide impact. Urban flooding is more particularly worse because of economic, social and economic functions of an urban centre.

In developing countries that at most times have poorly governed urban centres, most drainage are not installed and rely on natural drainage channels. At the same time, it is common for residents to encroach or obstruct these drainage channels. In Alam and Golam, 2007, they report incidence of such assertions in Dhaka, „where buildings have often encroached on or fill in drains and many natural drains to construct roads". Mombasa faces the same problem (Awour, Orindi and Adwerah, 2008).

2.4.1.1 Economic Impacts

The ability of people to respond and recover from a flood can vary. Vulnerable people, such as those who are old, disabled or have a long-term illness, are less able to cope with floods than others. Some people may have difficulty in replacing household items damaged in a flood as

well as lack the financial means to recover and maintain acceptable living conditions after a flood.

2.4.1.2 Social Impacts

The impact on people and communities as a result of the stress and trauma of being flooded, or even of being under the threat of flooding, can be immense. Long-term impacts can arise due to chronic illnesses, the stress associated with being flooded and the lengthy recovery process. Social impacts also translate in physical developments as residents are less motivated to develop their place of abode with the fear of being destroyed by floods and waste of resources.

2.4.1.3 Physical Impacts

Flooding can cause severe damage to properties. Floodwater is likely to damage internal finishes, contents and electrical and other services and possibly cause structural damage. The physical effects can have significant long-term impacts, with re-occupation sometimes not being possible for over a year. The costs of flooding are increasing, partly due to increasing amounts of electrical and other equipment within developments.

The damage flooding can cause to businesses and infrastructure, such as transport or utilities like electricity and water supply can have significant detrimental impacts on local and regional economies. Flooding of primary roads or railways can deny access to large areas beyond those directly affected by the flooding for the duration of the flood event, as well as causing damage to the road or railway itself. Flooding of water distribution infrastructure such as pumping stations or of electricity sub-stations can result in loss of water or power supply over large areas. This can magnify the impact of flooding well beyond the immediate community. The long-term closure of businesses, for example, can lead to job losses and other economic impacts.

2.5 Flooding In Ghana

In Ghana, rainfall is very important to farming. This is because of the countries inability to develop enough irrigation infrastructures to wean the country of rain-fed agriculture. The beginning of every rainy season is supposed to bring relief to the millions of Ghanaians who

are engaged in such activities. In many good rainy seasons, the country has usually recorded bumper harvest (Owiredu, 2011), which inadvertently lowers prices of agricultural commodities.

Regrettably, over some decades now, the rainy season has brought nothing but pain and grief to most Ghanaians, especially those in urban centres. Consistently over the period, deaths have been recorded every year because of flooding. On Sunday 20th June 2010, about 35 persons were reported to have died across the country from flooding, the worst hit being Ashaiman, where as many as 16 persons, including children, lost their lives - something that had stricken most families with grief ever since. This flooding was said to be the worst flooding catastrophe in a decade. Similarly, a 27th June 2009 edition of the Daily Graphic reported seven deaths from the 2009 flooding. Furthermore, a 21st October 2010 edition of the Daily Graphic carried the headline: "Rains cause havoc at Dansoman, elsewhere"". After only two major downpours in Accra, the month of February 2011 ended with the old ritual of flooding. There have already been several reports in the media on flooding across many locations in the Capital City and Kumasi this year.

These catastrophes seems to be the end for the year for the country as the rainy season gave way for the harmattan but a heavy downpour was recorded in the night, Accra and its immediate environs woke up on 26th November 2011 to a very devastating flood that turned a better part of these locations into temporary lakes. Five persons were reported to have lost their lives in Accra and properties running into million Ghana as usual were lost as floods invaded homes and business premises along the graphic road. Similar event in Kumasi led to the loss of lives, all children of the same parents. In 2010, severe floods in Swedru made the inhabitants to call on the President to call for a state of emergency (Owiredu, 2011).

Ahadzie (2011), documents the flood occurrence in the country as far back as 1936. The death toll and property lost seems to be increasing with population increase and urbanization. He laments the use of the same approach towards solving the perennial floods in the country (mainly engineering approach), which is not holistic enough to deal with the extent and rate our cities are flooding. Presented in Table 1 are flood occurrences in the country as reported by popular newspapers (167 newspapers, mainly Daily Graphic, Pioneer, Spectator, Ghanaian Times and Mirror).

Table 1: Chronology of Floods as reported in Ghanaian Newspapers

Year	Nature	Impact	Regional Spread
1936	Not Reported	Not Reported	
1995	Devastating	26 lives lost	
1999	Devastating	56 lives lost	
2000	Devastating	Properties destroyed	Floods occurred in Cape Coast in Central Region
2001	Devastating	At least 13 lives lost	Floods occurred in Accra in Greater Accra Region.
2002	Devastating	At least 3 lives lost in the Capital, Accra and properties worth million cedis destroyed	Floods occurred in Kasoa in Central region, Accra in Greater Accra Region and Sekondi-Takoradi in Western Region
2003	Devastating		Did not come across any known report

2004	Devastating	200 homes destroyed and about 1000 people rendered homeless	Floods occurred in Kumasi in Ashanti Region
2005	Devastating	Properties destroyed	Floods occurred in Saltpond in Central regions
2006	Devastating		Did not come across any known report
2007	Devastating	32 dead, several properties and infrastructure destroyed	Floods occurred in Accra in Greater Accra Region, Upper East, Upper West and Northern Regions. Some West African Cities such in Nigeria, Burkina Faso, Togo, Niger and Ethiopia.
2008	Devastating	4 dead	Floods occurred in Accra in Greater Accra Region
2009	Devastating	32 lives lost	Burkina Faso also affected
2010	Devastating	35 lives lost	Death toll was across the country

Source: Ahadzie, 2011.

Apart from the loss usually incurred by the victims of such flooding incidents, the central government, through the NADMO, spends several hundreds of thousands of Ghana cedis on the provision of relief support. The loss of lives and property to flooding every year generate lots of public discourses and commentaries. Sometimes these commentaries produce very good recommendations and suggestions, which, regrettably, are never seen to be considered by those responsible for decision making.

However, not many studies have been carried out in the management of floodwaters in the urban areas. In Accra, several master plans have been prepared to mitigate flooding. After the 1963 devastating floods in Accra, the first master plan on drainage was prepared and implemented. In 1991, this was reviewed and areas covered under the plan were extended. However, this is yet to be reviewed to include new developments and the Hydrological Services Department recently initiated a short-term programme to desilt all primary drains also as a way of reducing floods.

In Ghana, the incorporation of flood prevention as a parameter of urban planning is largely absent. Technical approaches to flood prevention strategies, which are mostly hydraulic

engineering interventions, are practiced. Rivers in Kumasi for instance have lost the natural existence as open physical ecosystems and are used as drainage or sewerage channels

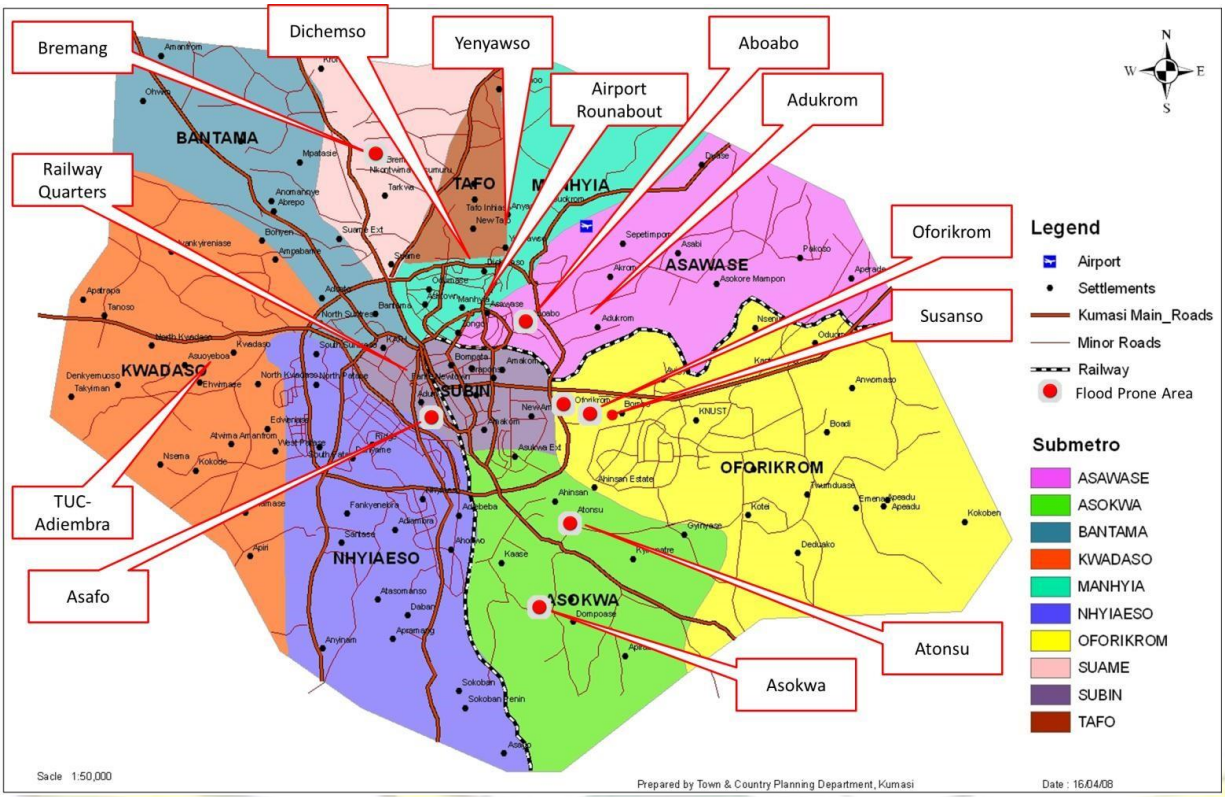
2.5.1.1 Nature of Flooding in Kumasi

There are essentially two major causes of flooding, namely coastal flooding and inland flooding. Kumasi‟s location makes it impossible to attribute flooding in the city to coastal flooding. Kumasi is located 221km from the coast of the country and therefore any form of flooding in the city can be confidently grouped under inland flooding, which is caused by prolonged and/or intense rainfall. Inland flooding can include a number of different types as discussed as follows:

i. Overland flow occurs when the amount of rainfall exceeds the infiltration capacity of the ground to absorb it. This excess water flow overland, ponding in natural hollows and low-lying areas or behind obstructions;
ii. River flooding occurs when the capacity of a water course is exceeded or the channel is blocked or restricted, and excess water spills out from the channel onto adjacent low-lying areas (the floodplain). This can occur rapidly in short steep rivers or after some time and some distance from where the rain fell in rivers with a gentler gradient; and
iii. Flooding from artificial drainage systems results when flow entering a system, such as an urban storm water drainage system, exceeds its discharge capacity and the system becomes blocked, and/or cannot discharge due to a high water level in the receiving watercourse. This mostly occurs as a rapid response to intense rainfall. Together with overland flow, it is often known as pluvial flooding. Flooding arising from a lack of capacity in the urban drainage network has become an important source of flood risk.

Inland flooding is worsening over the years in Kumasi and this has led the city authorities to consider flooding as major problem confronting the city. According to the Meduim Term Development Plan of the Kumasi Metropolitan Assembly, the following areas are considered flood prone areas Susansu, Oforikrom, Atonsu, Aboabo, Yenyawso, Dichemso, Anloga, Asafo, Asokwa and Bremang (Kumasi Metropolian Assembly, 2010). Mensah-Bonsu et al (2011), accepts these locations as true and also documents these areas as flood prone: The Central Business District (Kejetia and Central Markets); Zongo Estate; Railway Quarters (Kumasi, Accra Rail); Adukrom and TUC-Adiembra (Kwadaso Basin). These areas are shown on the map in Figure 8.

Figure 8: Administrative Map of Kumasi, Showing the Flood Prone Areas



Source: Town and Country Planning Department, 2009

2.5.1.2 Factors Contributing to Flooding in Kumasi

From the above types of floods possible to happen in Kumasi, three (3) main factors can be said to be contributing to the incidence of floods in the city. These factors are presented in Table 2.

Table 2: Factors Contributing to Flooding in Urban Areas

Human Factors	Hydrological Factors	Meteorological Factors

• Land-use changes (e.g. surface sealing due to urbanization, deforestation) increase run-off and may be sedimentation • Occupation of the flood plain obstructing flows • Inefficiency or non-maintenance of infrastructure • Too efficient drainage of upstream areas increases flood peaks • Climate change affects magnitude and frequency of precipitations and floods • Urban microclimate may enforce precipitation events	• Soil moisture level • Groundwater level prior to storm • Natural surface infiltration rate • Presence of impervious cover • Channel cross-sectional shape and roughness • Presence or absence of over bank flow, channel network • Synchronization of run-offs from various parts of watershed • High tide impeding drainage	• Rainfall • Cyclonic storms • Small-scale storms • Temperature

Source: Authors Construct, 2011.

According to Duncan (2000), a total of $5,764,065 was lost in damages to properties due to flooding in the 2000 floods in Ghana. Though figures are not readily available on health, an estimated 435,000 cases of malaria was reported, a situation that was readily attributed to the 2000 incidence of floods in the Kumasi Metropolis. Apart from that, productivity is reduced through absenteeism and treatment cost of potable water increases because of pollution contributed by flooding.

2.5.2 Groups at Risk from Climate Related Disasters

Urban studies have well documented locations of various groups in urban areas and in most of these areas, the poor live in the most hazardous urban environment. These may be floodplains, unstable slopes and other areas at high risk of flooding. Vulnerabilities for extreme weather may produce direct impact on health, living conditions and incomes/livelihood (Satterthwaite,

2007). Other indirect impacts of climate change related weather events include damage to poorer household asset bases or disruption in incomes.

Poorer groups are hit hardest by this combination of greater exposure to hazards (e.g., a high proportion living in makeshift housing on unsafe sites), lack of hazard-removing infrastructure and less capacity to cope (e.g., lack of assets), less adaptive capacity, less state provision to help them cope, and less legal protection. Low-income groups also have far less scope to move to less dangerous sites; indeed, the more dangerous sites are often the only sites where lower-income groups can find housing they can afford or can build their own homes. Wealth allows individuals and households to reduce risks – for instance by having safer housing, choosing safer jobs or locations to live in, having assets that can be called on in emergencies and protecting their wealth by insuring lives and assets that are at risk. It seems clear from the foregoing that vulnerability to climate change is closely associated with poverty, as the poor are least able to respond to climatic disasters.

2.6 Developing a Conceptual Framework for Adaptation

A review of frameworks used to assess the adaptive capacity of cities or areas shows a wide acceptance of the framework presented by IPCC, UNEP, UNDP and UN Habitat. However, these frameworks make vulnerability a function of exposure, sensitivity and capacity to adapt. In order to assess a city‟s adaptive capacity to climate change, it is prudent to assess its vulnerability contexts. The assessment process used in this research considered the recommendations and discussion frameworks presented in the IPCC third and fourth Assessment Reports, the UNDP-Adaptation Planning Framework, the World Bank‟s Climate Resilient Cities Primer, the UNEP Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies and the UN-Habitat‟s Sustainable Cities Programme (SCP) local assessment tools and methodologies.

2.6.1 The Concept of Adaptation

According to Kates (2000), most efforts to address climate change to date have focused on mitigation, or preventive action to limit greenhouse gases, rather than adaptation. A recent review of the current state of climate change research and analysis in India by Kandlikar and

Sagar (1999) provides a concrete example. These authors found that while India is advanced in terms of climate change research and analysis with respect to other developing countries, adaptation issues have yet to come to the forefront. Authors such as Lorenzoni et al. (2000) and Sharma and Kumar (1998), among others, argue that disproportionately greater attention has been paid to climate change mitigation than to adaptation measures.

Discussions of vulnerability and adaptation in developing country contexts often highlight the importance of poverty and inequality - or differential resource access (Adger and Kelly 1999). According to Ribot (1996), inequality and marginalization are among the most important determinants of vulnerability. Kates (2000) argues that different groups and places within countries differ in their ability to adapt and that division between rich and poor translate into differentials in people‟s ability to adjust and in access to adjustments. This author argues for a focus on poor people, rather than a focus on poor countries, in efforts to facilitate adaptation among the global poor. O‟Brien and Leichenko (2000), on the other hand, point out that vulnerability "is not exclusively related to poverty" and that both the wealthy and the poor can be adversely affected by the impact of extreme weather events.

There are many definitions of adaptation in climate related literature. According to Smit et al. (2000), they point out some of these definitions as follows:

i. Adaptation to climate is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides (Burton 1992, quoted in Smit et al. 2000);

ii. Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer-term climate change (Smit 1993, quoted in Smit et al. 2000);

iii. The term adaptation means any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change (Stakhiv 1993, quoted in Smit et al. 2000);

iv. Adaptation to climate change includes all adjustments in behaviour or economic structure that reduce the vulnerability of society to changes in the climate system (Smith et al. 1996, quoted in Smit et al. 2000); and

v. Adaptability refers to the degree to which adjustments are possible in practices, processes or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of change in conditions (Watson et al. 1996, quoted in Smit et al. 2000).

Smit et al. (2000) also discuss various typologies and distinctions related to the process of adaptation, which appear in the literature. For example, according to some of the typologies considered, adaptation can be planned or spontaneous; passive, reactive or anticipatory.

According to Smit et al (2000) and position adopted by the researcher, it may be that planned, anticipatory adaptations that are undertaken by governments or NGOs as a policy initiative (as opposed to those that are autonomous and/or mainly reactive) are those that require the most attention. However, as argued by Fankhauser et al. (1999), the distinction between autonomous and planned adaptation may be blurred in practice. The evaluation of adaptations must address the following question: "how good is the adaptation?" (Smit et al., 2000). Furthermore, it is likely in various settings.

According to the IPCC (2001), adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages. Furthermore, it is argued that human and natural systems, to some extent, adapt autonomously, and that, planned adaptation can supplement autonomous adaptation. However, options and incentives are greater for adaptation of human systems than for adaptation to protect natural systems.

The propensity of systems (e.g., socio-economic systems) to adapt is influenced by certain system characteristics that have been called "determinants of adaptation" in literature. They include terms such as sensitivity, vulnerability, resilience, susceptibility and adaptive capacity, among others. These influence the occurrences as well as the nature of adaptations. As Smit et

al. (2000) point out, there is some overlap in the concepts captured in these terms. The same authors argue that sensitivity, vulnerability and adaptability capture the broad concepts.

2.6.2 Definition of Terms

Using definitions adopted by the IPCC and Satterthwaite (2007), the recurring terms are defined as:

Vulnerability - Is the degree to which a city, its populations, economic sectors and infrastructures are susceptible to the adverse effects that the increase in climate means and extremes resulting from climate change is expected to generate. Vulnerability is a function of both exposure and sensitivity. The first refers to the character, magnitude, and rate of climate change and variability to which a city is exposed.

Sensitivity - Refers to a city‟s adaptive capacity, with lower adaptive capacity equating to greater sensitivity.

Adaptability - is the ability of a system (e.g. a city), a population (e.g. low income groups), a household or an individual to undertake the following:

i. Adjust to climate change (including climate variability and extremes);
ii. Reduce or moderate potential damages;
iii. Take advantage of opportunities; and
iv. Cope with the consequences.

From the aforementioned discussion, it can be deduced that adaptive capacity is the opposite of vulnerability. Elements of adaptive capacity include knowledge, institutional capacity, financial and technological resources. Low-income populations in cities tend to have lower adaptive capacity than the high income populations as they lack access to adequate and stable income sources and to an appropriate and stable asset base (i.e. ownership or right to use land, savings and stores, literacy and educational attainment) to withstand shocks. They also frequently have poor quality, insecure, hazardous and overcrowded housing, a key factor increasing health threats such as water borne diseases, and indoor air pollution along with other complicating factors such as inadequate provision of public infrastructure and basic services such as safe and sufficient water and sanitation or health care.

All urban centres have made considerable adaptations to the natural environment, site conditions and hazards in order to make it suitable to urban needs. For instance, land have been modified, dredged or altered to make it suitable for urban infrastructure. As such, urban areas are capable of adaptation in general. Through the tools and methods created, urban centres in some countries have been able to effectively modify conditions in order to withstand extreme weather conditions. For example, through building codes, land subdivision and regulations combined with standards, have been able to restrict building in areas considered risky. However, in countries, where planning laws, regulations and standards are flouted with impunity, risk to this natural phenomenon may be greater than it should have been if laws, regulations and codes are strictly adhered to.

Climate change poses a serious challenge to social and economic developments in all countries, although it has been established that developing countries are more vulnerable (OECD, 2011). Studies have shown that some adaptation actions such as behavioural adaptation may be effective and implementable at low cost while in some situations, adaptation measures call for infrastructural measures, which requires significant investment.

2.7 Improving the Adaptive Capacity of Kumasi: The Role of Planning Institutions and Stakeholders

City and municipal governments have the main responsibilities for planning, implementing and managing most of the measures that can diminish risks (and the high vulnerabilities of sections of the population) from the direct and indirect impacts of climate change – through provision of infrastructure and services, disaster preparedness and the planning and regulatory framework.

However, these institutions are weaker in low and middle income countries. These institutions and their services do not serve large areas of the urban centre. It is common to find so may illegal settlements formed outside official land use plan. These include “squatter settlements” (where the land occupation is illegal). These settlements tend to concentrate in areas at high risk from extreme weather, precisely because this high-risk area lowers the value of the land and increase the inhabitants‟ chance of avoiding eviction. For example it will be economical

for the squatter to settle on an area liable to flood because its economic value is not yet determined by its owners (see Satherwaite et al, 2007, Rain 1999).

Despite national decentralization programmes and the inclusion of good governance principles in national policies and strategies, many governments do not aptly consider local governments as important partners in the articulation of action plans. Meanwhile, the effects of climate change are mainly experienced at the local level with many households and livelihoods affected. Institutional design and structure can heighten or diminish society‟s exposure to climate risks, yet, a clear imbalance still exists between demands and the existing administrative and financial capacities in the context of decentralization.

An examination of the roles and responsibilities of municipal governments in low-income countries revealed that the municipal governments generally have the primary role in developing infrastructure and services that is essential for good quality living standard (see UNHABITAT (1996); Stren (1991); Davey (1992); Shah and Shah (2006). They again have the role in planning, implementing and regulating development for public health and safety. How well municipal governments are able to meet these responsibilities, have implications for their adaptation capacity for climate change related disasters.

This inadequacy is evident in the scale of provision for infrastructure and services that they are meant to provide, and the extents to which settlements fall outside any official plan. For instance, most urban centres in low-income nations in Africa have no sewers at all, including many major cities. In addition, most of the population in the major cities have no water supply piped to their home and no official solid waste collection service (UN-Habitat 2003; 2006; Hardoy, Mitlin and Satterthwaite, 2001). These inadequacies reflect local governments lacking the resources to meet their responsibilities and are often left with very limited capacities to invest (as almost all local revenues go to recurrent expenditures or debt repayment). These inadequacies often reflect local governments that are unrepresentative, unaccountable and anti-poor. Many reasons can be attributed to the inadequacies of institutions in meeting the needs of urban dwellers in many countries in Africa, but the inadequacies stems from institutional legacies, which are still a relic of colonial rule and the importation of urban planning models that have proved to be inappropriate to local context.

Climate change perspectives are not fully integrated within the broader framework of sustainable housing and urban development and the much needed holistic approach to participatory governance, urban environmental planning and management is not well articulated in the national plans of most developing countries. Local authorities are therefore in need of further support regarding capacity building, specified tools, and technical expertise, so that they can develop adaptation actions and strategies for reducing the severity of many of the impacts.

2.8 Managing the Impacts of Climate Change

Adequate attention must be given to respond to the impacts of climate change that are already occurring, while at the same time, preparing for future impacts. As a result, it is most urgent to ensure adequate and rapid support to the most vulnerable countries and communities. Increased investment in adaptive capacity, such as strengthening the ability of countries to reduce disaster risk, will safeguard economic progress already made, and increase the climate resilience of economies on the way to achieving overall development goals.

Using climate change, including adaptation, as a driver to undertake activities with multiple benefits can catalyse progress in achieving a country‟s sustainable development goals. Many countries are starting to take concrete action towards adaptation to climate change. Such action needs to be expanded and integrated into national and sectorial planning to ensure that sustainable development and adaptation are mutually enhanced. The following Adaptation options are advocated to help manage climate related disasters on the urban centre:

i. Behavioural change at the individual level, such acquiring permit before construction of houses;
ii. Technological and engineering options such as increased used of flood- proof houses;
iii. Risk management and reduction strategies such as early warning systems for extreme events;
iv. Promotion of adaptive management strategies at the District, Municipal and Metropolitan level;
v. Development of financial instruments such as insurance schemes; and

vi. Promotion of ecosystem management practices, such as biodiversity conservation to reduce the impacts of climate change on people, e.g. by conserving and restoring river buffers to protect people from floods.

2.9 Conceptual Framework

As defined by the IPCC and presented earlier in this report, adaptive capacity describes the ability of a system to adjust to actual or expected climate stresses, or to cope with the consequences while sensitivity refers to the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Exposure meanwhile relates to the degree of climate stress upon a particular unit of analysis. It may be represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events.

With the above, vulnerability is generally understood as a function of a range of biophysical and socio-economic factors, commonly aggregated into three components that include an estimate of the above elements namely (adaptive) capacity, sensitivity, and exposure to climate variability and change (Vulnerability = *f* (Exposure, Sensitivity, Adaptive Capacity) which is represented by Figure 9.

Figure 9: Assessment Framework for Adaptation

Source: IPCC, UNDP, UNEP, and UN-Habitat, (2000)

Based on data presented and measures used to measure climate change, it evidently shows that Kumasi is exposed to climate change. What was left is to define the other variables presented in the framework. Thus, data (primary) were solicited for to cover sensitivity and adaptation measures.

2.10 Conclusion

The world‟s climate is changing and will continue to change at rates unprecedented in recent human history. The impacts and risks associated with these changes are real and are already happening in many systems and sectors essential for human livelihood, including water resources, food security, and health.

Developing countries, especially those that are least developed, and the poorest in our communities, are the most vulnerable. In these vulnerable countries and communities, the impacts of climate change pose a direct threat to people‟s very survival. However, the

devastating effects of extreme events, temperature increases and sea level rise have consequences for all of us, particularly the poor, and will only worsen in the future.

Available data from the Ghana Meteorological Agency also support the assertion that climate change is taking place in Kumasi, though on a moderate scale as compared to other places in Ghana. This presupposes that erratic natures of climatic elements are because of this phenomenon and that flooding in Kumasi can be conveniently attributed to climate change.

Climate change has the potential to push developing countries back into the poverty trap and to undo many achievements that have been made to date with regard to the Millennium Development Goals (MDGs). Climate change impacts on all aspects of sustainable development. Future vulnerability depends not only on climate change, but also on development pathways. Sustainable development can reduce vulnerability. The implementation of adaptation needs to be integrated into local and national sustainable development priorities, as well as into national and sectorial development plans.

CHAPTER THREE RESEARCH APPROACH AND METHODOLOGY

3.0 Introduction

After reviewing related literature and evidences on climatic change and its effects on human activities, especially flooding in the Kumasi Metropolis, this chapter sets the framework to gather data to support arguments set forth in the previous chapter. The research approach adopted was dependent on the type of questions driving the study. The study intends to establish whether there is a relationship between the incidence of flooding in the city of Kumasi and climate change. It also seeks to assess the adaptation capacity of victims of urban floods within the city and subsequently provide policy recommendations to remedy the situation. This chapter outlines the various strategies employed in achieving the objectives of the research which have been outline and discussed in the subsequent sections of this Chapter.

3.1 Research Design

The selection of research approach is hinged on factors such as the level of control the researcher has on the subject to be studied, be it contemporary or historical, the purpose of the study, time availability and data needs. Taking cognizance of the fact that, the issue being discussed is a contemporary issue, the research adopted both flexible and fixed approach in order to maximize the advantage of the two and counteract the disadvantages of the two approaches.

Fixed or quantitative research designs are normally theory driven while flexible or qualitative research design allow for more freedom during data collection as some data needed (see section 3.4) are more culturally defined and not easily quantified. In addition, the case study approach was to help in understanding the relationship between flooding, climate change and adaptation measures of residents of the Kumasi Metropolis, thus necessitating the use of the two designs.

According to Kumekpor (2002), the case study is a systematic way of in-depth collection of information for investigating the circumstances of a person, a group, a commodity, an institution, or an incident. This necessarily implies a comprehensive examination, a critical

analysis and interpretation of available data or information on real situation of a particular issue, event, occurrence or problem. A case study is also an in depth study of the particular situation rather than a sweeping statistical survey. Also, the study places emphasis on actors, structures and the fact that multiple sources of evidence is required to establish the relationship between climate change, flooding and effects on urban dwellers, makes case study approach more ideal than other research design methods.

3.2 Selection of Study Area

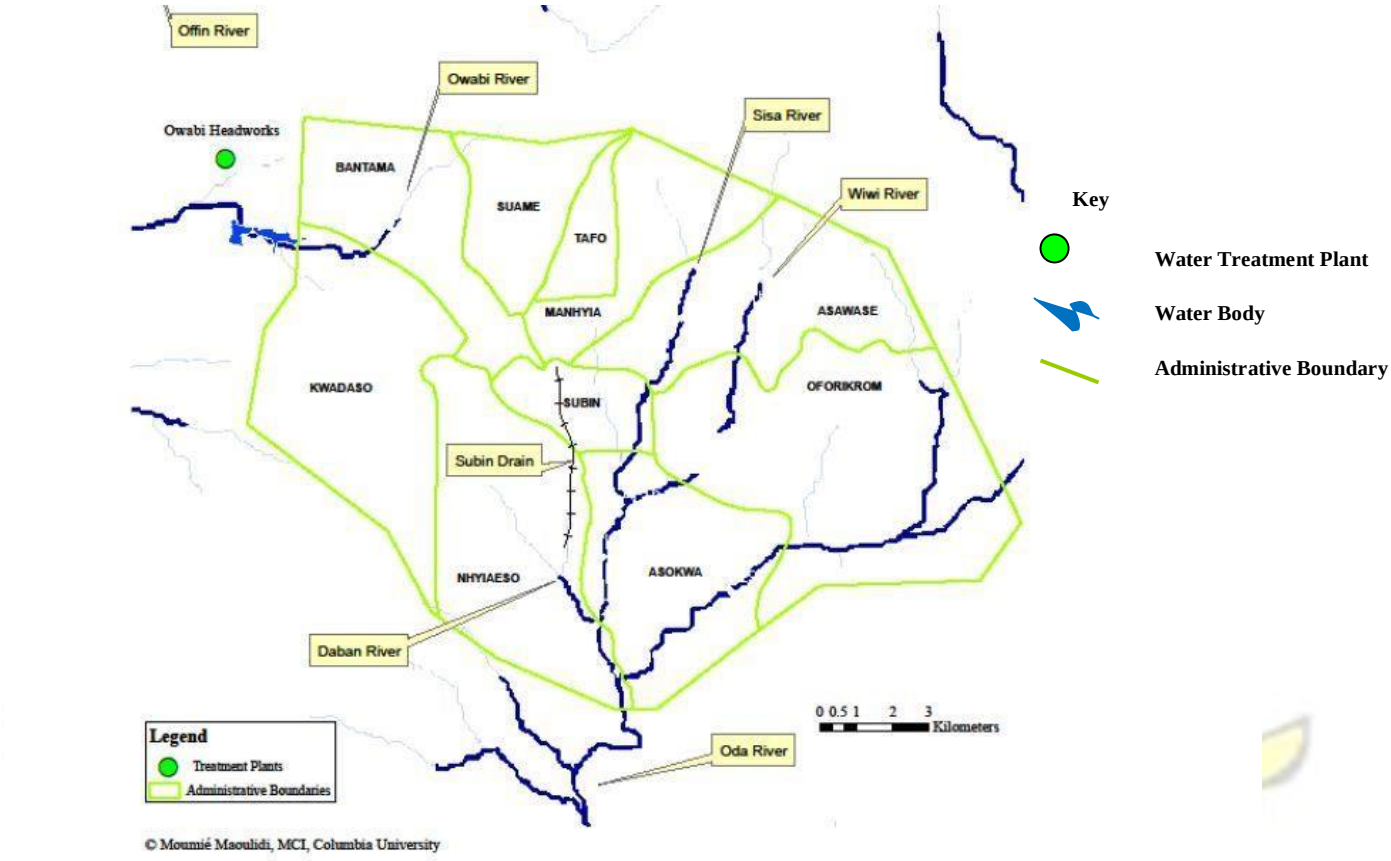
The scope of the study is discussed in terms of its geographical and contextual scope. The geographical scope looks at the location of the study whiles the context relates to the issues to be discussed.

The study was carried out in Kumasi, Ghana‟s second capital and second largest in terms of population of about 1,915,170 (KMA,2009). Kumasi is about 282 metres above sea level (Nsiah-Gyabaah, 2000) but altitudes vary from 250 to 300 meters (Holland et al., 1996). The landscape is much dissected though the variations in height are rarely more than 50 meters. Slopes are rarely over (7.5%) steep, thus making the city‟s susceptibility to flooding limited to certain parts of the city.

The city is traversed by major rivers and streams, which include the Subin, Wiwi, Sisai, Owabi, Aboabo, Nsuben among others with some taking their sources from the city or passing through it (See Figure 10). Their river channel serves as important drainage system. However, biotic activity in terms of estate development, encroachment and indiscriminate waste disposal practices have impacted negatively on the drainage system and have consequently brought these water bodies to the brink of extinction (Kumasi Metropolitan Assembly, 2006).

Figure 10: Map of Kumasi showing Major Water Bodies

Source: Moumie Maoulidi (2012), MCI Columbia University.



Kumasi"s location, as the central part of the country, shelters her from some noticeable climatic changes such as sea rise, leading to flooding and drought, which is noticeable in the Northern parts of the country. However, Kumasi faces a more eminent threat from climate change in the form of flooding. However, these threats have not been identified in literature to be related to either climate change or human factors. There is a dearth of literature on the relationship between increasing flood occurrence and changing weather variability in Kumasi. This largely accounts for the selection of Kumasi as the study area.

Conceptually, the study seeks to establish the relationship with current global climate change to increasingly reported flooding cases in Kumasi and assess how city dwellers, especially the poor and city managers are adapting to this problem.

3.3 Study Variables, Data Types and Sources

Based on discussions, logic and the problem being investigated, different data collections instruments were employed to obtain the needed data in answering the research questions and the objectives set. These were done with the peculiarities of sources characteristics in mind. Based on the identified variables and the type of data needed from each variable, questionnaires are designed for selected households in Kumasi, The National Disaster Management Organization (NADMO), the City Engineering Department of K.M.A and
K.M.A Planning Department, designated as the Metropolitan"s Management office.

Survey instruments designed for each sources took into consideration time availability, level of education and understanding of the phenomenon being investigated. The wording of each instrument was done to suit the understanding of each unit of investigation and where possible introductions were provided to better prepare respondents for the interview (see Appendix 3, 4, 5 and 6). In line with that, both open and close-ended questionnaires were used to ensure data collection was maximized.

In order to ensure the validity of the research instruments, a pre-test was done, especially the questionnaire for the selected households. This was used to review questions that were not clearly formulated, increase the list of options for some questions, assess the time, number of days and budget needed for collection and to make sure that all areas needed were covered in the final data collection exercise.

Based on the objectives, research objectives and questions of the study, the following variables and data types as listed in Table 3 were used for the study. The variables presented in Table 3 helped focus the research activities in seeking answers to the research questions.

Table 3: Data Variables, Types and Sources

Study Variables	Data Type	Possible Sources

1. Disaster Profile	Occurrence and Frequency Impacts Mitigation Measures	NADMO, Survey
2. Resource Use	Rate of use of urban land/ share of total land area buildable	TCPD, KMA Landlords
3. Physical Development	Number of Building Permit Issued. Areas susceptible to flooding	Building Inspectorate Division
4. Demographic and Characteristics of City Dwellers	Population Characteristics Population Density Economic Activities and Types Variety Income levels	Household surveys
5. Climate Data	Temperature, Precipitation Data	Ghana Meteorological Department. Literature
6. Drainage	Drains Water flow and channel depth	Hydrological Service Department
7. Institutional Capacity and Management	Permits Laws Governing the Built Environment and Enforcements Collaboration Capacity Problems Constraints Policies	Kumasi Metropolitan Assembly Development Office (Engineering Department) NADMO TCPD

Source: Author"s Construct 2012.

3.4 Sample Size Determination

Recognizance the fact that not all residents and institutions within the Kumasi Metropolis can be interviewed, sampling was adopted in selecting representatives of residents and institutions. Sampling techniques such as multi-stage and systematic sampling were employed. Multi-stage sampling involves the division of population into sub-groups. The selection of the sampled population was based on the location, which are flood prone within the city of Kumasi. This is because they provide the best avenue to assess vulnerability and the adaptive capacity of city dwellers in dealing with climate related disasters.

Kumasi, with a population of 1,915,170 is the fastest growing urban centre in Ghana with a growth rate of 5.6% (KMA, 2009). There are 10 Sub-Metropolitan Assemblies (Sub-Metros) in the metropolis namely Asokwa Sub Metro, Bantama Sub Metro, Kwadaso Sub Metro,

Manhyia Sub Metro, Nhyiaeso Sub Metro, Oforikrom Sub Metro, Old Tafo Sub Metro, Suame Sub Metro, Subin Sub Metro and Asawase Sub Metro.

Among the areas considered as flood prone (K.M.A MTDP 2010-2013; (Mensah-Bonsu et al (2011), Oforikrom, Atonsu, Aboabo, Asafo, Adiembra, Bremang and Dichemso were the focal point of investigation. These places served as locations for the administration of household questionnaires.

3.4.1.1 Sampling Method

The study used both probability and non-probability sampling methods in the selection of the samples for the study. Simple random sampling was used to select the seven suburbs in Kumasi Metropolitan Area to ensure that each suburb stood equal chance of being selected for the study. In this case, all areas considered flood prone were included in the first stage of sampling determination.

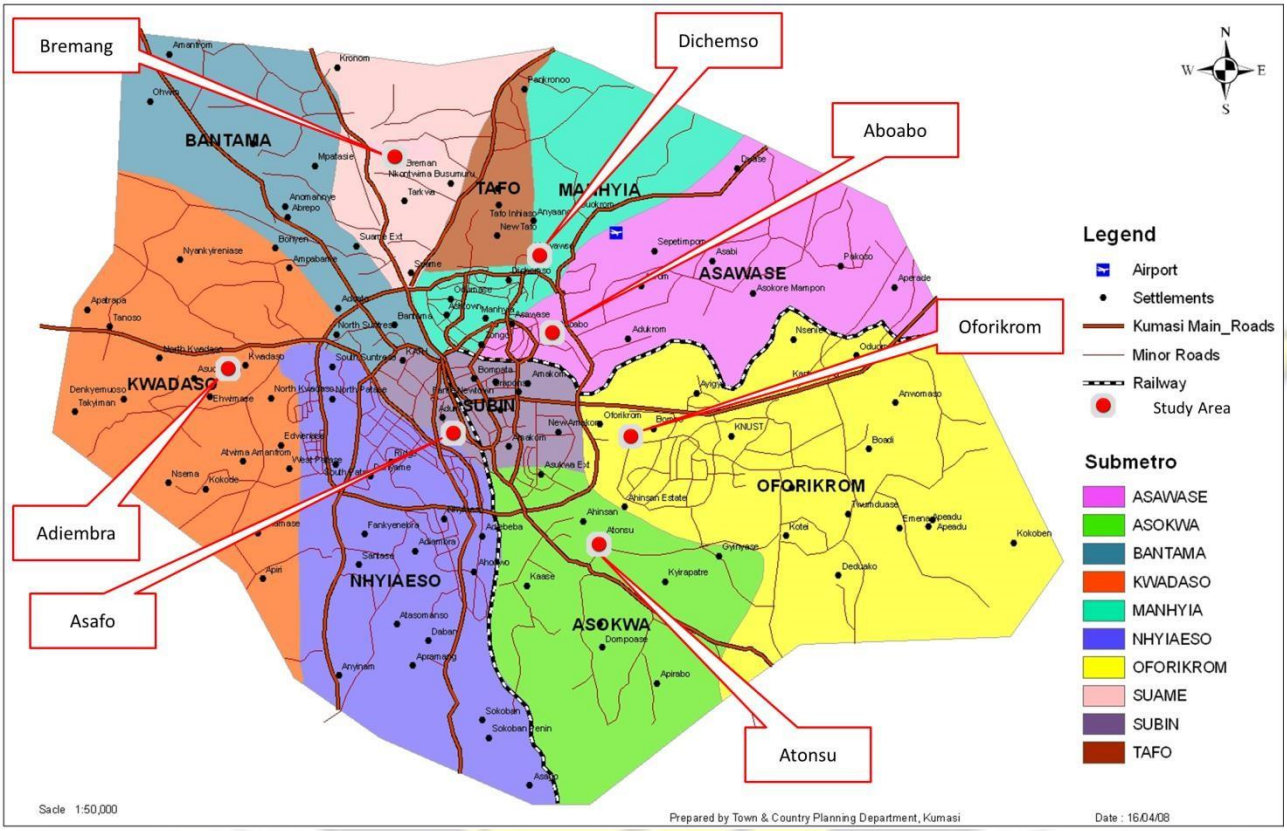
3.4.1.2 Sampling Frame

The main concern in sampling is representativeness. The sample should be large enough to allow inferences to be made about the population. A very small random sample, Blanche et al. (2006: 49) note may be quite unrepresentative, and the same is true for a large non-random sample. Sample size is determined in part by practical constraints such as the number of the population, finance and the time available.

A stratified sampling was first used to calculate the sample frame from the number of households per community (Details of calculation in Appendix 2) and a purposive sampling technique was adopted and households living within 100 metres of main rivers and their tributaries were considered eligible for interview. The interview guide was a structured and unstructured interview survey involving 156 household heads or their representatives selected randomly from the eligible households in the seven communities or suburbs in the Kumasi Metropolitan Area. Efforts were made to contact residents who have experienced climatic disasters as their experience helped enrich the research. Interview guides were administered to KMA and NADMO staffs. Household interviews were carried out in Twi, the most common language in the Metropolis.

A visit to these suburbs revealed that not all household live or are within reach of influence of a natural drainage system. However, effort was made to consider the views of residents not close to the streams during the questionnaire administration through a quota sampling technique. For convenience and spread of location of the selected suburbs selected, seven areas considered as flood prone were selected to gather information of flooding in Kumasi (Figure 11). These areas have the following number of houses as appears in the Table 4.

Figure 11: Administrative Map of Kumasi, Showing Study Area and their Spread



Source: Town and Country Planning Department, 2009: Adapted by Author.

Table 4: Total Number of Residents of the Study Area

Suburb	No. of Houses (2012)*

Oforikrom	14,590
Atonsu	18,622
Aboabo	12,577
Asafo	7,672
Adiembra	1,208
Bremang	17,439
Dichemso	7,978
Total	**80,086**

Source: Kumasi Metropolitan Assembly MTDP, 2010-2013
*Projected

The selection of a household from a house for the study was based on the availability and willingness of the person contacted to respond to the questionnaire in the study area. In this way, the researcher was able to meet the quota for the various communities. The sample frame represents was obtained as follows;

$$n = \left[\frac{N}{1 + N(e^2)}\right]$$

*Where n = sample size or 80,086(Total number of houses in the study areas)**
N = Sampling frame➔ Total Population
e = significance level➔ 8% or 0.08

Using the estimated population data from the Kumasi Metropolitan assembly"s Medium Term Development Framework, 2010), the sample frame is thus calculated as;
$n = \left[\frac{N}{1+N(e^2)}\right] \Rightarrow \left[\frac{80,086}{1+80,086\,(0.08^2)}\right] \cong 155.9$

From the above calculations, approximately 156 residents or households were be selected for the interview from the 7 suburbs. Table 5 presents the sample size distribution for the six selected suburbs.

Table 5: Sample Selection, Size and Distribution in Study Area

Suburb	No. of Houses (2012)*	Sample Distribution	Percentage

Oforikrim	14,590	28	18
Atonsu	18,622	36	23
Aboabo	12,577	24	15
Asafo	7,672	15	10
Adiembra	1,208	3	2
Bremang	17,439	34	22
Dichemso	7,978	16	10
Total	**80,086**	**156**	**100**

Source: Authors‟ Construct 2012.
*Projected

3.4.1.3 Survey Instruments

3.4.1.3.1 Interview Guide

The use of interview guide was the main method to gather primary data. This involved the use of semi-structured and unstructured interviews to solicit information from respondents residing in the flood prone areas. Personal interviews involved the interviewer asking questions and recording the answers in the questionnaires to obtain information from households. The adoption of this method considered the literacy levels of potential respondents as well as ensures the confidence of respondents in providing answers to questions.

3.4.1.3.2 Household Interview

Considering the low literacy levels among some of the respondents, especially, in the traditional and some of tenement housing sectors, the use of self-administered questionnaires was limited to some extent. According to Bulmer and Warwick (1983), the checklist approach is preferred to self-administered questionnaires when the literacy levels are not so high among the respondents. The questionnaires designed was in such a way that key questions concerning knowledge on climate change, adaptation strategies and experience relating to extreme events was made easy to understand and answer. Variables such as population characteristics, density, economic activities, income levels, flood occurrence and familiarity to extreme events were also investigated.

3.4.1.3.3 Institutional Interviews

Formal interviews were conducted in some selected institutions responsible for managing floods and ensuring good physical development and resource use in Kumasi. This was to help assess their efforts and capacities to manage floods and climatic variability in the Kumasi metropolis. The institutions interviewed include The Metropolitan Assembly Officials, The Town and Country Department, The Metropolitan Engineering Department, and The Metropolitan National Disaster Management Organization (NADMO).

The interview with the KMA officials did provide an overview of the current adaptation situation in Kumasi, problems of enforcement of environmental regulations and bye-laws, policy interventions as well as strategies to manage floods in the metropolis. More importantly, they helped explain the socio-cultural and political issues affecting adaptation strategies.

3.5 Data Collection, Process and Presentation

In other to fully achieve the research objective set forth earlier, a number of qualitative and quantitative research methods were used to gather primary and secondary data. These methods were selected, having in mind the complex and varied nature of Kumasi, including but not limited to the multi-functional and multi-institutional role it plays in the country.

3.5.1 Data Collection

Data collection was done during the month of May. The researcher selected and trained four field officers who helped in the data collection. Financial constraints and inability to monitor a large group at a time limited the number of field officers to four. Pretesting of the survey instruments was carried at Bremang. Responses were analyzed and observations made resulted in modifying the instruments and the final one was sent to the field. Data collection took the form of interactions and in the case of households, the heads of such units were interviewed or given the questionnaire to fill in cases where they request to fill it themselves.
In the absence of heads of households, qualified non-minors representatives of the heads of the households were answer on behalf of the family unit. This was to ensure that a 100% retrieval of questionnaires was achieved. In the case of institutions more than one visit was carried out.

Questionnaires were left with them for collection the following week. This was necessary as institutional procedures demanded it.

3.5.2 Data Processing and Presentation

In data processing, three things were carried out; including editing, inputting and presentation. Data collected from the field were edited with the aim of detecting and eliminating errors to ensure clean and reliable data. It is a routine task, slow, labourious and boring. Though errors are not avoidable in surveys, the editing ensured that they were minimised. In other to clarify answers taken from the field through the survey instruments into meaningful categories and bring out the essential patterns, the questionnaires were coded and inputted mechanically using Statistical Package for Social Scientist (computer software). Two forms of coding pre-coding and post coding were done. The pre-coding was done during the survey instruments preparation. The post-coding involved assigning meaning to categories that were not defined earlier and those that were identified on the field and grouped to ensure uniformity in analysis. Data from the field surveys were presented using tables, graphs such as bar, pie, scatter, line and histogram and maps.

3.6 Data Analysis

The research analysis was descriptive and qualitative. The integrated set of relationships between the various categories of people and activities being investigated in the Kumasi Metropolis provided a framework for analysis and assessment.

3.6.1 Analytical framework

The analysis of flooding in Kumasi involves a stronger conceptual and relevant framework that reduces ambiguities. The research focuses on flooding in the built up areas of Kumasi. This allows for the identification of the relationship between flooding and climate change in the city. The analytical framework recognizes the process of increasing weather variability and intensity, decreasing size of river drainages as a result of development and the negative attention it has generated.

The framework also acknowledges „*urban'* as it includes the state of vulnerability existing in urban areas and how extreme event can compound an already bad situation. The study therefore uses the concept of *'urban flooding'* to analyse and interpret the change in Kumasi. This is done within a spatial unit characterized as the *'sphere of influence'* which is defined as households living near or on drainage systems in selected suburbs in the Sub-Metros of the Kumasi Metropolis.

An effort to understand climate change and increasing weather variability has focused mainly on agriculture and rural areas that are considered poor. However, little or no assessments have been done in urban areas and their poorer populations whose means of coping with such changes may be severely limited.

3.6.2 Analytical Tools

Data cross-tabulation, disaggregation and the application of statistical techniques were employed during the data analysis. The combination of techniques was to ensure that generalization was based on credible means of analyses of data from the field. The SPSS was used to help in the analyses of data from the field.

Descriptive statistics was used to present large amounts of data with few limited summary variables. The two types of descriptive statistics, which were used in this study, include:

- Measures of Central tendency: This is the use of one value to represent the average of a variable. Three common measures of central tendency to be used are the mean, median and mode; and

- Measures of Dispersion: This uses one value to describe the extent of spread between the data points and the average. The two common measures of dispersion to be used in the research are the range and standard deviation.

In the context of this study, it was necessary to establish relationships between the variables under investigation and ensure that isolated analyses are not presented. Bivariate descriptive analysis was used to make inferences and establish the relationship that exists between the study variables and Climate Change. Regression analysis was used to determine how independent variable(s) affects a dependent variable and correlation analyses were used to

determine the relationship between two variables. The Pearson‟s Product Moment Correlation Coefficient was used to examine the strength of the linear relationship between two variables.

In addition, time dimension and spatial analysis were employed to set the research in context. The spatial analysis tool that was employed is the buffering. Buffering refers to the delineation of an area surrounding a target object with one or several fixed distances. From field data collected, buffer zones was developed, showing areas flooded annually and its effects, giving a better graphic presentation of the seriousness or otherwise of the issues being discussed.

3.7 Summary

This chapter has documented the various approaches and methods used in undertaking the study. It provides insight into the research design framework used, the study variables, the sampling methods used and ends with the framework for analyzing the data gathered from the field surveys. The next chapter outlines the incidence of flooding and adaptation mechanisms employed in Kumasi.

CHAPTER FOUR DATA ANALYSIS AND PRESENTATION

4.0 Introduction

The previous chapter sets the context for collecting data to support arguments set forth in previous chapters. It also presented the means for verifying all data collected and ensure that the objectives set forth in chapter one are achieved. The current chapter presents the data collected, the analysis and inferences drawn in an attempt at answering the research questions..

4.1. Brief Profile of Study Areas

The study region is the Kumasi Metropolitan Area, with seven selected suburbs in Metropolis as the study sites. The selections was based on the fact that these suburbs have documented evidence of flooding cases and are located strategically around the Metropolis. Their spread or location makes it ideal to capture concerns of all classes of people in the Metropolis. The study areas are profiled below.

4.1.1. Oforikrom

Oforikrom is located on the Kumasi-Accra road. For the purpose of this study, areas such as Sunsanso, Oforikrom and Anloga were clustered as Oforikrom. This was done to avoid the difficulty in boundary identification and benefit from their close proximity. The Sunsanso stream and the Aboabo River drain the area. At the Susanso stream, temporary structures intermixed with few permanent concrete buildings are dotted along the stream, with serious encroachment on the reservations bordering the stream. At the Anloga area, artisans and upstream dumping of waste have blocked the storm drain meant for the Aboabo stream and any over flow during the rainy season.

4.1.2. Atonsu

Atonsu is located on the Kumasi-Lake Bosomtwe Road, about 6 kilometres from the Central Business District. It is borded by Ahinsan in the North and West, Bokro in the South and Dompoase in the East. Ahinsan Land Use Scheme was first approved in 1972, which covered an area of about 247 acres. However, an update in 1999 by the TCPD showed encroachment on public spaces for residential purposes with green areas and marginal lands all built up or sold. This development has resulted in building on and along waterways as the green areas left in 1972 were for flood management. Now, the extent of flooding goes beyond the immediate areas encroached to the main roads bordering the community, Ahinsan, Dompoase and the main Kumasi-Ahinsan-Lake-Road.

4.1.3. Aboabo

Aboabo is located in the North Eastern part of the city and shares a common boundary with Dichemso. Hitherto, ethnic groups mainly from Northern Ghana and Burkina Faso have occupied Aboabo. However, because of rapid growth of the city, it is now home to a number of ethnic groups. Covering an area of 360 acres, the community has attained a residential status with development engulfing three traditional settlements namely Aboabo No. 1, Aboabo No. 2

and Aboabo Extension. The multifamily medium rise compound and single storey traditional compounds type houses dominate the community. Because of the unauthorised housing, many of these buildings are found on the embankment of river Aboabo and floods with the least rains.

4.1.4. Asafo

Asafo"s location in the centre of the city means that land values in this location are high and in high demand. This has naturally led to development of all available lands including encroachment and uses of lands considered as buffers and are marginal. Heavy development continues, despite their awareness of the danger posed by floods and its subsequent effects. An interaction with property owners shows that they are aware of the perennial floods and have taken measures to enforce their buildings. However, what they cannot guarantee is the flooding upstream which may endanger human life and properties.

4.1.5. Adiembra

Adiembra is located in the Kwadaso basin and is one of the plush residences in Kumasi. The furthest house selected for the interview was all located about 20 metres away from the river. Neighbourhood popularly known as Adiembra Nsuom is known for its frequent flooding whenever it rains. Recent rains had destroyed the bridge connecting the suburb to Atasemanso road and residents had to resort to using logs in order to safely cross the chasm created by the flood. The frequent flooding according to the community is because of the affluent building on waterways.

4.1.6. Bremang

Bremang is located in the Suame Sub-Metro of K.M.A and sandwiched between the Akyeampomene stream at Maakro and Adaasu stream at Kronum. Its location on the Offinso Kumasi road and the ease with which residents can get to the city centre attracted many people to the area, which increased the demand for land for development. This has led to encroachment on reservations near these streams and subsequent flooding of residents living near the streams. As at the time of field survey in May, 2011, all lands near the Akyeampomene and the Adaasu stream have been developed and most of the buildings have not been modified to withstand flooding as depicted in Plate 1.

Plate 1: Foundation of Building Affected by Erosion at Bremang

Source: Field Survey, 2012

4.1.7. Dichemso

Study locations in Dichemso are areas close to the Airport Roundabout and near the Aboabo River. This portion of the suburb is lower than surrounding areas and can be considered as the river basin. Buildings are persistently flooded every year so residents have constructed wooden bridges from the main street to their homes. This is to enable them reach their homes or walk to their homes during floods since it takes quite a long time for the floodwaters to recede and the land to dry. At certain places, big stones have been placed on the ground to provide access to buildings (see Plate 2). The area is generally swampy in nature and is inhabited by dangerous reptiles such as snakes especially during the rainy season. The area is sometimes completely cut off from the city for 3 to 4 days when the Aboabo River overflows its banks.

Plate 2: Stones placed in floodwaters to provide access to residence

Source: Field Survey, 2012

4.2. Demographic Data of Respondents

Flooding affects people of all demographic spheres and IPCC identify women and children to be the hardest hit when it comes to its impacts on livelihoods. In this vein, the data was collected on the demographic characteristics of respondents, mainly on gender, education and economic activities. This provides the means to assess the probability of one or groups finding themselves exposed to vulnerability.

4.2.1. Gender of Respondents

As indicated earlier, 156 households were selected across seven suburbs in the Kumasi Metropolitan Area. Out of this, 51.3 percent were males while the remaining 48.7 percent were females. Adaptation strategies vary for both gender and as Satterwaite (2001) has observed

female adaptation is less responsive than males. In the case of Kumasi, 48.7 percent females may present difficulties when it comes to vulnerability and gender.

Table 6: Gender of Respondents

Gender	Frequency	Percentage
Male	80	51.3
Female	76	48.7
Total	**156**	**100.0**

Source: Field Survey, May, 2012.

4.2.2. Educational Levels of Respondents

The educational level of people determines largely the nature of inhabitants" responses and understanding of the issues at stake. From the survey, 50 percent have attained a basic level of education (Primary and J.H.S), with S.H.S and tertiary accounting for 20.5 and 16.7 percent respectively. In all, 12.8 percent have not attended school or received any form of formal education.

Table 7: Educational Levels of Respondents

Educational Level	Frequency	Percentage
None	20	12.8
Primary	30	19.2
JHS	48	30.8
SHS	32	20.5
Tertiary	26	16.7
Total	**156**	**100.0**

Source: Field Survey, May, 2012.

This represents a negative indicator for climate related education and sensitization as well as the enforcement of any building and development regulation. This also confirms the findings of an earlier study by Satterwaite (2007) and Smit et al (2000), on the class of people who tend to build on marginal lands and flood prone areas.

4.2.3. Income Levels of Respondents

In all instances, people‟s capacity to avoid the hazard or to cope with it and to adapt is influenced by their income. For this reason, questions were posed to assess respondents‟ incomes. The mean income of respondents‟ observed during the field survey was GH₵ 474.93. The minimum amount earned was GH₵ 100 and the maximum amount earned is GH₵ 3,000. Income distribution is skewed towards high class and less dense residential areas, particularly Adiembra and Dichemso. The level of one‟s income affects ones adaptability or vulnerability and in case of flooding, residents in Oforikrom, Atonsu, Aboabo, Asafo, Bremang and some residents in Dichemso are likely to be exposed and their ability to recover their assets, severely hindered.

4.3. Flooding in Kumasi: Understanding the Level of Vulnerability

Residents in the Metropolis are not new to flooding but are wary over the increasing rate of floods in the Metropolis. According to the National Disaster Management Organization (2012), Kumasi has been experiencing floods yearly since 1998, a situation which was not so before 1998. Floods in the city before then had a return rate of three years. For example, on the 21st of June 2011, a three-hour rain in Kumasi exposed the poor drainage system in the city, rendered about 1000 people homeless by submerging their homes in the flooding waters of the Susan river and other rivers that traversed the city.

The areas mostly affected were Oforikrom, Susanso and Anloga junction area, Ahinsan, Atonsu, Bremang and the Dichemso (Airport roundabout area). At the Anloga junction and Airport roundabout for instance, some vehicles were stuck in the middle of the floods. An example was an Opel taxi with registration number AS 4021 Y which got completely flooded and had its windscreen smashed by the floods.

The heavy rains left many residents marooned in their homes while others were stranded in their attempt to get to their homes. In Adum, a number of houses, shops and kiosks were flooded with residents busily seen evacuating their belongings into the open, while others cleared up the mess caused by the floods. Some residents and shopkeepers were seen busily bringing out soaked items, some of which were still dripping with water. Some household items, which were affected by the floods, included footwear, furniture, carpets, electrical appliances, mattresses and clothing.

Plate 3: A Commuter Being Carried on the Back for a fee

Source: Field Survey, May, 2012.

Local trends indicate that maximum and minimum temperatures are increasing, suggesting that Kumasi is getting warmer. Meteorological data from the Kumasi observation station indicated that for the period 1960 to 2010, Kumasi experienced an increase in the number of hot days with temperatures exceeding 30°C. Kumasi‟s rainfall patterns were also affected. Although rainfall increased slightly, the distribution of that rainfall changed, with longer periods of no rainfall and shorter periods of intense rainfall. These changes, according to the Meteorological Agency (2009), is neither slowing nor changing for the better. Causes of flooding in Kumasi can be categorised into the following.

4.3.1. Lack or Overload of Drainage

The intense nature of rainfall in Kumasi has been compounded by the overload of drainage capacity of existing systems. The city‟s population have increased significantly but existing drainage infrastructures have seen little or no improvement or maintenance. As a result, in the event of rain, which exceeds the designed capacity of these channels, surface flooding becomes the end result. The city is also suffering from the consequences of flooding because of drain blockages as can be seen in Plate 4.

Plate 4: A Chocked Drain at Dichemso

Source: Field Survey, May, 2012.

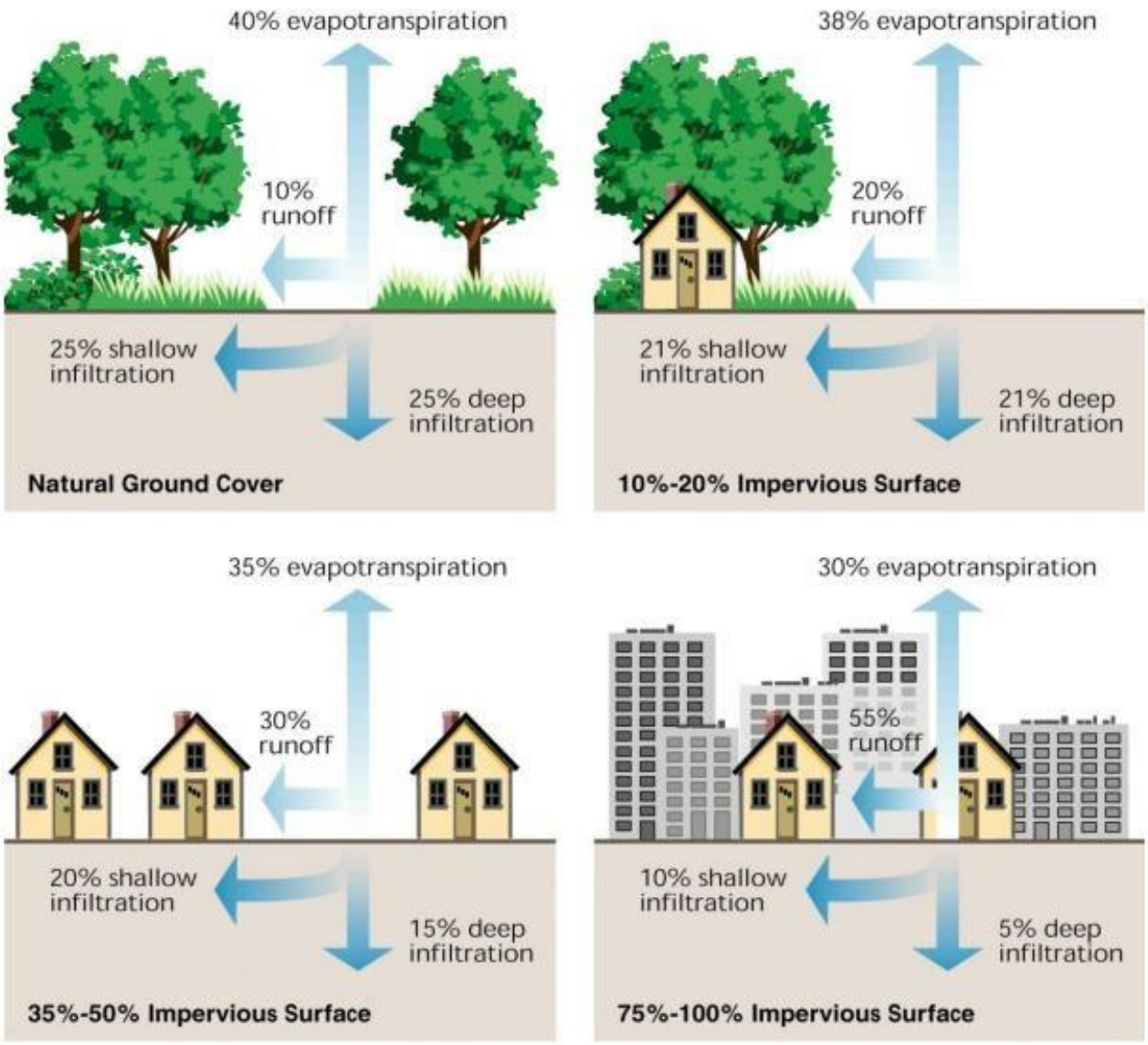
4.3.2. Land use Change

Changes in the use of land within urban settlements can increase the exposure of receptors to the risk of flooding. This may be the result of increasing land prices dictating that every square meter is utilized to the maximum extent. Open spaces and brownfield land are developed for commercial, residential and industrial uses. With changing land use and the concentration of resources in urban areas, exposed property and the rate of damages grow. Changes in the use of land can also contribute to the increased hazard from flooding by reducing the flexibility of the system to absorb excess water. Land use change in any part of a catchment may contribute

to increases in urban flooding downstream. This is the case in Aboabo S Line, which is a community downstream of the Aboabo stream. During rains and subsequent flooding, debris from Dichemso ends up in the small drains in the area. This reduces the capacity of the drains and result in overflows into houses near the main drains.

Other land use impacts include new infrastructure development such as transportation networks, which may introduce elevated structures obstructing previous natural flow paths. Other more natural land use changes can also destroy the delicate water and land balance leading to reduced storage and increased overland flow. For example, increased need for food crops could lead to the draining and protecting of fields against water ingress. This reduces the storage capacity of land and forces water to take an alternative path, which may include vulnerable receptors as can be seen in Figure 12.

Figure 12: Change in Watershed Characteristics after Urbanization



Source: Federal Interagency Stream Restoration Working Group, 2001.

Another factor related to land use changes is the uncontrolled development of flood plains. Development on flood plains is often seen as necessary, but if it is done in an unplanned fashion, it may lead to devastation. When development is not guided, planned or controlled, the land exposed to flood hazard is liable to be more highly developed due to its lower cost. According to the WMO (2007), choices of development are often made without proper awareness of the risk in the prevailing area. However, despite such knowledge, development continues in such areas as other priorities take precedence. Equally to blame is the lack of enforcement of planning laws prohibiting development in such areas. It is thus not surprising to find that, about 80 percent of development in and around the Kumasi Metropolis occurred

without appropriate building and development permits (Freiku, 2003). Equally, residents in the study areas squarely put the blame on poor planning practices in the metropolis (see Table 8).

Table 8: Possible Reason for Annual Flooding in Kumasi Metropolitan Area

Reasons for Annual Flooding	Frequency	Percentage
Poor Environmental Practices	60	38.5
Unprecedented Population Growth and migration	17	10.9
Poor Settlement Planning	62	39.7
A Combination of the Above Factors	17	10.9
Total	**156**	**100.0**

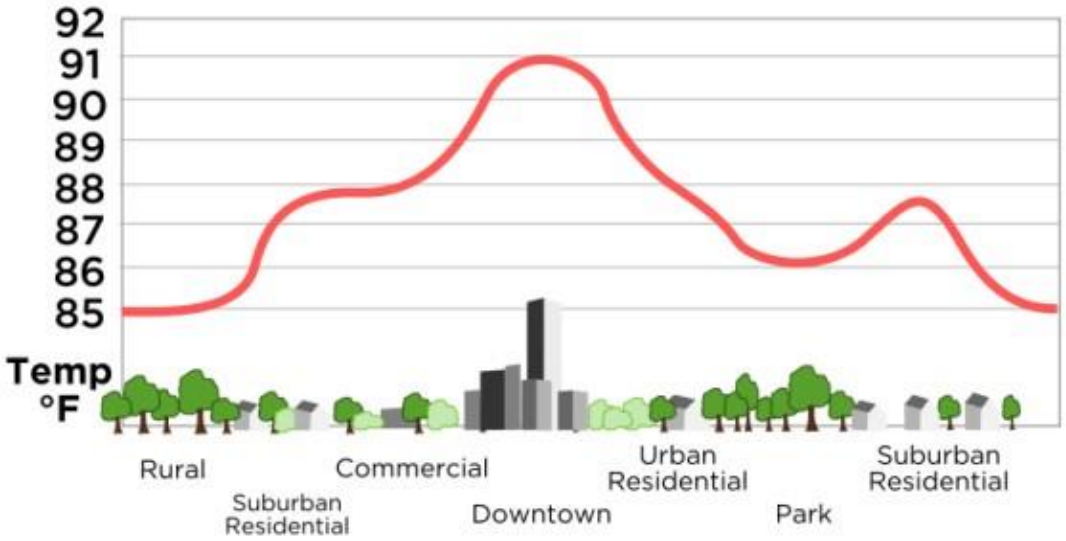
Source: Field Survey, May, 2012.

Though residents attribute the cause of flooding to poor settlement planning by city authorities, further question posed as to whether they have building permits from the TCPD office of the KMA turned out to be false as they only had an allocation notes from the land owners.

4.3.3. Kumasi Urban Microclimate

Kumasi was formerly known as the „Garden City", due to its greenery or shades that can be found all over the city. However, owing to the large scale modification of vegetation in the city, it has led to a modification in the hydrology of the city. The trees provided shade, absorb heat generated from structures and concrete surfaces and balance or maintain the microclimate of the city. Kumasi cannot claim its „garden city" status because the trees have cut and the greenery in the city greatly reduced due to urbanization. Therefore, heat islands are created, resulting in higher temperatures over the city, which is illustrated in Figure 13.

Figure 13: Microclimate Graph Showing Temperature Range Between City and the Surrounding Region



Source: The New Phobia via Wiki-Commons adapted from NASA data.

Kumasi experienced an increase in the number of hot days with temperatures exceeding 30°C over the 50-year period than its surrounding areas, with the change more pronounced in the last two decades (See Chapter 2). This change can conveniently be described as the microclimatic changes because of urbanization. Heat islands affect flooding by reducing permeability due to drying surfaces so that the amount of runoff can be much higher. They also may bring delay in the onset of rainfall and lead to more intense events. Intense rainfall is also caused by a combination of aerosols and localized regions of hot air, which generate cumulonimbus clouds (Shimoda 2003).

4.3.4. Population Increase

Increase in urban size is generated both by the migration of rural populations into urban area and by the general population expansion. With increased population levels comes, at the very least, an increase in the number of people at risk from a flood event. Urban flooding has become more dangerous and more costly to manage simply because of the size of population exposed within urban settlements. This change is predicted to increase and Kumasi is no exception. Kumasi‟s population rose from 260,286 to 489,586 and 1,171,311 in 1984 and 2000 respectively (GSS, 2002). Projections done by the UN Habitat in 2008, using the exponential growth function and growth rate of 3.34 puts the city‟s population at 2,397,000 in 2020, a more than double increase in the population in the next decade.

An interesting scene in Kumasi"s flood exposure demographics is the ethnicization of settlements in Kumasi. Notable areas in Kumasi that are organized along ethnic lines include the Anloga (Ewes), Fanti New Town (Fantis), Moshie Zongo and Aboabo (Northerners). These settlements came into being because of migrants from these ethnic backgrounds agglomerating at these locations. Migrants and minority ethnic groups face many challenges including isolation from the host communities and social exclusion, poverty, low socioeconomic status, or language difficulties, which can make them less resilient to flooding. Literature has it that as half of the overall growth of urban areas is due to migration, it can lead to an increasing vulnerability among urban populations. This was confirmed in the field data collected as the ethnic backgrounds of residents living in flood prone areas are mostly migrants and from the Northern part of the country.

Table 9: Ethnic Backgrounds of Respondents

Ethnicity	**Frequency**	**Percentage**
Ethnic Groups from the North	87	55.0
Akan	44	28.0
Ewe	14	9.0
Others	11	8.0
Total	**156**	**100.0**

Source: Field Survey, May, 2012.

From Table 9, ethnic groups from the Northern part of the country are mostly found and are likely to agglomerate on marginal lands in the city. Though Akans are in the majority in the city, their presence at these areas liable to flood is minimal. The reason assigned to the ethnic groups agglomerating is the language problem and identification for security and resource pooling. New migrants tend to find people from the same ethnic groups as their contact in settling in their new environment.

4.3.5. Rate of Flooding in Kumasi

Flooding events are experienced yearly in the Metropolis from intense but short rains, which are becoming difficult to predict and a combination of human induced factors such as building in waterways and indiscriminate refuse disposal in drains and streams. The Aboabo River

Basin, which is home to various communities, namely the Anloga, Dichemso, Aboabo and Amakom, is the hardest hit area with flooding affecting life and property. In some instances, as many structures including completed and uncompleted buildings are abandoned because of what is now an annual phenomenon.

From the survey, it was realised that about 61 percent of all respondents continue to live in the area, despite the annual flooding phenomenon. This is because they cannot afford the cost of moving to another place. Some 13 percent continue to stay on because of proximity to their places of work or their businesses being located in the flood risk areas. The remaining 16 percent remained in the area for other reasons such as having lived there all their lives or the fact that the land belonging to them or a family member. This validates the assumption that combinations of social and economic factors influence the decision of urban dwellers to stay in these flood prone areas.

4.3.6. Flood Reporting in Kumasi

Flood incidences in the Metropolis are primarily reported in the media (especially the Radio Stations in the City). In all cases reported or recorded by NADMO, it was the media that first made the issue known after which staff of NADMO visit the affected areas to ascertain validity or otherwise and the extent of damage and people affected. The data from the visit is then used to plan for interventions such as provision of relief items and evacuation. This form of responding to floods has its advantages and disadvantages as well. In areas where they are not reported earlier, it takes days for relief to be brought to those suffering. Such a delay may trigger other related effects such as diseases and crime. However, media reporting augments the inadequate staff of National Disaster Management Organisation (NADMO) and ensures that philanthropic organizations also help in relieving sufferers too.

4.3.7. Population Affected by Flooding in Kumasi

Residents interviewed in the flood prone areas of Kumasi were mostly migrants who have settled in the Metropolis to work, joined their families or to enjoy the services that the city affords (Refer to Ethnic Composition of Residents above). This underlines the difficulty in their

relocation to a less flood prone area because of the capital requirements of relocation. Residents who are indigenes and know areas that are flood prone try to avoid settling in those areas. However, it does not mean that some indigenes are not located in such areas. Evidence from the field survey indicate that some indigenes are forced to settle in flood prone locations because of poverty (such lands have not attracted a lot of economic interest), nearness to their place of work (economic considerations) and family ties (social factors). For some, their location was not easily flooded at first, but poor development planning has resulted in their houses being flooded.

4.3.8. Impact of Flooding

4.3.8.1. Economic Activities

Flood events have a variety of impacts on businesses, ranging from direct physical impacts to indirect effects. Direct impacts include damage to premises, equipment and fittings; loss of stock; reduced customer visits and sales as well as disruption to business activities are among the common effects experienced by businesses in the study areas. Indirect impacts experienced by businesses include remote factors such as the disruption in supply of goods from warehouses and wholesale outlets (i.e. Flooding in Kejetia means a disruption in supply to businesses in the suburbs).

Residents at Oforikrom whose businesses are affected are mainly woodworkers and traders. In Adiembra, Atonsu, Aboabo and Dichemso, it is the petty traders and hawkers who are unable to prepare their goods for hawking. In Bremang, a combination of activities of mechanics, petty traders and hawkers were affected. In Asafo, businesses such as the cold foods stores, restaurants and transport operators who are affected during flood events. Out of the 156 respondents interviewed, 22.9 percent were able to estimate the amount lost to flooding last year and that amounted to GH ₵10,650.

4.3.8.2. Housing

Most residences visited clearly showed signs of flood effects with some structures in need of urgent repairs. Some structures had their foundation exposed through the effect of erosion on them and others structural faults such as cracks and broken walls. The water from the floods has affected the aesthetics of the buildings as an effort to paint is seen as futile by owners. In

all, 75 percent of all residents interviewed have carried maintenance activities one way or the other on their buildings, which is listed in Table 10.

Table 10: Part of Building Maintained

Part of Building	Frequency	Percent
On Wall	31	19.9
Foundation	6	3.8
Roof	15	9.6
Drains around the Building	57	36.5
Whole House	8	5.1
Total	**117**	**75.0**

Source: Field Survey, May, 2012.

In areas such as Dichemso, Aboabo and Bremang, 5.1% of houses within the study location have been abandoned as a result of the annual occurrence of the floods, difficulty in accessing their homes during that event and the prolonged duration it takes for the flood waters to recede. This is shown in Plate 5.

Plate 5: A house abandoned in Dichemso due to annual flood occurrence

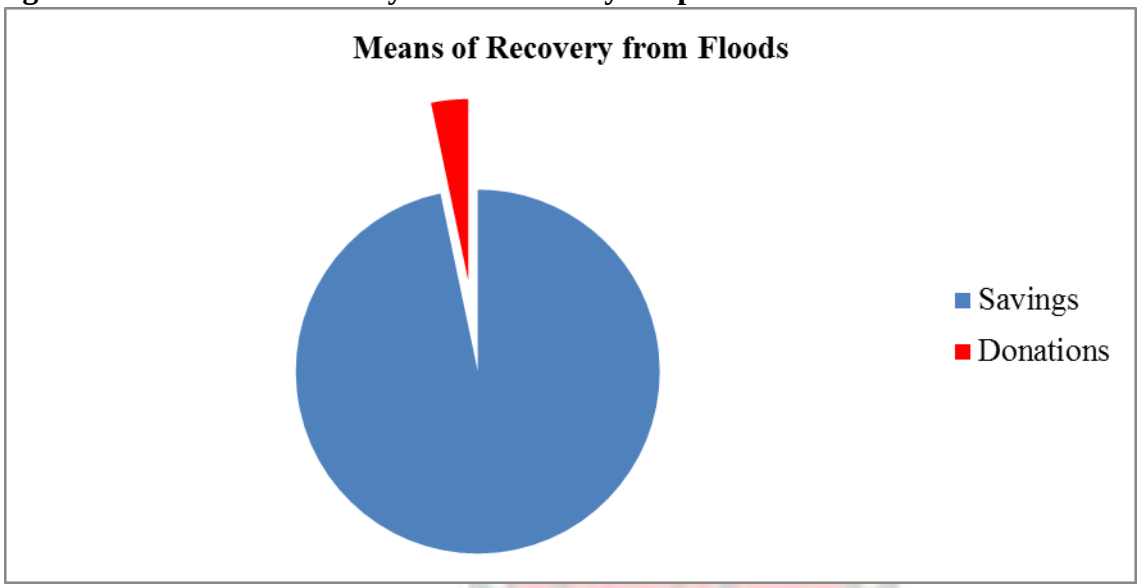
Source: Field Survey, May, 2012.

4.3.8.3. Property Damage

About 49.3 percent of respondents during the field survey reported of damaged properties from flooding. Properties of residents destroyed by floodwaters were mainly household furnishings and appliances such as furniture and electric appliances including television sets, radios and sound systems. A calculation of how much was lost was based on the market value of the item as at the time, it was bought and in all, the 49.3 percent lost a combined amount of GH₵41,540 from floods last year.

Most of these residents have to rely on their personal savings, loans and help from philanthropist in order to replace lost items, without any intervention from the Assembly or the government. They also lamented the unnecessary delay one has to go through in order to seek governmental support thus resorting to "self-help" (See Figure 13).

Figure 14: Means of Recovery from Floods by Respondents

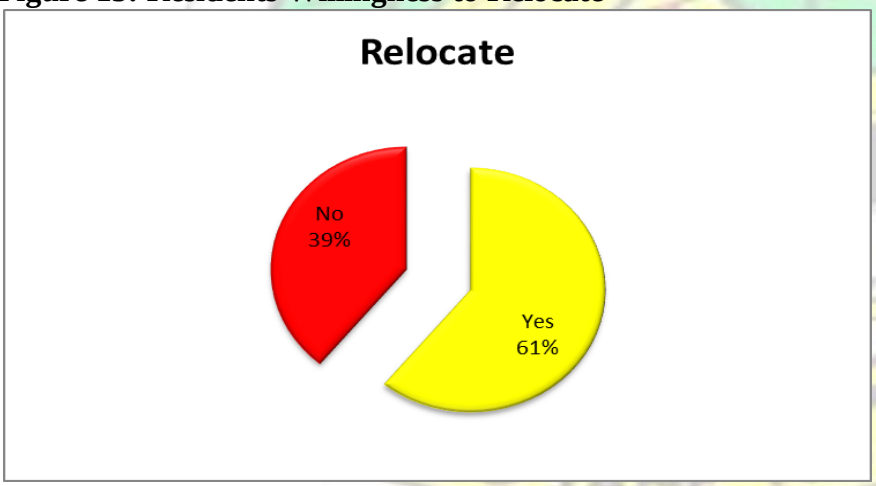


Source: Field Survey, May, 2012.

4.3.9. Future Plans

People tend to economize their location by settling at locations where they can easily reach their place of work and other activities. It is no wonder that in the face of looming problems, some residents are reluctant to move to a more safer locations if given the options or in the near future. Majority of residents (61%) surveyed indicated that they were reluctant to move citing economic reasons as to why they will not move.

Figure 15: Residents Willingness to Relocate



Source: Field Survey, May, 2012.

4.3.10. Management of Floods in Kumasi

The National Disaster Management Organization is given the responsibility of managing all disasters in the country and is represented by agencies at the various Metropolitan, Municipal District Assemblies and zonal levels. As part of their responsibilities, the National Disaster Management Organization (NADMO) is responsible for the management of disasters and similar emergencies. Since their inception in 1996 by an Act of Parliament (Act 517), they have been mandated to offer relief support items in times of emergencies in any location of the country. A major challenge that NADMO faces is lack of adequate resources to function effectively and the lack of legislation to ensure that it takes remedial actions before disaster such as floods strike as foregoing arguments points to the fact that most floods experienced in Kumasi are man-made.

Activities carried out by NADMO to curtail flooding in the Metropolis include pulling down structures along waterways in conjunction with the Metropolitan Assembly, warning residents of heavy rains or changes in the pattern of the weather and the regular yearly education programme, which is done at the national level. Apart from the above, the agency is handicapped but to wait for a catastrophe of a large scale to happen before being called in to act. At least, it is not unusual for the nation, as well as other parts of West Africa, to experience rainfall in June and July. However, the extent of the damage of the recent rains to the lives of our compatriots and their properties calls to question whether or not we have leant our lessons about the reality of the climate change that affects our weather patterns in Ghana and the world.

4.4. Measuring Adaptation

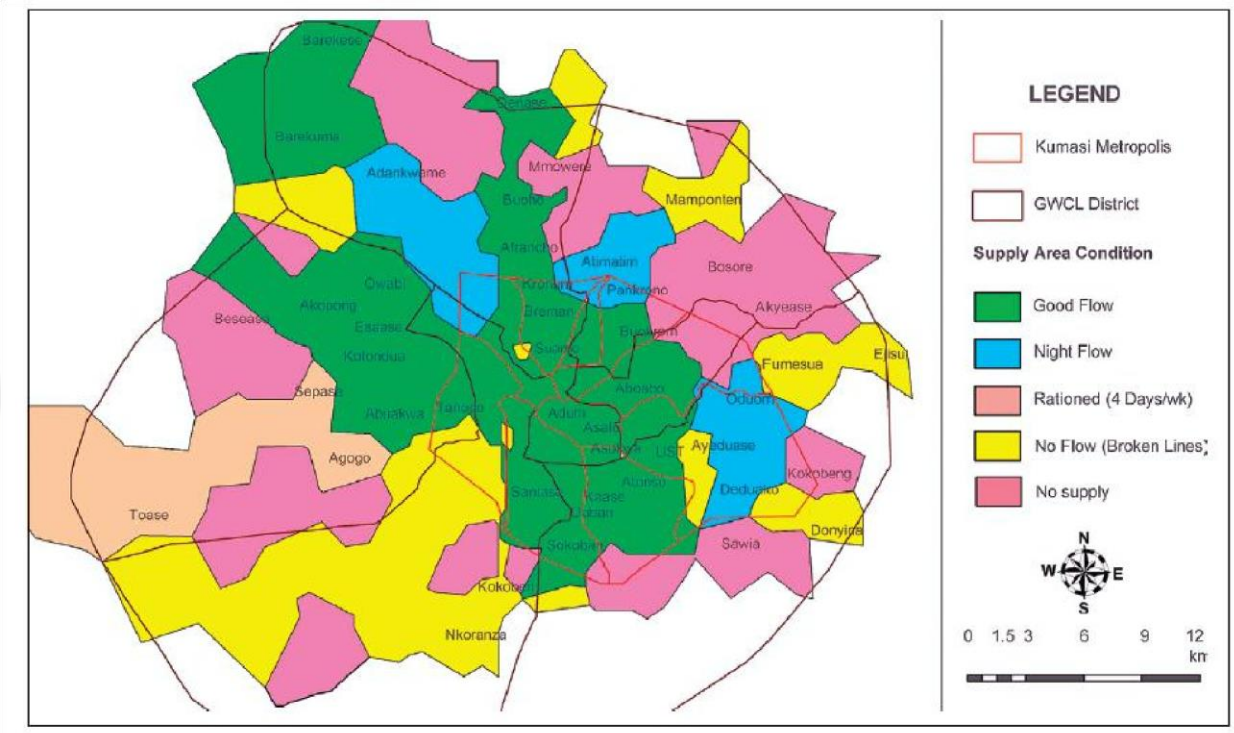
4.4.1. Flooding and Infrastructure

The inadequate infrastructure within the city will be damaged if present development path is continued or stakeholders continue to adopt the „business as usual posture". Damage can be expected from extreme events such as flooding, resulting in potential impacts to infrastructure and ultimately placing a significant portion of the urban population at risk. Climate change impacts are likely to increase the magnitude of existing problems linked to water availability, food security and health issues.

4.4.1.1. Water

Kumasi already faces constraints on water supply. According to Braimah et al (2011), the two water treatment plants serving Kumasi Metropolitan Area (Barekese and Owabi) supplied the city with 83,336m^3/day in 2010, an increase from 70,828m^3/day in 2000. However, the increase represented a decline from 76% to 62% coverage over the same period because of increased population. It must be noted that these production plants are producing at full capacity. Figure 15 shows a map of water supply condition for the city

Figure 16: Water Supply Condition for Kumasi



Source: Braimah and Adom-Asamoah TCPD, KMA. 2011.

Water supply is continuously being threatened by a combined climatic and human factor to water bodies in the city. Water availability in the Barekese river catchment is predicted to decrease by 157.8 million cubic metres for the period 2000-2010. This will lead to a reduction in the water available for human and industrial consumption in Kumasi. This is because of the fact that the catchment area of the dam has come under intense human activity in recent years, which is reducing the water yield to the dam. Encroachments of the dam"s catchment area for private land development, farming and logging have silted the dam and subsequently affected efforts to expand water production. It is also possible that migration of people from other volatile vegetation zones such as the North and areas dependent on agriculture in the country will increase, placing a greater burden on already stressed resources.

4.4.1.2. Electricity

Climate change does not pose a threat to electricity supply to the city but difficulties are likely in response to extreme events. Residents interviewed in the seven locations in the Metropolis were frustrated by power outages during heavy downpours and strong winds, when such utility is sourly needed. Power outages are not limited to houses only but to all activities and where health is concerned, medical facilities located in such areas may have to provide alternative or lose a life as reported to be the cause of recent strike actions by Junior Doctors at the Komfo Anokye Teaching Hospital (Daily Guide, 2012).

4.4.1.3. Urban Agriculture

Urban agriculture production in Kumasi is also likely to be affected, particularly in vegetable farming along rivers and streams where production yields are likely to decrease due to changes in rainfall and temperature. Vegetable farmers in the Metropolis use the fertile, cheap and sometimes free parcels of land serving as buffer along rivers and streams in the city to farm. The farmers mainly produce vegetables such as carrots, pepper, onions, lettuce and cabbage. Their activities rely on water from the streams and rivers but when it rains, their produce is lost.

4.4.1.4. Health

Temperature increases may also cause the spread of malaria to previously unaffected areas in Kumasi. Some impacts in this sector are direct (e.g. heat waves and extreme weather disasters), while others arise through disturbances to ecological processes (e.g. the distribution of infectious diseases, freshwater supplies and availability). Certain groups (e.g. the elderly, children and low-income and immuno-compromised individuals) are more vulnerable to these impacts than others. Data from the Metropolitan Health Directorate confirms Malaria (Both Complicated and Uncomplicated) accounted for about 52 to 54 percent of Malaria cases in 2005 to 2011 of all OPD cases reported in the city.

4.4.1.5. Economic Activities

Major economic and tourist areas are likely to be negatively affected. The effect is typically captured the downpour on the 11th of October, 2011, when business activities was on-going and no prior warning have been given of the impending rain or its intensity.

4.4.1.5.1. A Case of the CBD

Traders in Adum and the Central Market in Kejetia have observed that the patterns of rains and its accompanying floods are no more predictable, making preparations very difficult since the last decade. The "rains fall heavily in some years and in some years; it is not more than drizzling". The traders noted that it used to rain heavily in March through to the end of August or early October but this pattern has changed.

The changing nature of rainfall patterns results in loss of capital to traders. A case in point is the 11th of October 2011 flooding incident which virtually brought all activities along the main road in front of the central market to a halt and destroying an unspecified amount of goods. Such floods affect traders" capacity to recover their capital and pay bills including store rents, health and educational fees. Flooding in Kejetia is now more frequent with every small downpour appearing to produce intense flooding. Some of this is because the main drainage channel of originally 60cm deep is now less than 10cm deep because of an accumulation of sediments and rubbish. When probed further about the possible cause of floods in the city, they attributed the cause to the following:

i. Poor drainage: Even when the drainage channels are occasionally de-silted, the excavated silt is dumped alongside the channel and is washed back in;
ii. Poor Sanitary practices and management; and
iii. Overpopulation.

4.4.1.6. Sanitation

According to the Waste Management Department of the KMA, it seems that KMA is synonymous to Water Management in the city, whiles the other functions of the Assembly are hidden. Sanitation crises can occur if the volume of waste generated were to be washed by floods. The debris in the running water can cause more catastrophe than the floodwaters alone.

To them, floods in the city are mainly man-made because of the manner waste is handled in the city. Waste, especially plastics dumped in drains end up choking drains and reducing their design capacities, which ultimately results in flooding. Though the department concede that climate change may make it worse, most floods are man-made and sanitation is to blame.

Plate 6: A Choked Drain with Plastic Waste on the Aboabo Stream

Source: Field Survey, 2011

4.5. Residential Behavioural Responses and Physical Outcomes

It is encouraging to report that many residents of the city are aware of the change in climate, with respect to extreme weather events and disasters such as floods. However, the link with global climate change is deficient. Government officials, such as those at the Metropolitan Development office are aware of climate change. However, so far, they have not integrated climate change adaptation within the city‟s master plan for infrastructure and in the formulation and implementation of various citywide policies and plans.

The risk to human settlements could be reduced if people and enterprises could be encouraged to move away from low elevations or at least from the most risk prone areas (McGranahan, 2005). Data from the field survey shows urban population movements in Kumasi are in the opposite direction. A factor assigned to such movement is the fact that land

prices and rent at such locations are cheap. Given the characteristics of Kumasi"s urban development, this is seeing more people moving to the urban fringes (cheap prices of lands) and marginalized lands because of economic pressure on prime lands (eg. Adum, Bantama etc), such trend is likely to continue.

4.6. Future Trends of Flooding: Kumasi's Vulnerability

In analysing data so far, the question arises as to whether the number of floods is increasing or will increase in the future. In looking at the trends in flood disasters in the metropolis, country and the world, such events is increasing and will increase. However, the difference in the case of Kumasi is that flooding will be more of as a result of human factors than climate change, though changing climate is likely to exacerbate it. This means that if current development continues in the Metropolis with no concrete action on reducing floods, Kumasi should brace itself for more flood related disasters.

4.7. Reducing Kumasi's Vulnerability to a Climate Change

Respondents suggested a number of activities that could be carried out to minimize the city"s vulnerability to climate change, both in terms of adaptation and mitigation:

i. In order to adapt to climate change, all natural system effects should be allowed to occur and human impacts minimized by adjusting human use of risk zone (Flood prone areas). In Ghana, as in many other low-income countries, adaptation is the immediate priority in response to climate change impacts.

ii. To mitigate against climate change impacts, natural system effects such as flood waters should be controlled by soft and hard engineering, reduce human impacts in the zone that would be affected without protection.

To achieve the above points, efforts that range from immediate actions, such as enforcing the existing legislation, to long term measures, such as coming up with development plans that take into account future climatic conditions should be pursued. There is also the need to create greater awareness and sensitization about climate change at the global level and its interaction

with local effects. This could be done through awareness campaigns, the print and audio-visual mass media, and the education system at schools, among other. This could play an instrumental role in enhancing understanding of climate change and its impacts and, possibly, motivate the generation of innovative ideas and feasible options for adaptation at local and city levels. Enforcing the

Planning Acts and city bye laws should ensure that areas earmarked for basic services such as water and sanitation are not interfered with, which could help to reduce flooding and the outbreak of water-borne diseases. In addition, construction, expansion and maintenance of drainage facilities in settlement with near-zero gradient and poor water seepage could significantly reduce prolonged flooding and its resultant side effects. Local residents must be made aware of, and sensitized to, the need to improve the management of the areas they inhabit, even more so because of climate variability and its attendant impacts such as increased rainfall and flooding.

The issue of absentee landlords poses danger to developing any concrete mitigation plans by tenants. Modifications to houses to make it more resilient are lacking as a result of the landlord not residing in these houses and complains from tenants are attended to with “heavy legs”.

Building standards that can accommodate future climatic conditions, such as high temperatures, humidity and flooding, should be promoted. For example, it would be useful to construct buildings with strong, unoccupied open spaces on the ground floor or with foundations; these could avert damage and loss of property and life during floods. In addition, buildings could be designed and constructed in ways that promote natural air circulation and cooling to reduce temperatures and high humidity indoors. It would be important to engage qualified architects to provide guidance in designing such buildings.

4.8. Summary

Kumasi is clearly vulnerable to floods and so are the inhabitants. An almost equal number of males and females (51.3% males and 48.7% females) are at risk from flood disaster in the study areas. What makes their situation dire is the fact that most of the people at risk are not indigenes and may not have easy access to social mechanisms which can alleviate their vulnerability (except their immediate community, which is also vulnerable). Though these floods are not as

direct result of climate change, climate change will play a vital role in the future to come. This calls for pragmatic and innovative plans to address them and the next chapter discusses it.

CHAPTER FIVE FINDINGS, SUMMARY AND CONCLUSION

5.0 Introduction

In this chapter, the study concludes the whole study by generalising important research findings based on the objectives set out in chapter one. The previous chapter presented data collected from the study areas and tried to understand the reasons for flooding and their implications for sustainable city. The general objective of this study was to examine the relationship between climate change and flooding and its effects on the urban poor and the findings have been articulated to present the research position on such matter as described above.

5.1. Findings

Based on the objectives set out in the beginning of the study, important observations made are outlined as follows:

5.1.1. Frequency of Flood Occurrence in the Kumasi Metropolis

It has been evidently presented that flooding in the Metropolis is an annual affair with varying frequencies across the Metropolis. Flooding occurs in all parts of the Metropolis but chronically limited to Susansu, Oforikrom, Atonsu, Aboabo, Anloga, Asafo, Asokwa and Bremang (K.M.A MTDP 2010-2013). Mensah-Bonsu et al (2011), also documented these areas in Kumasi Metropolitan Area as flood prone including the Central Business District (Kajetia, Central Markets and Asafo Market Area); Zongo Estate, Airport Roundabout;
Railway Quarters (Kumasi, Accra Rail); Yenyawso; Dichemso; Adukrom and TUCAdiembra (Kwadaso Basin). Whereas those documented by Mensah-Bonsu et al (2011) do not occur frequently in the rainy season, Susansu, Oforikrom, Atonsu, Aboabo, Anloga, Asafo, Adiembra and Bremang occurs every rainy season.

5.1.2. Nature and Causes of Flooding in Kumasi

Kumasi‟s flooding is as a result of two main factors. The first is overland flow because of intensified rainfall exceeding the infiltration capacity of the ground to absorb it or the drains to

carry it. While the former is because of development, increase in impervious surface area of the Metropolis, the latter is as a result of dumping of refuse, or waste into natural and artificial drains as it is the case of the study areas. Because the channel or drainage is blocked or restricted, excess water spills out from the channel onto adjacent low-lying areas (the floodplain).

As much as the study tried to relate the causes of floods in the Metropolis to changing climate patterns, the major cause identified for this phenomenon is human. Flooding in inhabitable areas is not an issue. However, when people choose to settle in areas liable to flood or modify their environment and make themselves susceptible to floods, then that is an issue. It presupposes that planning has done little to prevent people from putting themselves in "harm" way and people will always plan for themselves when institutions responsible for their welfare fails to do so.

Negative human activities in the metropolis in the form of dumping of refuse in drains causes localised flooding as shown to be the case for Aboabo, Atonsu and Oforikrom. These activities restrict movements and impinge the free flow of liquid waste and rain water in these drains. As a result, these drains are not serving their designed capacities and overflows causing mayhem.

Institutional hiatuses have contributed in part to this wretched situation because of lax enforcement of regulations of physical development in the Metropolis. It can be safely concluded that the statutory regulatory institutions have become more reactionary than proactive. This explains the low level of patronage of permits from the Assembly exhibited by the sampled household and the general disregard for building regulations and laws. As much as we can safely conclude their culpability, one must also understand the huge constraints with which they are working under. Their inability to raise adequate funds to support their activities is the major impediment, even as they collaborate to prevent and manage flood disasters. However, the existence of these institutions and their existing working relationship present an opportunity to pool their resources for better service delivery to the populace.

5.1.3. Impact of Flooding in the Kumasi Metropolis

Flooding in the Metropolis is responsible for disrupting socio-economic activities all the seven suburbs studied. Both infrastructures such as roads, electricity, water and housing and

livelihood activities are affected. It has been shown that roads are destroyed in the metropolis, electricity and water supply disrupted; houses affected or destroyed because of recurring floods. A few (22.9%) who could estimate their loss totalled at GH ₵10,650 for last year floods alone. Flood impacts have its toll on business, health, social lives and livelihoods. Flooding in the city is also responsible for the increasing incidence of malaria as shown in chapter four of this study.

5.1.4. Relationship between the Incidence Flooding and Climate Change in the City of Kumasi

According to Ahmad and Ahmed (2000), IPCC (2001a), NEST (2003), and Hengeveld et al. (2005), increasing temperature; increasing evapo-transpiration; increasing rainfall; increasing disruption in climatic patterns; and increasing frequencies and intensities of extreme event are used as indicators for measuring evidence of climate change in a region. The study compared available climatic data in the Metropolis over the years. Kumasi‟s temperature and rainfall data shows an increasing temperature and rainfall patterns since 1961 with variations for temperature of about 0.2°C above the mean for the last ten years (1990-2009), evidently an increment of about 0.4°C for the decade with fluctuations.

However, this increment does not represent a sharp increase in rainfall and temperature patterns for Kumasi. It must be understood from Figures 2 to 7 that Kumasi is experiencing climate change but those changes are not responsible for flooding in the Metropolis. Rainfall change patterns do not present a stronger argument in favour of climate change responsible for flooding. This is also supported from socio-economic data on Kumasi, which suggest strongly that Human factors such as sanitation measures and uncontrolled and physical development are responsible for flooding in Kumasi.

However, changing climate means we can no longer expect to keep water away from urban settlements. This dynamic leads to unpredictability in hazard, exposure and vulnerability and has often been overlooked by the traditional approach to the defence of urban areas (i.e. water has been directed away from urban settlements using hard-engineered defences often early on in the pathway near to the source of flooding). However, changing flood patterns resulting from climate change, increased intensity of rainfall is likely to ensure that such an approach will be less feasible in the future. Flash flooding and overtopping mean that the full complexity of flooding within an urban setting will need to be addressed.

5.1.5. Adaptation Measures and Capacities of Communities and City Authorities in Dealing with Flooding

People affected as demonstrated by respondents in the suburbs studied consciously plan for natural disasters. Through reinforcing walls of their buildings, using high tables or moving away during rains are all remedial actions by the people. However, and generally lacking is the Metropolitan Plan to prevent or mitigate floods and protects the people normally affected. The lack of plan does not invariably mean that there is no action by them. The Metropolitan Assembly‟s action have been limited to engineering and political actions which include drainage construction and widening of existing ones; and demolishing exercises carried out immediately after a flood disaster. There is no long term plan laid out in dealing with floods or the human factors that cause them.

5.2. Recommendations

After examining the existing situation and its derived problems, it is imperative to suggest workable solutions to improve conditions if not totally remove the problems for a resilient city. Nevertheless, considering the financial demands of implementation and the gestation period, short and long term recommendations have been made.

5.2.1. Long Term Actions

These strategies and programmes require enormous resources to undertake and results are not felt immediately, but serve as a basis to draw short term activities.

i. Among the recommendations is that Government must reclaim reservations through gradual acquisition of land or properties affected. In this way, we will be safeguarding lives, properties and the meagre budget of the assembly from disaster management cost.

ii. The agencies and department should be strengthened institutionally, through employment, adequate remuneration and retention of sensitive staff. This can be

complemented by providing the necessary equipment and logistics required for effective and efficient operation of the institutions.

iii. The KMA, through its Disaster Management Sub-committee should in corporate disaster planning in plan preparation and implementation to make the metropolis resilient and adequately respond and absorb the shocks of flood disasters in the wake of increasing occurrence of disasters in cities.

5.2.2. Short Tem Actions

In achieving the long term goals ascribed above, these short term actions will invariably help in achieving the overall aims of a sustainable city.

i. Efforts that range from immediate actions, such as enforcing the existing legislation, to long term measures, such as coming up with development plans that take into account future climatic conditions. There is also the need to create greater awareness and sensitization about climate change at the global level and its interaction with local effects. This could be done through awareness campaigns, the print and audio-visual mass media, and the education system at schools, among other. This could play an instrumental role in enhancing understanding of climate change and its impacts and, possibly, motivate the generation of innovative ideas and feasible options for adaptation at local and city levels.

ii. Planning Acts and City Bye Laws should ensure that areas earmarked for basic services such as water and sanitation are not interfered with, which could help to reduce flooding and the outbreak of water-borne diseases. In addition, construction, expansion and maintenance of drainage facilities in settlement with near-zero gradient and poor water seepage could significantly reduce prolonged flooding and its resultant side effects. Local residents must be made aware of, and sensitized to, the need to improve the management of the areas they inhabit, even more so because of climate variability and its attendant impacts such as increased rainfall and flooding.

iii. The issue of absentee landlords poses danger to developing any concrete mitigation plans by tenants. Modifications to houses to make it more resilient are lacking as a

result of the landlord not residing in these houses and complains from tenants are attended to with “heavy legs”.

iv. Building standards that can accommodate future climatic conditions, such as high temperatures, humidity and flooding, should be promoted. For example, it would be useful to construct buildings with strong, unoccupied open spaces on the ground floor or with foundations; these could avert damage and loss of property and life during floods. In addition, buildings could be designed and constructed in ways that promote natural air circulation and cooling to reduce temperatures and high humidity indoors. It would be important to engage qualified architects to provide guidance in designing such buildings.

Implementing many of these changes/recommendations requires support from the various government departments, civil society organizations (including NGOs) and the public, in general. This will only be achieved if people are made aware of, and understand the need for, such action now rather than continue with business as usual. This is because effective and timely early warning systems are needed to deal with climate related disasters. There is a need for the Metropolitan Assembly to work with meteorological departments, relevant government ministries and other stakeholders to facilitate coordinated efforts.

Enforcement of city bylaws to ensure that people only construct buildings in safer and approved areas far from the flood prone zones and low elevations, and avoid sewage lines and drainage. etc. should be ensured. This will also reduce the risk of flooding and piped water contamination.

The government should resolve problems of landlessness and absentee landlords in the city by repossessing land by purchasing legally acquired land from absentee landlords, and subdividing and allocating this land to the poor equitably. This would enable security of land tenure and encourage people to follow guidelines and build houses according to set standards. To implement the recommendations above, appropriate capacity, both at the individual and institutional levels, and enforceable regulations and economic incentives are required. These depend upon political will, funding and human capital.

5.3. Conclusion

The Kumasi Metropolis is a complex system with interacting related activities, which ensures the development of its constituents and demands to be managed to reap its full benefits. Failure to effectively manage the system leads to entrenchment of inefficiencies, poor service, high living costs, falling standards of living and deepening of poverty. The problem of the urban economy are often hydra-headed and requires the collaboration of all stakeholders, not only in discussing but pooling of human and material resources to reinforce each other in finding a lasting solution. Individually, it appears the residents of the Kumasi Metropolis, the institutions and the private sector are powerless against the floods, often negating the gains made by each other and allowing the phenomenon to go on, amidst much suffering. It is important therefore to tackle urban flooding with zeal to extricate the urban populace from the undesirable effects and ultimate impact of flooding (disrupting social and economic activities) firstly by prevention and risk minimisation and finally by preparing for the once in fifty years and once in a hundred years floods that can hardly be forecasted. To conclude, it must be noted that flood management cannot be neglected, considering the fact even elaborate defences are susceptible to breach.

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APPENDICES

APPENDIX 1

Temperature and Rainfall Distribution for Kumasi from 1961 - 2009

	Temperature				Rain					
	Hot Season (February and March)		Cold Season (July and August)		Major Rainy Season(Apr, May & Jun)		Minor Rainy Season (Sept & Oct)		Dry Season (Dec, Jan & Feb)	
Year	HTmax [°C]	HTmin [°C]	CTmax [°C]	CTmin [°C]	Total [mm]	Mean [mm]	Total [mm]	Mean [mm]	Total [mm]	Mean [mm]
1961	34.0	21.3	26.6	20.6	515.20	171.7	250.00	125.1	66.3	22.1
1962	32.6	21.2	27.4	21	857.70	285.9	195.00	97.3	109.7	36.6
1963	31.8	21.5	28.5	21.8	603.00	201.0	566.00	283.2	183.6	61.2
1964	33.0	21.4	26.9	20.5	579.70	193.2	240.00	119.8	133.4	44.5
1965	31.9	21.4	27.4	21	523.50	174.5	443.00	221.7	130.1	43.4
1966	32.5	21.5	27.8	21.3	791.00	263.7	263.00	131.6	125.2	41.7
1967	32.6	21.5	27	20.7	542.90	181.0	239.00	119.5	143.2	47.7
1968	31.8	21.6	28.2	21.5	750.60	250.2	482.00	240.8	178.1	59.4
1969	33.1	22.3	27.2	21.1	557.80	185.9	295.00	147.7	44.5	14.8
1970	32.5	22.5	27.6	21.1	467.20	155.7	329.00	164.6	51.6	17.2
1971	32.5	22.0	27.6	20.8	325.40	108.5	355.00	182.6	88.6	29.5
1972	32.3	21.7	27.6	21	609.80	203.3	394.00	197.0	190.2	63.4
1973	33.8	22.5	28.6	21.4	346.70	115.6	372.00	186.1	109.9	36.6
1974	33.2	22.0	28.2	21.1	526.60	175.5	248.00	124.0	61.3	20.4
1975	32.8	21.8	27.5	20.8	522.30	174.1	386.00	192.9	127	42.3
1976	32.6	21.7	27.4	20.6	607.20	202.4	219.00	109.4	91.3	30.4
1977	33.6	22.6	27.5	20.9	414.90	138.3	355.00	177.7	50.1	16.7

1978	32.9	22.3	27.8	20.7	578.20	192.7	428.00	213.8	176.8	58.9
1979	33.7	22.8	28.4	21.7	361.90	120.6	435.00	217.5	61.5	20.5

1980	32.6	22.5	28.1	21.5	460.30	153.4	288.00	144.1	127.6	42.5
1981	33.2	22.7	27.5	20.7	461.50	153.8	246.00	122.9	54.1	18
1982	33.8	22.2	27.4	20.8	356.20	118.7	197.00	98.4	143.6	47.9
1983	35.2	23.2	28.3	21	457.90	152.6	138.00	69.0	139.4	46.5
1984	34.5	24.1	29.1	21.5	392.90	131.0	354.00	176.8	10.2	3.4
1985	33.5	22.2	28.6	21.2	431.30	143.8	303.00	151.3	64	21.3
1986	33.1	22.3	27.8	21.1	493.50	164.5	285.00	142.4	132.1	44
1987	33.5	22.6	29.2	21.9	463.20	154.4	263.00	131.6	84.2	28.1
1988	34.2	23.3	28	21.3	588.10	196.0	322.00	161.0	88.9	29.6
1989	34.3	22.2	28.9	21.6	513.80	171.3	468.00	233.8	64.2	21.4
1990	34.8	22.4	28.2	21.5	440.80	146.9	297.00	148.3	188.3	62.8
1991	33.5	23.0	28.7	21.8	612.00	204.0	266.00	132.9	138.8	46.3
1992	35.0	23.4	27.3	21	435.80	145.3	362.00	181.0	16.2	5.4
1993	33.7	22.5	27.8	21.6	631.60	210.5	425.00	212.6	81.8	27.3
1994	34.4	23.1	28.4	21.7	519.90	173.3	355.00	167.6	7.3	2.4
1995	34.9	23.1	28.9	21.4	529.70	176.6	235.00	117.3	116.3	38.8
1996	32.8	22.9	28.7	21.8	363.50	121.2	154.00	77.2	135.8	45.3
1997	34.2	22.9	28.2	21.3	765.70	255.2	259.00	129.3	98	32.7
1998	35.1	23.9	28.4	21.7	639.40	213.1	151.00	75.6	110.1	36.7
1999	33.4	22.6	29.1	21.6	536.60	178.9	340.00	169.8	87.2	29.1
2000	34.9	22.5	28.3	21	748.00	249.3	264.00	132.0	69.6	23.2
2001	34.7	22.4	28.3	21.6	419.40	139.8	330.00	164.9	39.9	13.3
2002	34.8	23.5	28.6	21	709.00	236.3	443.00	221.3	14.6	4.9
2003	34.3	23.6	28.7	21	572.90	191.0	280.00	139.8	138.3	46.1
2004	33.5	23.1	27.9	21.4	214.10	71.4	476.00	238.0	173.1	57.7
2005	33.6	23.1	27.6	20.6	539.80	179.9	411.00	205.5	91.2	30.4

2006	32.6	22.8	29.3	21.6	399.60	133.2	270.00	134.9	213.2	71.1
2007	34.8	22.5	29.1	22.1	651.10	217.0	688.00	344.2	36.4	12.1
2008	34.7	23.0	29.2	22.2	658.3	219.4	246.00	122.9	108.5	36.2
2009	33.5	23.2	28.6	21.7	681.1	227.0	238.00	119.0	164.8	54.9

APPENDIX 2
CALCULATING SAMPLE POPULATION

Area/year	1948 – 1960	1960 – 1970	1970 – 1984	1984 – 2000	*2000 – 2006
Kumasi	7.9	4.5	2.5	5.2	5.4

Growth Rate – 5.4% = 0.054

$Pt = Po e^{rt}$ e = 2.718, r = 0.054, t = 12

$e^{rt} = 1.92$ $^{rt} = 0.68$

$$r = \frac{log Pt - log Po}{t log e}$$

Areas	2000 Pop	2012 Pop (Projected)	AV HH Size	No of Houses
Oforikrom	38155	72952	5.0	14590
Atonsu	45778	87528	4.7	18622
Aboabo	34206	65402	5.2	12577
Asafo	18457	35290	4.6	7672
Adiembra	3666	7009	5.8	1208
Bremang	41956	80220	4.6	17439
Dichemso	21281	40689	5.1	7978
Total				80086

APPENDIX 3

SURVEY INSTRUMENT FOR HOUSEHOLDS

Preamble

This Research Instrument is designed to seek relevant primary data for the conduct of the above academic exercise. Your support and co-operation is very much anticipated and please be assured that your responses will be treated with utmost confidentiality.

Name of Interviewer:

Community: ……..

Name of Respondent: ….....

Status of Respondent (In the Household): .....

Date of Interview: .....

Demographic Data

1. Educational Level None
   - Primary
   - JHS
   - SHS
   - Tertiary

2. Age
   - ……

3. Gender
   - Male
   - Female

4. Place of Former Residence
   - ……..

5. Reasons for moving to current location?

……

……

6. Location of House? (Observe distance from natural drainage)

   ……

7. Type of Building Materials used in Building

   □ Sandcrete

   □ Landcrete

   □ Adobe

   □ Other (specify)…….

8. Have the building been maintained before?

   □ Yes

   □ No

9. Where on the building was the maintenance carried out?

   □ On wall

   □ Columns

   □ Foundation

   □ Roof

   □ Drains around the Building

10. Average Monthly Income

    □ ……

Extreme or Unusual Weather Events

11. Have you recently experienced any extreme/unusual weather events for example, storms, and floods?

    □ Yes

    □ No (Go to Q 19)

    □ don't know/can't remember

12. . If "yes", please describe the most recent significant event:

When did it happen? .....

……

What happened? .....

……

13. How much was lost to such event? ₵……..

14. How are you able to recover from such events?

- Insurance
- Savings
- Donations

15. Do you receive assistance from any state institutions?

- Yes (specify)……
- No

16. Do you receive any early warnings before such events starts in Kumasi?

- Yes
- No

17. If yes, please indicate your source? ……..

18. What is the possible reason for the annual flooding in your area?

- Poor Environmental Practices
- Unprecedented Population Growth and migration
- Poor settlement planning

Climate Change Knowledge

19. Have you noticed any changes in your environment over the past 10-20 years?

- Yes
- No

If yes (see specific questions below),

If Interviewee is not sure, interviewer needs to elaborate.

20. If "yes", can you tell me what changes you have noticed in the RAINFALL?

- No change
- Less rain
- More rain
- Rainy Season Erratic
- Other (specify)…….

21. If "yes" can you tell me what changes you have noticed in the TEMPERATURE?

- No change
- Hotter
- Cooler
- Other (specify)…….

22. If "yes", can you tell me what changes you have noticed in the WIND?

- No Change
- Stronger
- Weaker
- Winds from different direction so usual
- Other (specify)…….

Adaptation to Climate Change Short & Longer Term

Note: To be read by Interviewer

"Adaptation means doing something NEW or DIFFERENT to what you or your community did in the past in order to adapt to climate change"

23. What have you done ALREADY to adapt to climate change?

- Have reinforced the building
- Planted trees and bushes around the house
- Stopped littering around and in drains
- Other (specify)…….

24. Have you already planned to do any of these things in the FUTURE to adapt to climate change?

- Move from present location
- Make building more flood proof

 Other (specify)…….

25. If necessary, in the long term, would you be prepared to move with your family to?

 A place less flood prone

 Another city

 Not sure

 Other (specify)……

APPENDIX 4

SURVEY INSTRUMENT FOR NATIONAL DISASTER MANAGEMENT ORGANIZATION

Introduction

Climate change is a reality. In its latest assessment report, the Intergovernmental Panel on Climate Change (IPCC) concluded that the global climate is in fact changing, and this change will affect the hydrological cycle and thus rainfall intensity and unpredictability. Adaptation to a certain degree of climate change is therefore inevitable. IPCC stresses that the impacts are locally specific. The level of specificity of knowledge at the local level is limited, however, and thus global knowledge needs to be downscaled.

The thesis will look at the relationship between climate change and flooding and provide local data needed to prepare adaptation plans for a resilient city. This work will be targeted to support in particular cooperation and decision-making in mitigating the perennial floods that plagues the city and serve as a step in developing a Flood Prevention programme for the city. The work will address the possible impacts of climate change on flood, with its consequence on local economy, livelihood and health.

The aims of this questionnaire The aims of this questionnaire are:

- To collect information on the degree of awareness concerning the issue of climate change impacts on flooding in Kumasi;
- To assess the City‟s vulnerability to flooding;
- To compile potential adaptation measures and strategies as well as information on implementation experiences in The Metropolis.

Why should you answer the questionnaire?

By answering this questionnaire, you will:

- Ensure that the particular concerns of your department are adequately considered in the report;
- Contribute to a comprehensive appraisal of potential climate change impacts and flooding management adaptation strategies in the Kumasi metropolis.

1. Type of flooding experienced in Kumasi?
   ……

2. Please outline the extent of damage of flooding in the city
   (Please specify on map areas reportedly flood prone and infrastructure types affected).

……
……

3. Please outline important dates of flooding in Kumasi and extent of damage.

Date	Location in Kumasi	Extent of Damage

4. Which areas in Kumasi are vulnerable to flooding? Please classify according to severity?

Location	Severity		Reason for Vulnerability
	High	Low	

5. Is flooding an important policy issue in the Metropolis?
   - Yes
   - No

6. If yes, what are the policies in place to address flooding in Kumasi?
   .....
   .....
   .
7. Is new policy and legislation being prepared to manage flood?
   - Yes

 No

8. Is flooding issues related with climatic change in the Metropolis?
    Yes. (Explain) …….....
    …….

    No. (Explain) …….....
    …….

9. Is there an orientation towards space for water or towards more green development?
    Yes
    No

10. What kind of measures, apart from technical measures is being adopted for flood management?
    Reservoirs are being adapted for flood management?
    Retention in the catchment (forests, flood meadows, meandering brooks)
    Retention in urban areas (decreasing impervious areas, decoupling roofs)
    Retention along rivers (storage areas for flood water)
    Floodplain restoration (removing obstacles, (re)introducing river channels, setback)

11. Are these measures combined with other objectives, such as nature restoration, recreation, new housing areas, landscape reconstruction?
    Yes
    No

12. Is hazard zoning part of national, regional and local plans? Yes
    No 13. If yes, is it obligatory?
    ……..
……
……..

14. What categories of zones are used? (Please specify each zone conditions and requirement).
    ……
    ……

15. Is flood damage compensated by the state or metropolitan Assembly?
    Yes
    No

16. Is commercial insurance against flood damage available?

- Yes
- No

17. What incentives are available for preventing flood damage?
    ……
    ……
18. What are the roles of planning procedures in mitigating flooding the city?
    ……
    ……

APPENDIX 5

SURVEY INSTRUMENT FOR CITY ENGINEERING DEPARTMENT

1. Do you consider climate change is present in the Kumasi Metropolis?
   - Yes
   - No

2. How is the climate of the city different now compared to 10 years ago?

……
……

3. Is climate change given the necessary conditions in city planning and management?

……
……

4. Which are the areas and activities most affected by climate change in Kumasi?

……
……

5. Is climate change adaptation part of your program? If yes, how?

……
……

6. Which policies, strategies, and or projects were successful for climate change adaptation? Which ones were not?

……
……

7. Who is responsible for flood management in the Metropolis?
   - NADMO
   - AESL
   - PWD
   - Others (Specify) …….

8. What kind of measures, apart from technical measures is being adopted for flood management?
   - Reservoirs are being adapted for flood management?
   - Retention in the catchment (forests, flood meadows, meandering brooks)
   - Retention in urban areas (decreasing impervious areas, decoupling roofs)
   - Retention along rivers (storage areas for flood water)
   - Floodplain restoration (removing obstacles, (re)introducing river channels, setback)

9. Which areas in Kumasi are vulnerable to flooding? Please classify according to severity?

Location	Severity		Reason for Vulnerability
	High	Low	