RISK FACTORS, EFFECTS AND MANAGEMENT OF FLOOD IN THE ASHAIMANN MUNICIPALITY OF THE GREATER ACCRA REGION

BY

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DECLARATION

I declare that the information written represent my ideas in my own words except where due reference is made to the original source. I have adhered to the principles of academic honesty and integrity.

I further declare that the thesis has not previously formed the basis for the award of any Diploma, Degree or other similar Titles of recognition.

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DEDICATION

The study is wholeheartedly dedicated to the Almighty God for his guidance, strength, protection, power of mind and good health.

To my beloved parents for the source of inspiration and who continually provided moral, spiritual and emotional support.

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ABBREVIATIONS

ARC GIS-	Geographic Information System
ASTER GDEM-	ASTER Global Digital Elevation Map
DEM-	Digital Elevation Model
DRR -	Disaster Risk Reduction
EM-Dat	Emergency Events Database
ENVI-	Environment
EPA	Environment Protection Agency
GAMA -	Greater Accra Metropolitan Assembly
GIS -	Geographic Information System
GMet -	Ghana Meteorological Agency
GPHC -	Ghana Population and Housing Census
GPS-	Global Positioning System
GSGDA -	Ghana Shared Growth Development Agenda
GSS -	Ghana Statistical Service
IFRI -	International Forensic Research Institute
IIED -	International Institute of Environment and Development
ILWIS -	The Integrated Land and Water Information System
NADMO -	National Disaster Management Organization
NGOs –	Non-Governmental Organizations
RMSE-	Root Mean Square Error
UTM-	Universal Transverse Mercator
VNIR-	Visible and Near-Infrared

ABSTRACT

Flooding is a perennial problem in most parts of Accra for many years resulting in loss of lives and properties. Ashaiman is one of such areas within the Metropolis that record pockets of flood annually. Some flood prone areas in Ghana such as the Odo Basin have received major flood management interventions from the Government to mitigate the floods and its effects; others are yet to receive the required attention. This research sought to analyse the risk factors for flooding, its effect and the possible management of flood within the Ashaiman Municipality in order to attract the necessary intervention. A Remote Sensing Images, Ariel view and rainfall pattern analysis of the flood prone areas of the municipality was conducted. A survey among the residents of the Ashaiman municipality was also conducted to capture their views on flooding. Face to face interviews were conducted with key Officials that are involved with flood and flood management to identify the main risk factors of flooding, effects and the flood control measures in the Municipality.

The research found that the Ashaiman Municipality is a low land with a high-water table. It is also a natural waterway therefore prone to flooding. Anthropological activities such as massive development and haphazard settlement have contributed and exacerbated the issue of flooding in the area. Some effects of flood within the Ashaiman Municipality include; increased tropical diseases such as malaria, typhoid and in extreme cases diarrhoeal diseases during flood seasons. Drowning, deaths and loss of physical properties are also recorded during flooding. As control measures, research it is recommended that structural and non-structural interventions to mitigate the flood and its effects, the Drains need regular maintenance and management by the Hydrological Services Department in conjunction with the Municipality to de-silt and dredge the major drains.

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Flooding, though a natural phenomenon which should not result in major problems has become a worldwide issue with Ghana being no exception and this is often due to the increasing concentration of human population and increasing scale of economic activities around river basins and water ways. Flooding is a common environmental disaster after diseases and accidents (Jonkman, 2005). Bubeck, Otto & Weichselgartner (2017) defined flooding as a natural hazard which displaces people by destroying their land, houses and other tangible goods and in many cases claiming human lives. Flooding is often considered to happen due to heavy rainfall however, it can occur due to a number of ways which may not be directly related to ongoing weather events. Hence, a comprehensive definition of flooding must include processes which may have nothing or little to do with meteorological events (Doswell III,2003).

In England 2007, the summer floods resulted in loss of lives and major impacts on the health and wellbeing of people living and working in the areas affected was estimated to cost more than £3.2billion. In November 2019, France, Italy and Greece also experienced one of the deadly flood incidents (Diakakis, Andreadakis, Nikolopoulos, Spyrou, Gogou, Deligiannakis, & Tsaprouni, 2019). In 2007, countries in West Africa experienced a kind of most awful flood which has not occurred in thirty years, as reported by the United Nations Regional Coordinator (2007) which affected almost half of all West African countries resulting in the total death to more than three hundred and fifty (350) people with a further hundreds of thousands of inhabitants being displaced (Agence France-press, 2007). Ghana in that very year, 2007 experienced floods which affected about three hundred and fifty thousand (350,000) people with Forty-Nine (49) casualties in the Northern parts of the country alone causing an estimated damage of over one hundred and thirty (130) million United States Dollars (US$), not including long term losses (EPA. 2012).

Again, in June 3rd 2015, Accra, Ghana's capital experienced an unprecedented flash flood event, coupled with an explosion at Ghana oil (GOIL) filling station that resulted in a death of over one hundred and fifty-two (152) lives at Circle, a suburb of Accra (Asumadu-Sarkodie, Owusu & Rufangura, 2015). It was the tenth flood that had slammed Accra with several experts arguing that the flood was caused by poor waste management, poor structural settlement, and poor hydraulic performance of the basins in Accra. The Greater Accra Region, which capital being Accra and encompasses the Ashaiman municipality however, has experienced periodic floods for a long time. Between 1955 and 1997, about three hundred (GH¢300) billion worth of properties were destroyed, with over a hundred (100) lives being lost either during the flood period or after the floods and a further ten thousand (10,000) people being displaced from their homes (Gyan –Boakye, 1997).

Flood risk is differentiated from the classic risk definition because the hazard which causes it though related to the probability of an occurrence of a heavy rainfall, is materialized by the ensuing flood resulting from the contribution factors of both the rainfall and the basin. flood risk management, therefore can be modify the hazard through structural measures that aim to control and mitigate floods (UNESCO, 2013).

Currently, the global population at risk from flooding is about 1.2 billion and it is projected that an estimated 20 percent more will be exposed to flooding by 2050 (WWAP/UN-Water, 2018). Laid before the English parliament in 2011, it was reported that between 2005 and 2009 flooding in Cumbria and the widespread England summer flooding in 2007 resulted in loss of lives and major impacts on the health and wellbeing of people living and working in the affected community. And in Ghana, annual records indicate that between 2001 to 2015, there were about 13 major floods which affected over 178,000 people, causing 250 fatalities, (Asumadu-Sarkodie et al., 2015).

1.2 Problem Statement

At the global level, the devastating effect of flood is evident everywhere. Annual data shows that flood claims twenty thousand (20,000) lives and adversely affects twenty (20) million victims worldwide (EPA, 2011). Ghana records annual tragedy, injuries, deaths and loss of property particularly in the Greater Accra Region including the Ashaiman municipality. Irrespective of the many suggested solutions in mitigating these floods, Ghana still experiences flood challenges almost every year. Flood is the second most common national disasters in Ghana, occurring about eighteen (18) times in the last 5 decades and has killed over four hundred (400) people (Asumadu-Sarkodie et al., 2015). Furthermore, an estimated 3.88 million people have reported affected damages worth over one Hundred and Eight (108) million dollars. These facts highlight how urban flooding has become an undeniably growing challenge to development in Ghana.

Accra in recent times has seen continual erection of concrete structures by individuals and private estate developers on waterways with national statistics indicating that between 1955 and 1997, about three hundred billion GHS (GHS300,000,000,000) worth of properties were destroyed, hundred (100) lives lost either during the flood period or after the floods and 10,000 people were displaced from their homes (Gyau-Boakye, 1997; Adinku, 1994). This caused for the setup of some statutory supervisory agencies such as the Ministry of Works and Housing, City Engineers of Accra Metropolitan Assembly and Lands Department by the government of Ghana to control and manage the reduction of flood and their effects on life and properties (NEDECO, 1962, 1967; WATERTECH, 1991; NADMO).

Consequently, it was expected that the activities of these government statutory supervisory bodies will help manage or mitigate flood by identifying the potential risk factors and flood prone areas, developing strategies, enforcing rules and regulations on constructions. Though some work has been done it seems woefully inadequate and this account for the reason Ghana still records serious floods and their dangerous effects. Therefore, there is a need to explore new approaches at identifying the flood risk factors and implementing measures that will help in managing the problem. It is however evident from literature that more flooding should be expected due to climatic changes and variability as well as the population increase and growth in human settlement (Ahadzie, 2011; Okyere, Yacouba & Gilgenbach, 2013).

The Ashaiman municipal area has been experiencing pockets of flood almost every year since early 1990s when massive development started in the area. That notwithstanding there has been phenomenal flood events in the area since the year 2010 with loss of human lives and domestic animals coupled with massive destruction to property and even farm lands. After all the literature reviews done, no research has been done on the flood situation in Ashaiman which forms the rationale for this research. Due to several human and domestic animal deaths and illness, the destruction of properties and the influence of flooding on the quality of social and economic life of the people living in the Ashaiman municipality over the past twenty (20) years, this research is aimed at finding out the risk factors associated with the development of flooding in the municipality, the various effects of these floods and how to possibly manage these floods in the area so as to restore and improve the quality of life to the residents in the area.

It is therefore necessary to explore new ideas and approaches that can be incorporated to existing structures to manage this problem (Asumadu-Sarkodie et al., 2016). To conduct a cross-sectional study among a sample of people (young and old) within the Ashaiman municipality and assay expert advice so as to describe the causes, effects and possible solution of the flood in the municipality.

1.3 Significant of Study

The study will be of several benefits to the community, the government and academia. For the community, this study by exploring the perception of community will help the community better understand and appreciate the risk factors of floods and be better prepared for future flood events. For government, community leaders and other stakeholders, results and recommendations from this study will provide vital information for dealing and effectively managing flood and its effects in the society. And finally, for academia, this study will contribute to the literature on flooding in Accra and Ashaiman to be specific as well as provide directions for future studies.

1.4 Conceptual Framework

Flooding in most communities in Ghana is normally due to human activity and structural developments the Ashaiman municipality is no exception. The following risk factors can be considered attributable concepts or hypothesis for the flood situation in the municipality and other regions in Ghana. Increasing urbanization and its related activities such as construction of residential buildings and paved roads have impacted negatively on the drainage systems in the Greater Accra Region. Also, disregard for building regulations has led many settlements in the region to be built in the Green Belt (buffer zones), causing depletion of vegetation and making these areas more prone to erosion and flooding. Furthermore, most buildings in some parts of Accra are wrongly situated close to river bodies and drains or even across natural waterways which increase the risk of flooding of these settlements.

According to NADMO, the landscape of Accra is generally low-lying and this also makes the city prone to severe perennial flooding. The smaller sizes of culverts coupled with the clogging of the major drains from the accumulation of silt and rubbish due to years of neglect and lack of maintenance causes flooding in most areas. Improper waste management practices are another trigger of flooding in most areas. This is because the volume of solid waste in the form of silt or rubbish, non-biodegradable materials particularly plastics, cannot be collected by existing systems. Also, the unprecedented urbanization has culminated into a lot of pressure on public sanitary facilities. Additionally, some people in most parts of Accra and other cities dump solid waste directly into drainage facilities such as culverts and drains with a typical example being the drains at the Korle Lagoon which are often blocked with refuse and silt resulting in reduced capacity of the flow of water through them. Major rivers and their tributaries in Accra are a depot of domestic and industrial liquid waste as well as solid waste including faecal matter which poses a serious concern to public health.

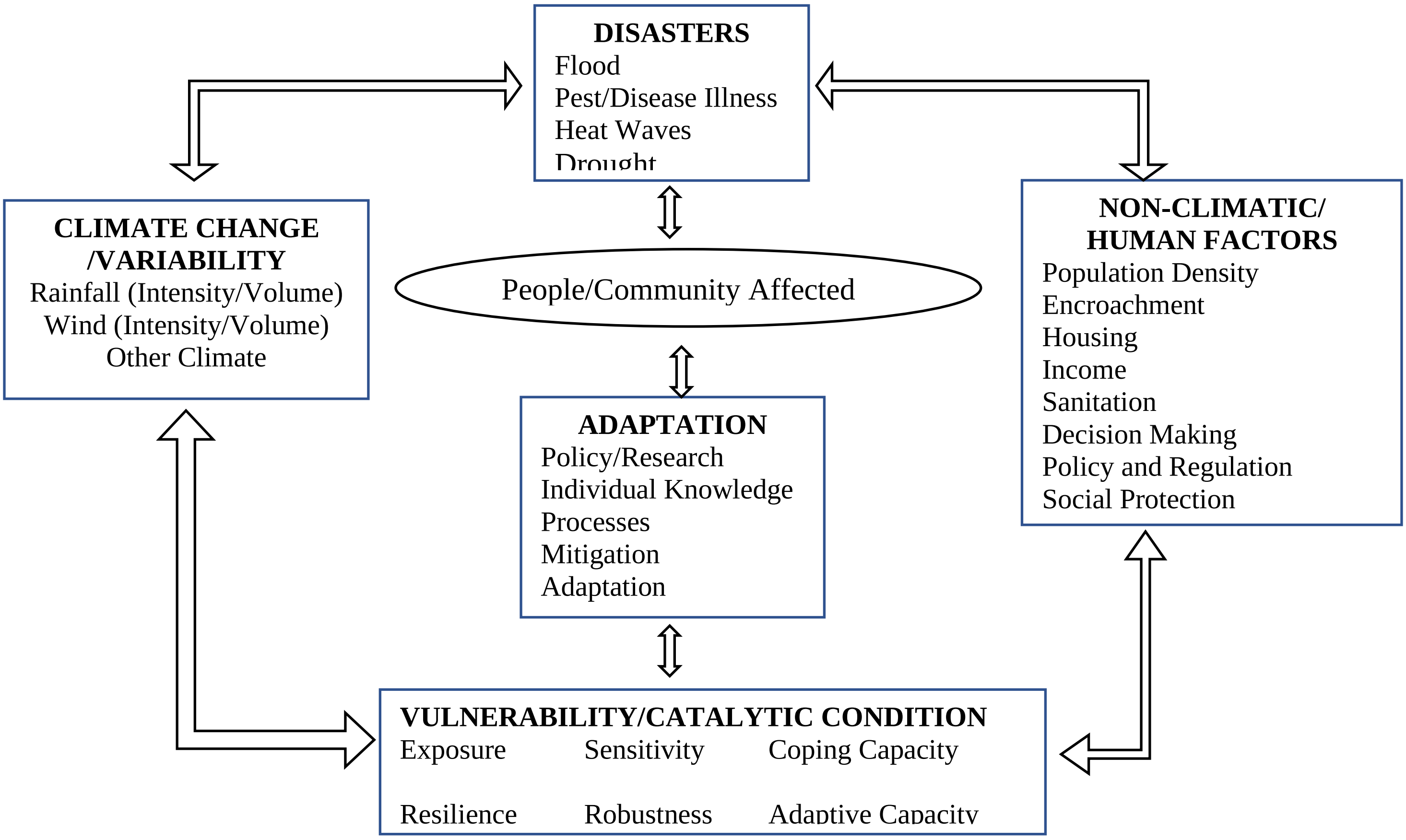


Figure 1.1 Conceptual Frame Work on Flood Disaster, Causes and Adaption
Source: Adapted and modified from Macchi, 2011

1.5 Research Questions

The following research questions were asked in order to explore and understanding the effects of flooding in the Ashaiman community.

1. How often do floods occur in the Ashaiman Municipality?
2. What are the various risk factors of flood in the Ashaiman municipal area?
3. What are the various effects of flood in the Ashaiman Municipality?
4. What possible measures can be applied in managing flood in the Municipality?

1.6 Research Objectives

The general objective of this research is to explore the nature of floods and to determine the various risk factors contributing to flooding in the Ashaiman municipality, the effects of flooding in the area and the possible solutions to the flooding menace in the municipality.

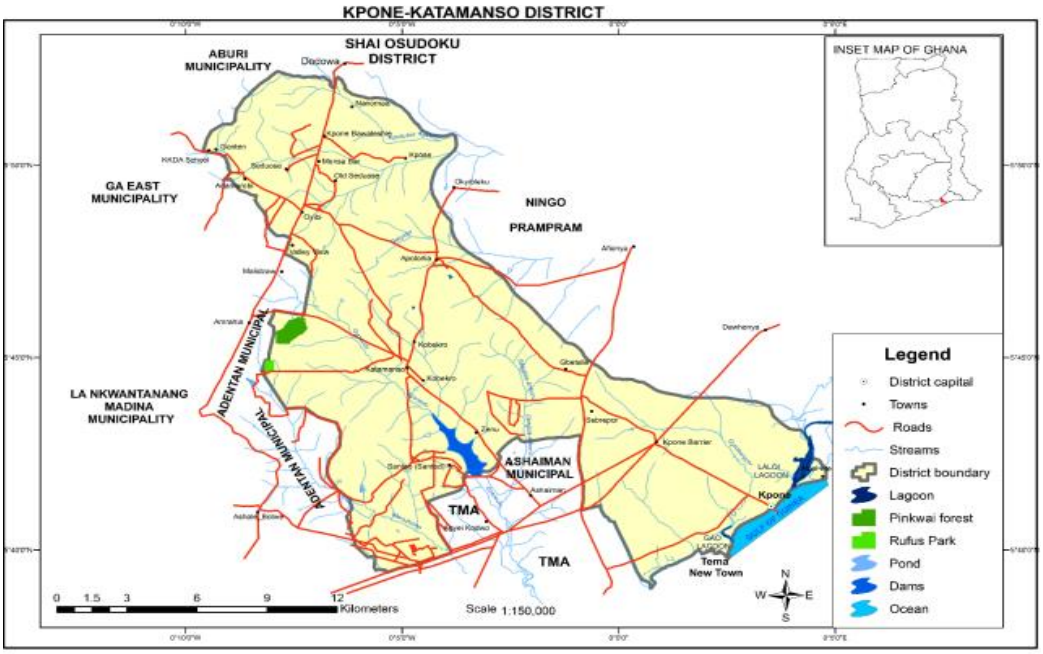
1.7 Specific Objectives

The following specific objectives of the research is listed below;

1. To explore the flood-prone areas in the Ashaiman Municipality with a mechanical Drone and also to examine the various reasons why these areas are flood prone areas.
2. To use 60-year historical rainfall data to assess the trend of rainfall pattern in the Ashaiman catchment area.
3. To compute (2-year, 5-year, 10-year, 20-year, 25-year, 50-year, 100-year, 200-year, 500-year, 1000-year) flood return period of the Ashaiman catchment areas.
4. To determine the water bodies (rivers, lakes, lagoons) and their borders in the municipality. How the waters are contained during heavy rains, and how far the waters overflow its banks during heavy downpours.
5. To determine the extent of flooding in the Ashaiman catchment area during heavy rains. The level of water measured in meters during heavy or low downpour and the coverage of the water in terms of spread in the area and compute flood-depth-damage function of different land use types in the catchment area.
6. To sample the perception of the residents of Ashaiman on the risk factors, the effects and possible management of flooding in the area.
7. To interview experts concerned with flood and flood control; the risk factors, effects and management of flood.

1.8 Profile of Study Area

This chapter presents the physical characteristics including location, relief and drainage, climate and vegetation, the population dynamics, the economic features, as well as governance systems in Ashaiman. These provide enough background information of the research location to facilitate smooth transition to the analysis of the results of the survey, with the intent of achieving the objectives of the study.



Map 1.1 Map of Kpone Katamanso Area Including the Ashaiman Municipality

Ashaiman is located in the Greater Accra Region and the capital of the newly created Ashaiman Municipal Assembly. It is located about 30km from Accra and about four kilometres to the from Tema. It shares boundaries to the East with Katamanso Traditional Area, on the South with the Tema Township and on the West with Adjei Kojo. It is a sprawling “urban settlement” most parts of which exhibit characteristics of a slum. From the 2010 Population and Housing Census Report, the population of Ashaiman is 190,754 with a growth rate of 2.1%. The population of the municipality has 31.9% being youthful (0-14 years), highlighting a larger base population pyramid and tapers off with 2.4% elderly persons. Males make up 49.1 percent with females representing a majority 50.9 %.

Currently, Ashaiman is home to people from several ethnic groups with an estimated fifty (50) plus different ethnic groups. In terms of the formal education, literate males make up 51.5% which higher than females of 48.5%. Again, 43.1% of the literates indicated the ability to speak and write both English and some Ghanaian language. Also, 75.1% of the population aged 15 years and older are economically engaged with the remaining 24.9% being unemployed. Males constitutes the highest portion of each employment category except for self-employed.

The municipality has a household population of 185,804 with a total number of 49,936 households with an average household size of is 3.7 persons per household. The main construction material for outer walls of household is cement/concrete for 76.7 percent with 20.3 percent for wooden outer walls. The majority of households in the municipality rely on national grid for is electricity and the national water supply for pipe borne water. Sixty- three percent (63.5%) of all households in the municipality result to the use of public toilet with four percent (4%) having no access to toilet facility and nearly two-fifth (38.5%) sharing bathrooms in the same house. Most households (62.6 %) have their solid waste collected by waste collectors or the trashmen with the remaining 27.4% of households having their solid waste disposed of at the public dump containers.

The relief of Ashaiman is generally flat and forms part of the Accra-Togo plains hence, experiences a climatic condition that extends from the east coast of Ghana into Togo. however, there are isolated hills in the general area but even these barely reach 65m high (www.ghanadistricts.com). Rainfall in this area ranges from 730mm-790mm. The major raining season starts from April to July and September to November forms the minor season. One of the main streams in the community is the Gbemi Stream, and it flows through localities such as Lebanon, Jericho, and Roman Down. There are well engineered drain systems along major roads in the town however several of them are clogged. the residential units have very poor drainage which are not well-engineered. Temperatures are high throughout the year with temperatures reaching 32ºc during the day and 27ºc at night. The temperatures are much cooler from May-September with a high of 27-29°c during the day and 22-24°c in the night. Humidity often varies with the seasons and records a high of 60-80% in the wet season and low of 30% in the dry periods. The vegetation of the area consists of savannah grasses and shrubs due to the present low rainfall regime. However, due to human activity, the natural vegetation no longer exists and not much agricultural activity goes on. Only about 3.8 percent households are into agriculture.

1.9 Scope of Study

The scope of the study is the Ashaiman municipality. The study explores the risk factors that contribute to the development of flood in some of the communities that normally experiences flood in the municipality. The study also considers some of the effects of flooding and the interventions that could be applied to mitigate the floods. The main interest is the impact of the interventions and its benefit to the communities.

1.10 Chapter Organization

The reminder of this report consists of five more chapters. Chapter Two contains the literature review that discusses various themes on flooding and how attempts have been made to mitigate floods. The third chapter contains the methodology which includes research method and design, study population, ethical consideration and study limitation. Chapter four is the presentation of results of the data analysis based on key research variables. The fifth chapter discusses the results linking research questions, objectives, key variables, literature reviews and citing the relevant references. Chapter six focuses on conclusion and recommendation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of related literature on the study. It focused on the flood risk in the greater Accra region specifically the Ashaiman Municipality. It also presents a review of extant literature on flood risk managements, history of flooding in the Ashaiman Municipality as well as the human related development changes around the various water bodies in the Ashaiman Municipality.

2.2 Types of Flood

Flooding is usually considered to be as a result of heavy rainfall, but they can occur in a several ways that are not directly related to ongoing dramatic changes in weather events. Flood are generally categorized into three main different types.

2.2.1 Pluvial Floods (Flash Floods and Surface Water)

A pluvial flood are floods which are independent of an overflowing of any water body but rather occurs as a result of a heavy downpour of rain or other water sources. These are the most common kinds of floods often experienced in many situations. Contrary to the common misconception that one has to be located near a water body to be at risk of floods. Pluvial flooding can happen within any given location, urban or rural; even in areas with no water bodies in the vicinity There are two common types of pluvial flooding.

2.2.1.1 Surface Water Floods (Areal floods)

These types occur in urban settings when excess water either rain or manmade cannot penetrate deep into the soil in low-lying areas and flows onto the streets and into nearby structures due to choked drainage system or concrete. It usually occurs gradually with the water level being shallow rarely over a 1 meter deep, which provides people enough time to move to safe locations and does not create immediate danger to lives but can cause significant damage to property.

2.2.1.2 Flash Floods

They are caused by intense, high velocity excess runoff water and are often as a result of torrential rain occurring within a short time period within a particular area or on a nearby elevated/steep terrain (Myrtle, 2000). It may also occur due to sudden release of water from an upstream levee or an overflowing dam. Unlike surface floods, flash floods are severely unsafe and very destructive because of the force of the water and also due to the momentum of debris often carried in the flow.

2.2.2 Riverine Floods

These are floods which occur from the overflows water in a water bodies especially rivers onto the surrounding banks and neighbouring land. The rise in the water level of the water body could be as a result of excessive rain or outpour from other water sources. Their damages can be widespread since the overflow can also affect smaller rivers downstream, which can also cause dams and dikes to break swamping nearby lands. The severity of river floods is influenced by the duration and volume of rainfall in an area.

2.2.3 Coastal Floods

Coastal flooding is the inundation of shores ad beaches by seawater. Coastal lands may be flooded by storm surges, high tides and even large wave events at sea or in severe cases by Tsunami or Tropical Cyclones, resulting in waves which can over-top flood and sea defences.

Storm surge is created when high winds from windstorm push water onshore are also a leading cause of coastal flooding.

2.3 Effects of Floods

Covey (2005) opine that people all over the world are vulnerable to natural disasters. Floods are the costliest and devastating of all the natural disasters. They are responsible for up to fifty (50) thousand deaths adversely affect an average of about twenty-five (25) million people worldwide per year. The societal effects of floods on world are substantial with floods being responsible for many drowning fatalities in tropical cyclones, storm surges or freshwater rain-induced flash floods (Needham, Keim & Sathiaraj, 2015). Borrows and De Bruin (2006) opined that flooding caused more deaths than any other single-hazard natural catastrophes. In the decade 1986 to 1995, flooding accounted for 31% of the global economic loss from natural catastrophes and 55% of the casualties.

The effects of floods depend on the magnitude and the duration of the flood event. It also depends on the vulnerability of the local community. It can be described as direct when the loss occurs immediately after the flood event examples are accidents or deaths. It can also be indirect when the effects are less easily connected, are long term and are sometimes more important. Examples are Psychological health problems by victims and emotional torture. Some of the effects can either be tangible or intangible. The effects can be categorized as Physical, Health (where our interest lies most), Social, Economic and may also be Political.

2.3.1 Physical Effects

This forms the category of effects that are tangible and direct. Physical damage to properties is one of the major sources of tangible loss in floods. In the Ashaiman municipality this category of damage includes; damage to houses, shops, farms (farmlands, livestock) and foodstuff, roads and the destruction of vehicles, pylons and cables, home appliances, furniture and many more.

Flood water sometimes enter the homes of people especially houses built along and around waterway or close to main drains to a level about one (1) to three (3) meters destroying the content of the houses and sometimes claiming lives. The rooms of victims sometimes become filled with water and are unable to walk freely, beds and mattresses soaked in water making rest and sleeping difficult. Some home appliances such as televisions, radios, cookers (gas or electric) get damaged and make victims frustrated. For those who use coal pots, their charcoal gets soaked and is rendered unusable for many days. Foodstuff either get spoilt or are washed away, victims thereby suffer hunger. Clothing also bears the brunt of the havoc. Sometimes the flood water is very high (waist level) and victims become so restless such that they rather find comfort on top of their buildings or abandon their home in such of temporary residents elsewhere. Some people return weeks to months when situation normalize. Unfortunately, kiosks and containers with sometimes human occupants are occasionally carried away.

Public infrastructure such as bridges, roads and water supply systems are often damaged by Flooding. It also causes loss of farm crops and livestock. dwellings built with mud especially common in rural areas also often collapse since they lack proper foundations and strength. the summer 2007 flooding left several hundred people homeless with many living in cramped conditions (NADMO, 2008).

2.3.2 Social Effects

The social effect is linked to the level of well-being of individuals, community and the society. It includes aspects related to the level of literacy and education, the existence of peace and security, access to basic human rights, systems of good governance, social equity, traditional values, movement, ideological beliefs and the collective organization (living with Risk, 2002).

Due to the inadequacy of storm drains, most of the roads within the municipality especially those along or within the water ways gets flooded and less motorable. This impedes vehicular movement and creates intense traffic. The Ashaiman New-Town, Jericho, Ashaiman Official-Town, the Adjei-kojo areas are typical examples. People commuting places of work, schools, markets, hospitals, homes and for social events find it difficult.

Recreational centres such as football field, play grounds, drinking bars, restaurants are sometimes flooded. The flash flood prevents people from accessing these entertaining areas. Most of these events require are also disrupted by electrical power outage due to destruction of electrical pylons and transformers. These negative effects though are short lived; they prevent people from engaging friends and family at social gatherings which has a psychological ill in the long term.

Intense and continuous rainfall often flood schools which prevents students, pupils from attending schools. A typical example is Streams of Life School at New-Town Junction behind the GOIL filling station and other schools. The schools get so flooded that the students are invariably asked to stay home for a while. This off course disrupts the academic calendar of the school and eventually has an untoward effect on the performance of the kids. Furniture, books and other learning materials also get spoilt, offices and classrooms gets flooded and sometimes takes days or weeks for situation to normalize.

There is been reports of Criminal activities during flood events because criminals take advantage of the darkness as a result of power outage or capitalize on the vulnerability of victims of flood to steal, vandalize and potentially assault, rape and sometimes kill.

2.3.3 Economic Effects

Economic activities often come to a halt in Accra, whenever it rains heavily. Both public commercial business and private trading activities are halted as the roads become flooded and are rendered impassable in most cases. Telecommunication also suffers with communication systems sometimes being submerged in waters, with even factories shutdown for floods to recede. Flooding also causes huge financial costs with the annual flood damage increasing from US$2 million to US$4 million over the next few years (NADMO, 2008). The cleaning up of the streets and community of mud and debris left behind when floodwaters recede can be costly, with the additional long-term costs in restoring drinking water service to the residents of a flooded area. The 2007 summer floods in Accra alone caused an estimated US$0.5 million of clean-up costs (NADMO, 2008).

Factors that contribute to recovery or non-recovery in flood situation are dependent on the severity of the flood, the degree of the resulting financial hardship, age and socioeconomic status of the victim. This means that severe flooding can impose a range economic lost on flood victims, their businesses, the community, the local economy and eventually the national economy. These effects may linger for few days or years after the flood event and may result in financial hardship for the victims.

Intense rainfall in the Ashaiman municipal almost always floods the main Ashaiman market due to poorly engineered storm drains. This market is the biggest in Ashaiman. It houses a lot of small, medium scale enterprises and businesses, petty traders and many more who engage in the sale of various commodities for a living. Flood water damages most of these items and become an economic burden to the business owners leading to hardship on victims that may eventually affect the local economy. Victims are sometimes unable to meet their financial obligations such as falter at their social and family responsibilities.

The economic loss due to floods to the municipal assembly and the nation at large is enormous. Through NADMO the government spends millions of Ghana Cedis to alleviate the plight of flood victim. NADMO is engaged in search and rescue (for the dead, injured, missing) healthcare, psychological counselling, food, clothing, shelter, financial support to victims and many others. The economic burden to loss human of life cannot be estimated. According to NADMO the estimated property damage over since 2010 is three million (3,000,000) Ghana Cedis and that the government has spent about one million twenty-two thousand (1,022,000) Ghana Cedis in managing the flood situation. Flooding is a natural phenomenon and so it cannot be prevented. However, it can be mitigated but if its occurrence is perennial in a particular area then it calls for lots of concern. The municipality has recorded quite a number of floods for about two decades with its devastating effects therefore a comprehensive solution to the risk factors will go along to reduce the financial burden to individuals, families, the local economy and that of the nation.

2.3.4 Political Effects

How do you govern a people continuously affected with a natural disaster such as flood? People that wake everyday thinking about the next flood and how devastating it may be. The sense of insecurity that grips people about the effects of flood to their homes, businesses and quality of life anytime the rainfall seasons approach. How effective will the municipal assembly be if the governance structure is broken with flood water destroying their documents, instruments and gadgets? There is no doubt that the security, governance and administration of the people in the municipality become a big issue whenever there is intense flood.

2.3.5 Health Effects

The effects of flood on the health care system and issues uncounted in an attempt to access to the health system are all matters of great concern. Floods trigger numerous health problems. Floodwaters typically contain suspended silt and potentially toxic microorganisms and dissolved chemicals which can pollute the water. Floods usually contaminates drinking water supplies leading to short-term disruptions in potable water supply. Open wells are often easily contaminated, leading to severe gastric problems, and increased cases of cholera and diarrhoea. After flooding occur, there is increased concerns of the possible outbreak of waterborne diseases such Bilharzia. Again, other disease-causing insects and vectors such as black flies after flooding has occurred causes river blindness (EPC, 2008).

Flooding has extensive and significant effect on health spanning long and short term and ranging from drowning, injuries to infectious diseases and sometimes mental health. The health effects may be direct or indirect. Direct consequences result from direct exposure to the water and flood environment (examples include, drowning, injuries from debris, chemical contamination of water and hypothermia). Indirect consequences are those associated with risks associated with the damage done to individuals and the built environment (examples include; Infectious diseases, malnutrition, poverty related diseases and diseases associated displaced population). The health consequences may also be described as immediate, medium-term and long term though they overlap.

Natural disasters like flood do not usually result in massive outbreak of infectious diseases though they sometimes increase the potential for disease transmission. The most frequently increased incidence of infectious diseases is caused by contamination of water and food with faecal matter (mainly enteric fever). The risk of such disease outbreak is related to population density and displacements. Flood conditions sometimes increases the pressure on water and food supplies and the risk of contamination, the disruption of pre-existing sanitation services, sewage and failure to maintain or restore normal public health programs in the immediate post-disaster period.

In the long term an increase in the vector borne diseases occur in some areas because of the disruption of vector control efforts following flood events. (Examples are the mosquito breeding sites). There is sometimes the displacement of wild and domestic animals near human settlements which results in the risk of zoonotic infections. In disasters where malnutrition, overcrowding and where there is lack of most basic sanitation, catastrophic outbreaks of gastroenteritis such as cholera have occurred as in Rwanda/Zaire in 1994.

2.3.6 Disruption of Health services

Potential damage to health facilities from floods may require displacement of patient and staff. Flood may impair access to healthcare resources or the ability of healthcare personnel to provide their services. Floods can limit access to primary healthcare and results in changes in demand for services. During Hurricane Katrina, the Louisiana Department of Health and Hospitals in the United States of America was extensively damaged, thus limiting the surveillance for illness, injuries and toxic exposure[33]. Flooding can also cause loss of medical records which will disrupt the provision of healthcare. It can also cause the destruction of health resources such as consumables, loss of medication, medical devices and many more. In Ashaiman municipality, the Jericho Bridge, the new-town junction bridge especially and other roads sometimes gets so flooded and become un-motorable such that transporting patents to hospitals or clinics become difficult.

2.3.7 Death

The leading cause of deaths from flood is drowning and most of these deaths are due to flash flooding rather than the slow riverine flood. Drowning often occur when individuals under-estimate the power of the water current or the depth of the water during late evacuations, attempted salvage or inappropriate conduct. Flood deaths can also be attributed to motor vehicular movement in flooded roads, waterways or from injuries associated with crashes occurring on wet roads. The two soldiers who died on the Accra-Tema motorway near the Adjei-kojo Bridge were as a result of veering off the road and their vehicle being carried away by the water current. Drowning also occurs when people are carried away from their vicinity while attempting to cross a bridge, rafting in storm drains or during evacuations. Quite a few deaths from drowning may not be recorded or known by the local people or authorities. In the survey conducted 25.9 percent of the people admitted to flood related deaths.

2.3.8 Injuries

Flood-related injuries normally occur as individuals attempt to escape from danger or as a result of collapse of buildings or other structures (shops). Injuries may also be caused by objects or debris in the fast-moving water. It can also occur when people attempt to clean up their flooded homes and business places such as markets and shops after floods. (Fall from height, sprain, strain, touching bare powered cables and many more). Individuals also can get injury from the use of cutlasses, chainsaws to clear fallen trees and other debris at home, business places and on the roads. In the survey conducted 33.1 percent of the people admitted to flood related injuries.

2.3.9 Potential Effects

2.3.9.1 Hypothermia

Hypothermia with or without submersion into water occur in some floods and may occur in any season. Most flood water is below human body temperature and so individuals that wallow in rainwater can be affected by hypothermia. Children who play in rainwater are the most affected. For kids in slum residents, stagnated water or storm water becomes a source of swimming pool to have fun and to enjoy them only to go back home and suffer the effects of hypothermia.

2.3.9.2 Electrocution and Gas Explosion

Electrical injuries may occur as a result of flooding where electric poles are broken and high-tension cable lies on the ground or in water. Rescue boats may also come into contact with overhead power cables. Skin burns may also result from explosion of propane or natural gas lines, tanks, power lines and chemical storage tanks, oil and other inflammable low-density liquids may explode and allow fire to spread. An example is the incident which happened at Kwame Nkrumah Circle that claimed about hundred and five two (152) lives and the damaged property is estimated to be in millions of Ghana Cedis. The Ashaiman municipality has not recorded any of such incidents yet but electrocution and gas explosion may be potential hazards of flood if the flood situation is not mitigated.

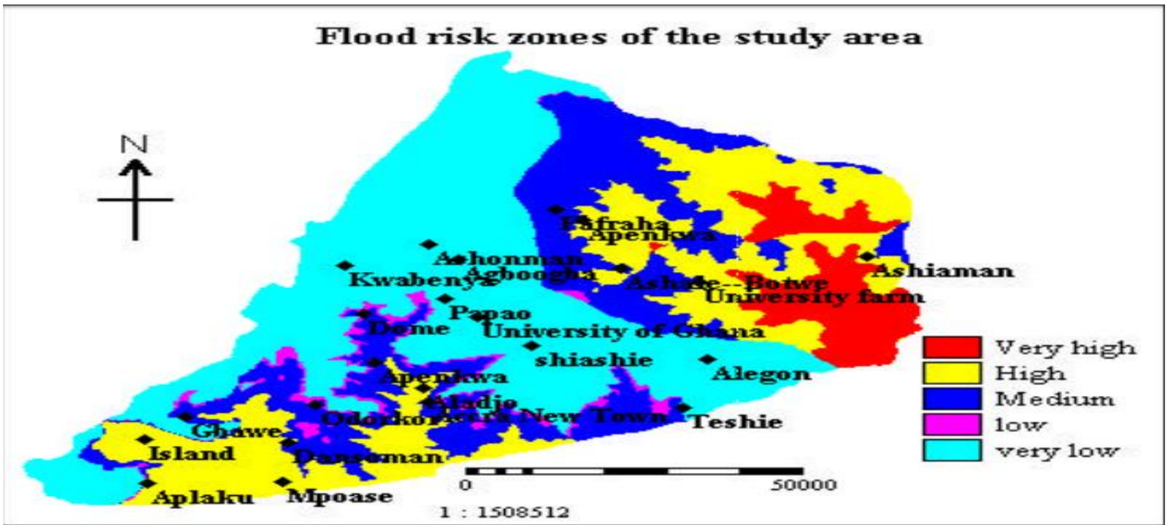
2.4. History of Floods in The Greater Accra Municipality

Urban flooding has been a major issue in Accra, Ghana since the early 1930s (Karley, 2009) with significant flood disasters having been recorded in the years 1955, 1960, 1963, 1973, 1986, 1991, 1995, 1999,2001, 2002, 2010 and 2011 respectively (Twumasi, & Asomani-Boateng, 2002; Karley 2009; Rain, Engstrom, Ludlow, & Antos, 2011). In June 28, 2001, an early morning downpour submerged portions of the city, affecting many houses and structures within Madina, Achimota, Dzorwulu, Avenor, Santa Maria, and Adabraka Official Town. In February 24, 2011, a downpour wreaked extensive havoc on properties in most parts of Accra and some of its surrounding communities. In November 1, 2011, a downpour occurred in Accra that affected forty-three thousand and eighty-seven (43,087) people with fourteen (14) deaths. In May 31, 2013, heavy rains caused flooding in some parts of Accra such as: the Kwame Nkrumah Circle, Darkuman, Kokompe, the Obetsebi Lamptey Circle and portions of the Graphic Road, Santa Maria and the Dansoman Roundabout (Asumadu-Sarkodie et al., 2016). In June 6, 2014, Accra's poor planning was exposed when a deluge hit the national capital after more than 10 hours of downpour. The heavy rains caused flooding in the city and its environs, including Adabraka, Awoshie, the Kwame Nkrumah Circle, Mallam, North Kaneshie, Abeka, Dansoman and Odorkor (Ghanaweb.com, 2015). The tenth flood in Accra occurred on 3rd June 2015, when a heavy downpour in Accra claimed over one hundred and fifty-two (152) lives as a GOIL Fuel Station exploded at the Kwame Nkrumah Circle (Relief web, 2015). About four hundred and fifteen (415) people out of 3.86 million affected people have been killed since 1968-2015 (excluding 3rd June, 2015 floods that was coupled with an explosion at the GOIL filling station in Accra which claimed over 152 lives in Accra) as a result of flood events.

In the 2010 flood event eighteen (18) deaths, one hundred and forty-seven (147) injuries were recorded and five hundred (500) homes destroyed. On 4th June 2015 heavy flood was recorded in Mantseman general area with several properties destroyed. On the 20th June 2015 there was rainstorm with one person dead and several properties destroyed. On 31st January 2017 several properties were destroyed in a forty-five (45) minutes heavy downpours. One hundred and forty-three (143) people were affected. On the 18th June 2018 another flood was recorded with several homes destroyed. On 10th November 2019 four zones in Ashaiman Lebanon recorded flood. The 15th July 20 flood and rainstorm resulted in destruction of homes, wall and roofs of houses the flood prone areas in the municipality include; Middle East, Dam-site, Roman Ridge, the Lebanon Zones, Community 22, Jericho, Asensuba, Valco Flat, TDC Old Quarters, Ashaiman Newtown.

2.5 Flood Prone Area in Greater Accra

Flood prone maps has significantly improved the control and managements of floods of both private and public beneficiaries. Accra landscape are primarily lowlands with some dispersed hills and has an average topography between 20 and 70m above sea level (Kortatsi & Jørgensen 2001; Nyarko 2002). The metropolis is approximately 300 km^2 (Grant & Yankson 2003; Møller-Jensen, Kofie, & Yankson, 2005) and lies between longitude 0° 1′W and 0° 15′E and latitudes 5° 30′Nand 5° 50′N, respectively (Nyarko, 2000). It has a generally gentle slope at below 11%, with a varying water table between 4.80 and 70 m below the surface (Nyarko, 2002). Greater Accra is highly susceptible to flooding, however several areas in localities have different severities. Such areas with the high possibility of flood occurrence include Accra Metropolitan and Ledzokuku Krowor and Ga West and Ga South but most part of Ga West and some of part of Ga East and Adenta and Ashaiman are with high possibilities of flood occurrence (Kwang & Osei, 2017).



Map 2.1 Flood Risk Zones in Accra Taken From: Flood Risk Zoning of Accra

There are some 82 informal communities within the city of Accra which have been identified by the Accra Metropolitan Assembly (AMA) with the support of the local office of UN Habitat has identified to accommodate an estimated 366,823 of residents forming about 22.2% are living in flood-prone zones making them vulnerable to flood hazards (AMA & UN Habitat 2011). These slum dwellers have also caused massive destruction in Accra since 1955 when the first significant flood event was recorded, Twumasi et al., (2002). Reports from 1955 and 1997 has shown that over US$30 million worth of property was destroyed whiles 100 lives were lost with 10,000 people being made homeless during and after the flooding events (Adinku 1994; Gyau-Boakye 1997). Again, 56 lives were lost during major floods in 1999(Ahadzie & Proverbs, 2011).

2.6 Some Risk Factors for Flooding in Ghana

Many risk factors have been attributed to these flood events within the metropolis. Rain *et al*. (2011) and Appeaning Addo, Larbi, Amisigo & Ofori-Danson, (2011) both have determined the possible role of climate variability and change of flooding in Accra. It can be seen from the Remote Sensing image that the Ashaiman Municipality lay between the high and very high-risk zones and this call for serious concern. They claim that climate change has been related to changes in rainfall and temperature patterns and coastal inundation and erosion. Changes in the climatic conditions has resulted in heavy precipitation and increasing peak run-off discharge. Kwaku and Duke (2007) in their analysis of projected return period of rainfall patterns in Accra predicted that a maximum of 84.05 mm in 1 day, 91.60 mm in 2 days, 100.40 mm in 3 days, 105.67 mm in 4 days and 109.47 mm in 5 days is expected to occur at Accra every 2 years. Similarly, a maximum rainfall of 230.97 mm, 240.49, 272.77 mm, 292.07 mm and 296.54 mm is expected to occur in 1 day, 2, 3, 4 and 5 days, respectively, every 100 years. Rainfall intensity is perceived causes of climate change and variability.

Other research cited poor physical planning and flaws in the drainage network (Karley 2009); massive growth of the city, preventing infiltration by impervious surfaces (Arnold & Gibbons, 1996; Yeboah, 2000, 2003; Afeku, 2005); informal housing development practices especially among slum dwellers (Aryeetey-Attoh, 2001); and poor physical development control and waste management practices in the cities (Karley, 2009) which are indicators of rapid and unplanned urbanisation. The rapid urbanization in the metropolis has also resulted in changes in the natural hydrology of Accra (Nyarko, 2002; Adank, Darteh, Moriarty, Osei-Tutu, Assan, & van Rooijen, 2011). Uncontrolled informal settlements and occupation has been linked Accra's perennial flood (Afeku, 2005; Karley, 2009). Karley's (2009) opined that increasing occurrence of flooding experienced in the city recently cannot be explained by any unusual rainfall experienced. Old recognised slum areas which are flood-prone but however were developed ahead of land use planning, lack the needed municipal infrastructure to prevent or control the occurrence of flood hazards. This is one of the major contributing factors to flooding in most areas in the Metropolis.

As more people require more space to put up residencies, dried up rivers and waterways become opportune grounds for buildings. Both suspecting and unsuspecting people tend to either encroach or buy these lands along the dried river valleys from landowners (Chiefs or other relatives) who are aware of the dangers of the land situation but fail to warn prospective buyers. This results in people building on potentially swampy areas below sea level which are prone to frequent tidal and fluvial flooding usually due to high tides from the Gulf of Guinea (Karley, 2009). Large parts of communities such as –Alajo, Kpehe, Kotobabi, Avenor, Kokomlemle and the whole of Korle Dudor and Ussher and James Towns, Glefe, Gbegbeyiese and Mpoase are all known flood-prone zones.

The inadequate or limited social amenities and public infrastructure such as sanitation and drainage facilities in both the city and its peripherals are a key contributing factor to the city's vulnerability to flooding. Researchers such as Boadi and Kuitunen (2002, 2003) and Afeku (2005) argue that these factors coupled with increased waste generation and the city's poor waste disposal practices, break-down of gutters and drainages due to continuous choking, poor maintenance and the absence of storm drains supports flooding. Douglas et al. (2008) opined that floods in urban areas in Africa including Accra is also related to changes in the buildings of the city themselves and not just as a result of heavy rainfall and extreme climatic events. Implying that urban flooding manifests a significant interrelationship between uncontrolled urbanisation and climate change in most African cities.

Rain et al. (2011) suggested a probably contributing role of climate change in flooding experienced in Accra's but further argued that the massive growth of the city' was a significant flood hazard is which rendered more residents vulnerable to floods. With further support by from several studies which confirms the impacts of climate change/variability in sea-level rise, tidal waves and storm surges in the coastal areas along the west coast of Accra such as Gbegbeyiese, Mpoase, Glefe and Pambros area (see Rain et al., 2011; Appeaning-Addo et al., 2011; Amoani, Laryea, & Appeaning-Addo, 2012; and Appeaning-Addo, 2013).

2.7 Management of Floods

Countries worldwide are implementing several flood mitigation/control measures such as and not limited to desilting of drains, dredging of canals, rivers and lakes, demolition of buildings sited on water ways, reforestation exercises especially along rivers, proper town and country planning and the putting up of levees and other barriers. According to Nelson (2012), mitigation of flood hazards can often be expressed in two main forms; an engineering approach to control flooding and a regulatory policy designed to minimise the vulnerability to flooding.

However, other natural methods such as wetland preservation are also deemed to be very helpful in to control and prevention of floods. Also, the construction of dams for temporal storing of excess water and canal modifications to reduce the incidence of flooding by increasing the speed at which runoff water is carried away from human habitation reducing drainage time. Artificial dam and retention ponds are also effective in reducing floods (Costa, 1985).

Legislature, regulations and law enforcement such as Restrictive building codes, Floodplain zoning is a useful way of reducing vulnerability to floods and can help prohibit the development and habitation of floodplains, ensure the prevention and minimization of the effects of floods on lives and properties (Acreman & Dunbar, 2004).

Wetlands serve as a mini-ecosystem and without such areas; populations of countless species would be threatened (Attipoe, 2015). Researchers, Dixon and Wood (2003) and Hove and Chapungu (2013) argue that wetlands play critical functions including environmental, hydrological and socio-economic role to the local communities by recharging rivers and serve as reservoirs for dry water supply (Du Toit, 1994; Hove & Chapungu, 2013). In addition, they serve to purify and improve river water quality whiles also serving as habitat for large numbers of both terrestrial and amphibious organisms (Bowden, 1987; Taylor, Fletcher, Wong, Breen, & Duncan, 2005; Beas, Smith, LaGrange & Stutheit, 2013). Hove & Chapungu, 2013).

CHAPTER THREE

METHODOLOGY

3.1 Research Design

This study is going to employ a mixed method approach consisting of both qualitative and quantitative research method. Qualitative research methods aim at testing theories, determining facts, demonstrating relationships between variables and predicting outcomes (Bluhm, Harman, Lee, & Mitchell, 2011; Yilmaz, 2013). Quantitative research methods make it possible to put features in categories, sum them and develop statistical models that allow easy explanation and observation (Yilmaz, 2013). Primary and secondary sources were used to gather relevant information for the study.

In this research, a structured close and open-ended questionnaire was used as the main instrument to collect data alongside interviews with some experts involved in flood management and also direct observation of the study area. The use of this method will enable me capture different dimensions of the study.

3.2 Data Collection Techniques and Tools

The study used structured question as an interview guide to collect data. The questionnaire was structured into two parts, sections A and B. The first sought to gather general and demographic data. The second section was designed to gather substantive data to address the subject matter of the study. Other sources of data were obtained from the relevant departments involve with flood and flood control.

The researcher in this study concealed his real identity and interacted with members of the community while activities of people were observed. The researcher employed a "rapport" alongside to get first-hand information. This is because some important facts or information about the attitudes and behaviours of people in the flooded area cannot be obtained from questionnaire or interview. This enhanced the researcher's knowledge on the study since almost every year pockets of flooding were recorded in Ashaiman. The importance of this method was that, it ascertained and verified the other sources already employed to collect the information. In other words, it was used to cross check the data already gathered and analysed.

The tools used for the study include; Phantom Three (3) Advanced Drone which shoots high definition images, Advanced Space-borne Thermal Emission Radiometer (ASTER) Digital Terrain Model, Geographic Information System (GIS), Global Positioning System (GPS) Device, cameras and others. Questions were translated into the local languages for ease of understanding by some respondents. Interpreters were employed in some cases for the language translation.

3.3 Study Population

The sample population is made up of residents living in the Ashaiman Municipality. The study targeted about four hundred and ten (410) people from an estimated population of about two hundred thousand (200,000) residents in the Ashaiman area. The questionnaires were administered in the Ashaiman Municipality especially areas along the waterway. The questionnaires were administered in these areas; Adjei-Kojo, Lebanon, Jericho, New-Town, Dam-Site and Atta-Deka general areas.

3.4 Study Variables

The dependent variable is the perception of people on the independent variables such as risk factors for flood, effects of flood and the management of flood.

3.5 Sampling

The sample of a study is a section of the population that is drawn to make inference or projections to the general population. Participatory survey was used in collecting primary data from respondents in Ashaiman and also an interview with a respondent from the metrological agency. This sample size is calculated based on a previous research on awareness of the risk factors contributing to flooding in Accra. Using 70% awareness,

The sample size will be calculated using the Cochran's formula as shown below;

$$n = \frac{Z^2 \times pq}{e^2}$$

Where,

n = sample size (Cochran, 1977)

Z = the z-score that corresponds with 95% confidence interval which is 1.96

p = Proportion of people who are aware of the risk factors which is 70% which is equals to 0.70

q = Proportion of which people who are not aware is equal to 1-0.70 = 0.30

e = Margin of error set at 5% (0.05)

Therefore,

$$n = \frac{(1.96)^2 \times (0.7 \times 0.3)}{(0.05)^2} \cong 323$$

A non-response rate of 10 % resulting to about 32 respondents will be added to the minimum sample size to get 355 participants.

Only residents who live along the earth drains in the Ashaiman Municipality who are of sound mind and are eighteen (18) years and above and Departments and Agencies involved with flood and flood management were drawn as respondents. Non-residents and non-workers at the Ashaiman general area were not allowed to take part in the study. Department and Agencies not involved with flood and flood management.

Secondary data of Historical monthly rainfall (60-100) data was collected from Ghana Meteorological Agency. Secondary date on Advanced Space-borne Thermal Emission Radiometer (ASTER) Digital Terrain Model was downloaded from the internet.

However, listed below are the method used in gathering data for some of the specific objectives listed in chapter one of this study which needed technical equipment and expertise are (see appendix for remaining);

3.5.1 Objective One

Ariel video footage of the Ashaiman Municipality especially the main watercourse was taken with a mechanical drone. The primary and some of the secondary waterways were captured. The footage stretched from the main source of the waterway at the Aburi Mountains through Damfa near Ayi-Mensah, Oyarifa, Ashaiman, Sakumono which then collects in the Sakumono Lagoon and then finally end in the Sea (Gulf of Guinea).

3.5.2 Objective Three

The Gumble Extreme Value Probability Distribution was used in analysing the rainfall data. Data was basically process in Microsoft excel, the maximum rainfall recorded within each month was used as the maximum discharge (m^3/s) for the calculation. First of all, the mean value of 59-year data was calculated. The standard deviation of the set data was equally calculated.

$$Mean = \frac{sum\ of datapoints}{of\ data\ pointsnumber} \ldots\ldots\ldots..(1)$$

Standard deviation, $\delta = \frac{1}{N}\sum_{i=1}^{N}(x\text{i} - \mu)2$

N= the size of the population, X_i= each value from the population μ= the population mean .

From table 1(see Appendix 1), the reduced mean and standard deviation was extracted. The reduced variate Yτ for each of the flood return period was calculated using the formula

$$Y\tau = -[ln. ln\frac{T}{T-1}]$$

Where Y_τ = reduced variate, τ= flood return periods.

The frequency factor K was also determine using $K = \frac{(Y\tau - Yn)}{Sn}$ where K = frequency factor; Yτ = reduced variate; and Yn = reduced mean and Sn = reduced standard deviation. The value of maximum rainfall for the return periods were then calculated using $X\tau = \bar{x} - K\delta(n-1)$ where $\bar{x}$ = mean; K = frequency factor and δ= standard deviation.

3.5.3 Objective Four and Five

Remote Sensing Images were used to identify the flood areas and the flood prone areas. Remote Sensing refers to the science and technology of acquiring information about the earth's surface (land and ocean) and atmosphere using sensors onboard airborne (aircraft and balloons) or space borne (satellites and space shuttles) platforms (see appendix 2).

3.6 Pretesting

Pretesting of the questionnaire was done at the Alajo along the main watercourse which has housing and development characteristics just like the Ashaiman waterway areas. The pre-test was used to test the participants' level of understanding and administration of questionnaires and their experience enabled corrections to the made to the final questionnaire used for the research. The team was composed ten (10) surveyors and three (3) supervisors. Each supervisor had daily face-to-face interaction with the surveyors they superintend over. In addition, three (3) technicians who assisted in operating the Mechanical Drones, three (3) Remote Sensing Technologist person who assisted with the Remote Sensing and a Topographic Person who assisted with the sketches, a Camera Man, three (3) Motor Riders and others.

3.7 Data handling

Data collected with questionnaires was screened for completeness and errors. The data was entered using Microsoft excel 2019. The principal investigator was responsible for data cleaning and management. The original entry of the questionnaire was used as source data. Soft copies of all dataset and work done were sent to the investigator by e-mail, and on an external drive. All completed individual questionnaires and data will be kept under lock and key and also at the Ensign library for ten years.

3.8 Data Analysis

The data was analysed using R Statistical Computing Environment, ArcGIS/ILWIS and Excel. The analysis is in line with the stated aims of the study. Agrimet-soft online Gumbel calculator system was used to generate a graphical representation of result.

3.9 Ethical Consideration

Ethical approval for the study was obtained from the Ethical Review Committee of Ensign College of Public Health. The Ashaiman Municipal Authority was approached and the nature of the study explained to them. Permission was obtained from NADMO and Meteorological services. Interviewers were trained adequately. The purpose of the survey was described to the participants or respondents and their verbal consent obtained before proceeding to administer the exercise. Participants had the option of declining from the study. Honesty and confidentiality were maintained during data collection and the interviews conducted. Data access was limited to the principal investigators, research assistants and supervisors only. The consent letter design for this purpose is attached in appendix of this research.

3.10 Limitations of The Study

1.Records and record keeping is a big issue. Most of the departments visited had a challenge with the collection and storage of data hence it was difficult to get data beyond the past two years and sometimes very hard to get current information.

2.Some people did not want to grant us audience during the questionnaire administration and the interviews because of COVID-19. Some individuals thought we were rather spreading the infection; others too demanded money to complete the questionnaire simply because of the pandemic.

3.The study demands a lot of time and resources in order to write a comprehensive report. The issue of the pandemic prevented us from getting some human and the financial resources for the project work. People were not willing to assist freely. The lockdown worsened the situation as there could be no movement in and out of the project location so had limited the time to complete the thesis. The cost of internet service and access was also a challenge.

4. Some people within some communities were uncooperative. The research team was confronted and harassed on several occasions by the residents. Others thought our research was to inform the government about available land for government’s confiscation so seized our equipment at some point.

CHAPTER FOUR

DATA ANALYSIS

4.1 Introduction

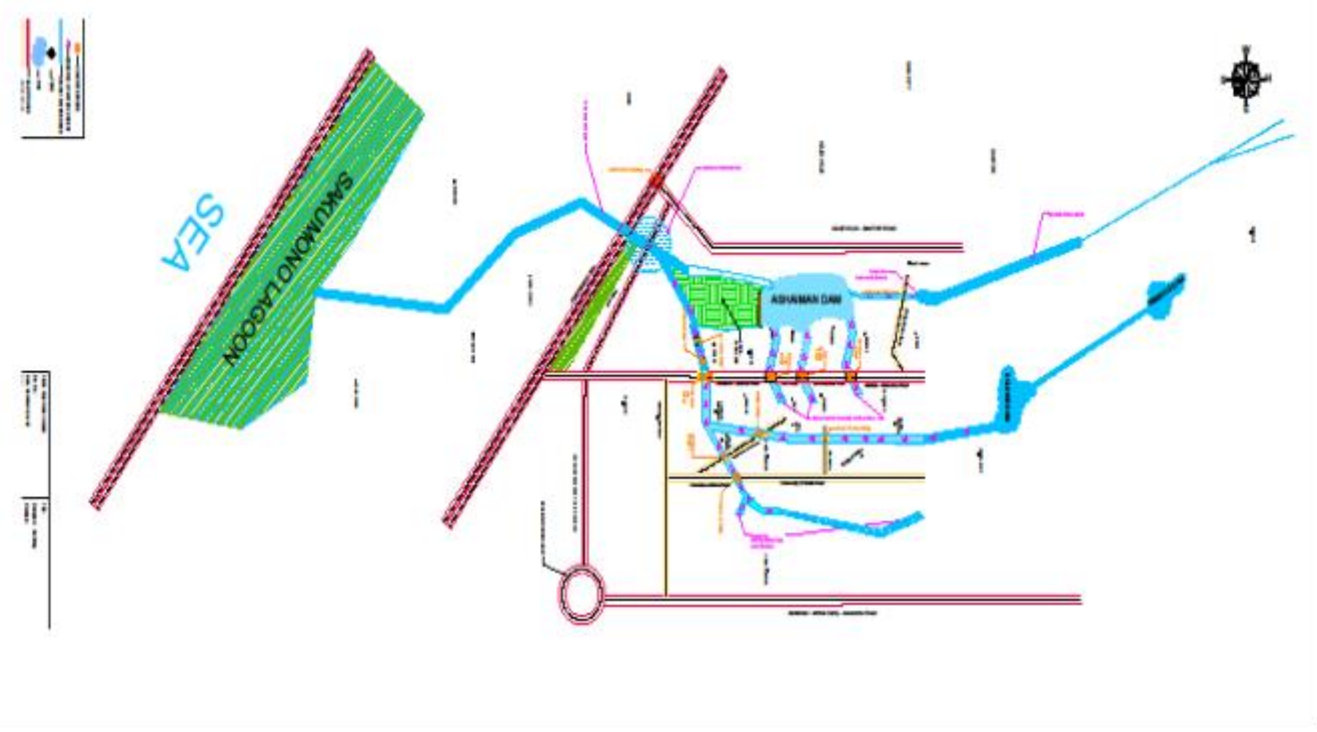
This section presents findings and analysis of results. The data was analysed using R Statistical Computing Environment, ArcGIS/ILWIS and Excel. The analysis is in line with the stated aims of the study. These analysis and results are presented in two part, the first presents the results of the qualitative geological field works whiles the second part presents the analysis and results of the quantitative data collected from the respondents. The analysis consists of descriptive statistics of the demographic characteristics of the respondents.

4.2 Geological and Hydrological Field Work

4.2.1 Objective One

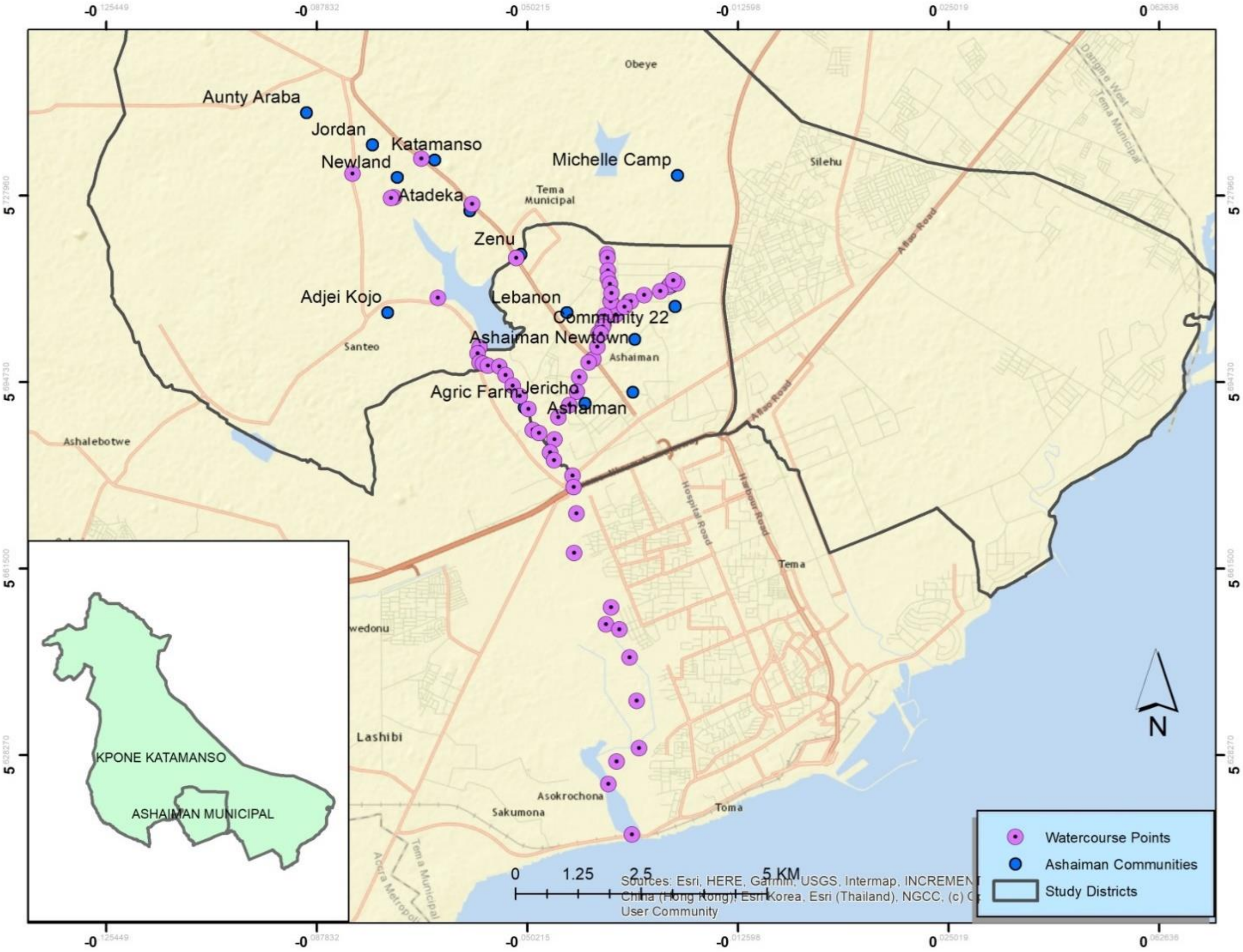
Ariel view of the Ashaiman main natural waterway (the Dzorwulu River, the Gbemi and Amatsuru Streams) and some parts of the municipality were taken. The Dzorwulu River was traced all the way to the Akuapem Ridge precisely from the Aburi Mountains (it has two main sources, the Jamaica Spring and the Daween Spring). From the mountains the water passes through several communities downhill. On approaching the Ashaiman municipality the Dzorwulu River passes through Aunty Araba Community to Jordan Community then to the Ashaiman main dam (IDE). Other sources of water to the dam include storm water from Ashaiman Lebanon, Zenu, Attadeka, katamanso and the environs. From the Dam the water goes through the Ashaiman rice farm, then through to Ashaiman Adjei-Kojo Under-Bridge general area which serves as the catchment for the area. The Gbemi Stream which takes its source from the Michel Camp Dam is joined at some point by the Amatsuru Stream. The Michel Camp Dam is also connected to the Gbetsele Dam upstream. The Ghemi Stream flows through Ashaiman community 22, 21, and 22 Annex. Furthermore, it flows through Ashaiman Newtown through Mali Estate to Jericho then meet the Dzorwulu River at Adjei-Kojo.

The confluence of both water channels and the storm water in the Ashaiman general area is at Adjei Kojo Under-Bridge Area. Fitaline area acts as a buffer zone receiving all the excess water in the catchment area. The water then passes through the water channel under the main Accra-Tema motorway to Tema community 12. The waterway was further followed all the way to the Sakumo Lagoon at Teshie then to the Sea (Gulf of Guinea). The GPS coordinates of the Earth Drains (the Dzorwulu River and Gbemi Stream) was also taken.



Map 4.1 Major Waterways in the Ashaiman Municipality

The sketch shows the pathway of the major waterway (the Dzorwulu River and the Gbemi Stream). The dams are irregularly shaped and coloured blue, the pathway of the water is in light blue. The road network is in red and the bridges, yellow. The main Ashaiman farm is coloured green.



Map 4.2 The GPS mapping of the main waterways in the Ashaiman Municipality, its connection to the Sakumo Lagoon and finally ending up in the sea.

4.2.2 Objective Two

Assessing the Trend Pattern in Ashaiman Catchment Area Using Bayesian Time Series

The study assessed the trend pattern in Ashaiman catchment area using a Bayesian time series starting from January 1960 to January 2020. Based on the figure below, there was fluctuation of the intensity of rainfall for the study period. Most of the floods that occur in the catchment area spanned between the months of May to August each year. (Fig. 4.1)

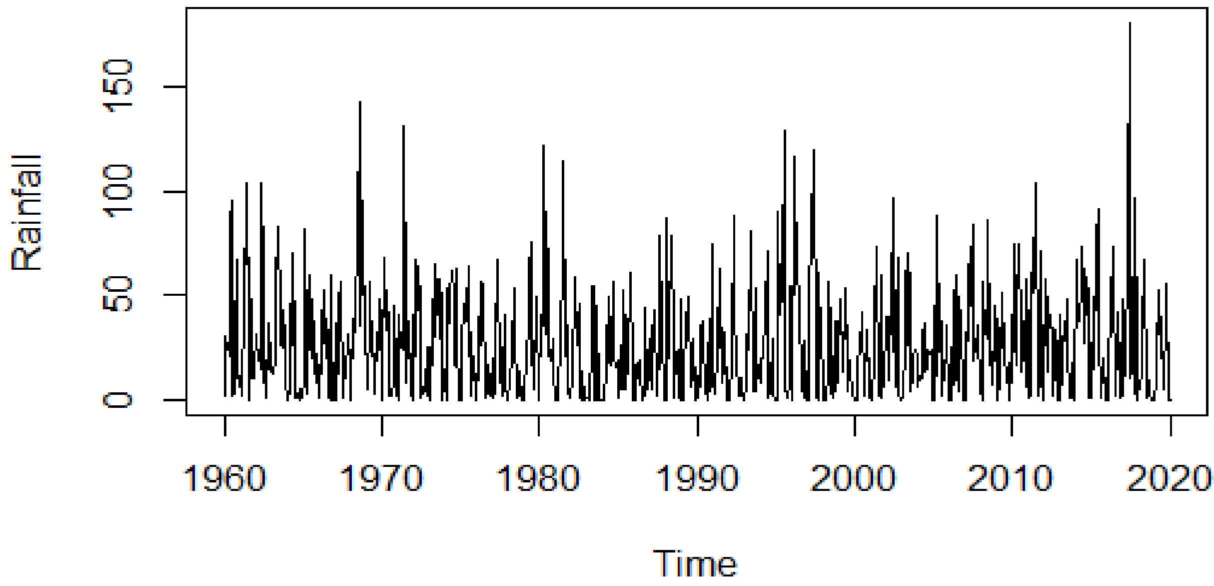


Figure 4.1 Trend of Rainfall Pattern in Ashaiman Catchment Area

Posterior Distribution of Rainfall Pattern in Ashaiman Catchment Area

The Figure (Fig 4.2) below displays the pictorial view of the posterior distribution of rainfall pattern in the Ashaiman catchment. A graph of index on time was plotted against the posterior distribution. The graph shows that relatively most of the rainfalls lie below fifty (50) of the posterior distribution. This means that the Ashaiman municipality does not experience heavy rainfall frequently and so the continuous flooding is not as a result of heavy downpour. This implies that the flooding experienced could be due to defective and or inadequate drainage system and other anthropogenic effect.

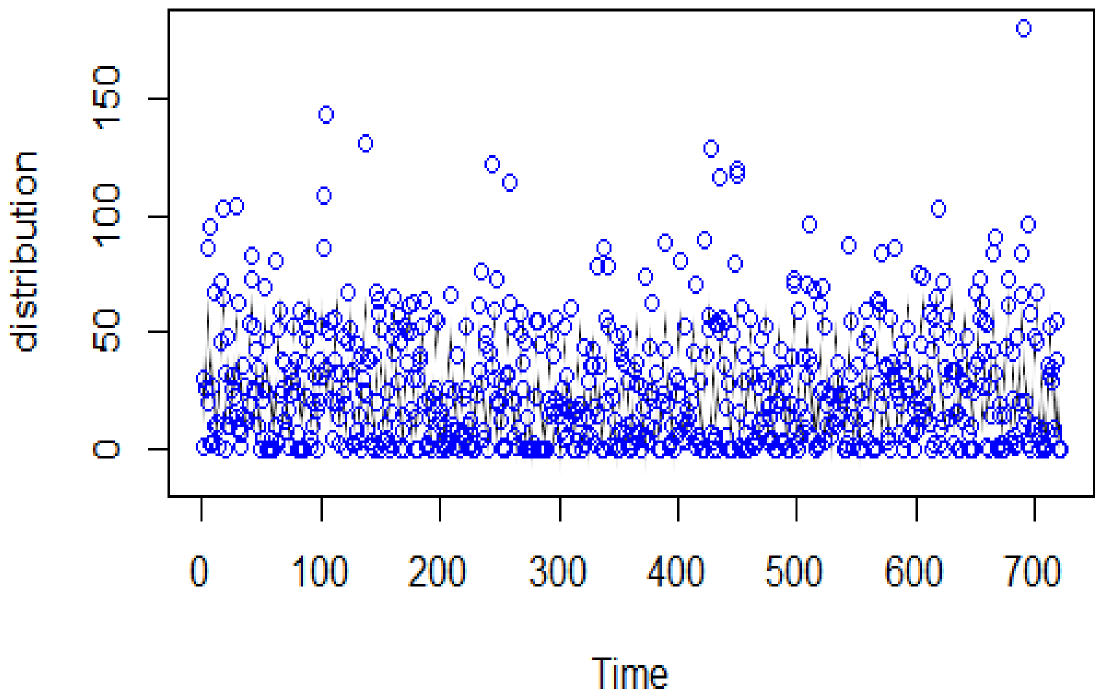


Figure 4.2 Posterior Distribution of Rainfall Pattern in the Ashaiman Catchment Area.

Out of Sampling Validation

A good way to test the assumptions of a model and to realistically compare its forecasting performance against other models is to perform out-of-sample validation, which means to withhold some of the sample data from the model identification and estimation process, then use the model to make predictions for the hold-out data in order to see how accurate they are and to determine whether the statistics of their errors are similar to those that the model made within the sample of data that was fitted. Based on this assertion, the study constructs an out of sample validation for Bayesian model using exchange rate data

Table 4.1 Out of Sampling Validation

Date (2019)	Actual	Forecast	Error	%Error
JAN	0.0000	0.0200	0.0200	2%
FEB	7.6000	7.5802	0.0198	2%
MARCH	36.5000	36.7339	0.2339	23%
APRIL	31.6000	32.0878	0.4878	49%
MAY	52.2000	52.0790	0.1210	12%
JUNE	29.0000	29.2678	0.2678	27%
JULY	34.3000	34.6390	0.3390	34%
AUGUST	5.4000	5.6713	0.2713	27%
SEP	8.6000	8.8280	0.2280	23%
OCT	37.8000	37.8678	0.0678	7%
NOV	55.0000	55.0993	0.0993	10%
DEC	0.0000	0.2802	0.2802	28%
MAE			0.2030	
RMSE			0.4505	
MAPE				24%

The Mean Absolute Percentage Error (MAPE) is the mean or average of the absolute percentage errors of forecasts (Hyndman & Koehler, 2006). According to Hyndman and Koehler (2006), the smaller the MAPE, the better the rainfall forecast. The study results show that the MAPE is 24%, (Table 4.1) This implies that, on average, the forecasting model is giving errors of 24%.

Forecast of Rainfall in Ashaiman Catchment Area for the next 12 Months

The study presents a forecast of Bayesian Time series for the next 12 months of 2020. The results were presented in (Table 4.2). It was found that this year from May to July; the Ashaiman Catchment area will experience a heavy rain, especially in the month of June.

Table 4.2 Forecast of Rainfall in Ashaiman Catchment Area for the next 12 Months

Year	**Month**	**Forecast**
2020	February	21.51
2020	March	25.30
2020	April	35.12
2020	May	44.07
2020	June	51.54
2020	July	41.17
2020	August	21.46
2020	September	20.06
2020	October	21.99
2020	November	10.06
2020	December	1.62
2021	January	5.01

4.2.3 Objective Three

Compute 2year, 5-year, 10-year, 20-year, 25 year, 50 years, 100-year, 200-year, 500 year and 1000-year flood return period of Ashaiman catchment area using the Gumble extreme Value Probability distribution. Gumbel Extreme Value Probability Distribution will be fitted to the historical rainfall data using graphical method. The flood return periods will be calculated from the equation of a straight line.

Table 4.1 The Return Period Interval (T), Reduced Variate (Yτ), Estimated Discharge

T	Yτ	Xτ(m^3/s)	parameter	Yτ
2	0.366513	72.557601	μ	90.8359142541612
5	1.49994	101.59811	β	23.4413424026499
10	2.250367	120.82545	Mean	104.367
20	2.970195	139.26878	Standard Deviation	30.065
25	3.198534	145.11925	Significant	True
50	3.901939	163.14178	KolmogorovSmirnov Test	0.482
100	4.600149	181.03123	P-Value	Less than 0.01
200	5.295812	198.85541		
500	6.213607	222.37103		
1000	6.907255	240.14358		

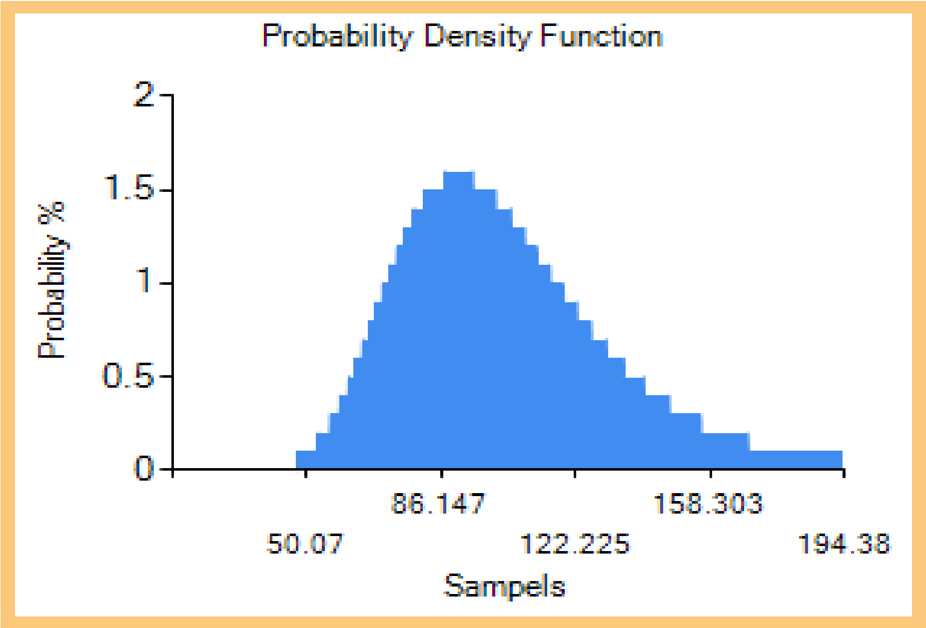


Figure 4.3 Graphical Representation of Gumbel Extreme Value Probability Distribution

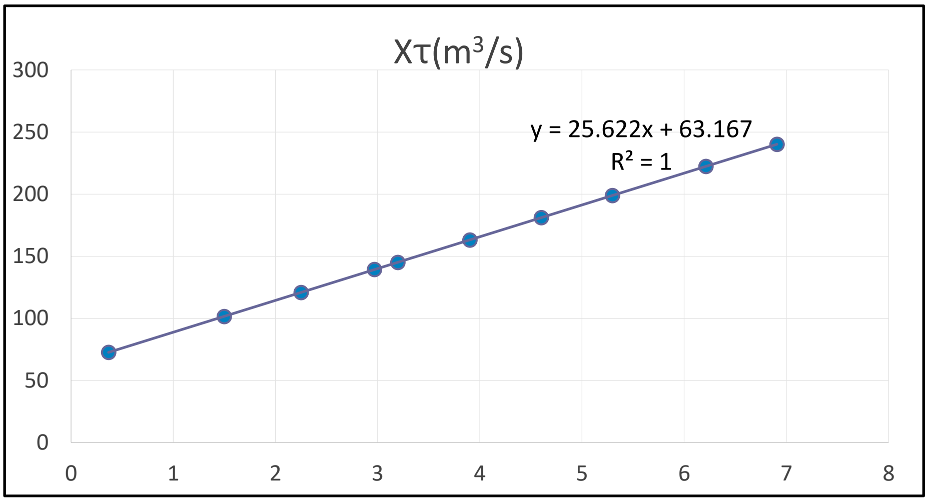


Figure 4.4 Trend Analysis of Estimated Discharge

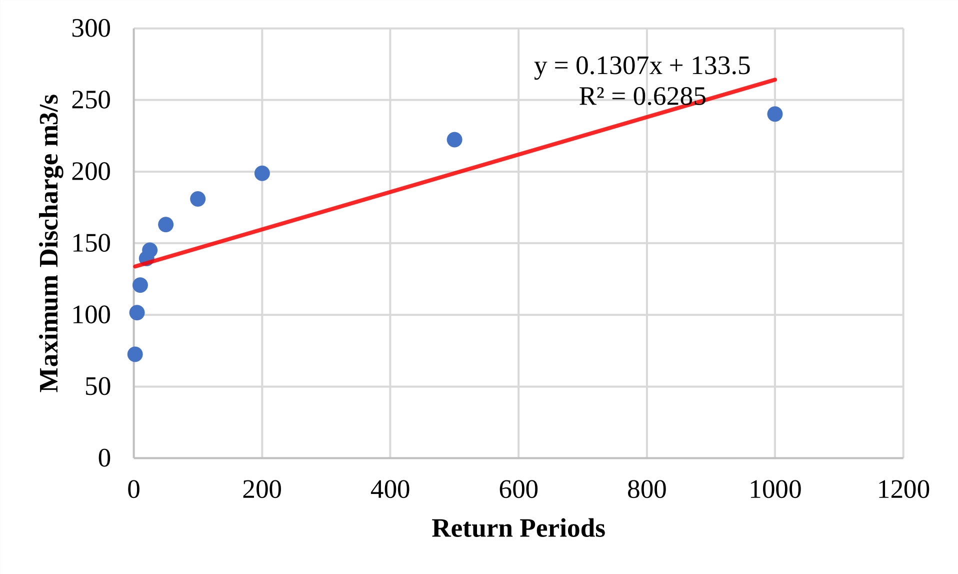


Figure 4.5 Graphical Representation of Gumbel Extreme Value Probability Distribution

The flood frequency curve is used to relate flood discharge values to return periods to provide an estimate of the intensity of a flood event. The discharges are plotted against return periods using either a linear or a logarithmic scale. In order to provide an estimate of return period for a given discharge or vice versa, the observed data is fitted with a theoretical distribution using a Cumulative Density Function (CDF). This helps the users in analysing the flood frequency curve. The flood return period of 2years, 5-year, 10-year, 20-year, 25 year, 50 years, 100-year, to 200-year ranges between $50m^3$ to $200m^3$ *(*see Figure 4.5). The interesting thing is that the volume keeps increasing. However, in about 100 years, flood discharge will be expected to be around $250m^3$ *(*see Figure 4.5). It has been established that the steeper the slope of the flow duration curve, the greater the variability in flow (Selaman et al., 2007). From the steepness of the slope, it can be said that the variability in the flood discharge is great but it is important to consider that the extent of damage caused by flood in just a forty-five (45) minutes rainfall is due to the improper planning in the Ashaiman municipality.

4.2.4 Objective Four

Objective 4: To determine the water bodies (rivers, lakes, lagoons) and their borders in the municipality. How the waters are contained during the heavy rains and how far the waters overflow its banks during heavy downpours. Aster data was processed to extract drainage pattern of the Ashaiman catchment area using ArcGIS hydro-processing module.

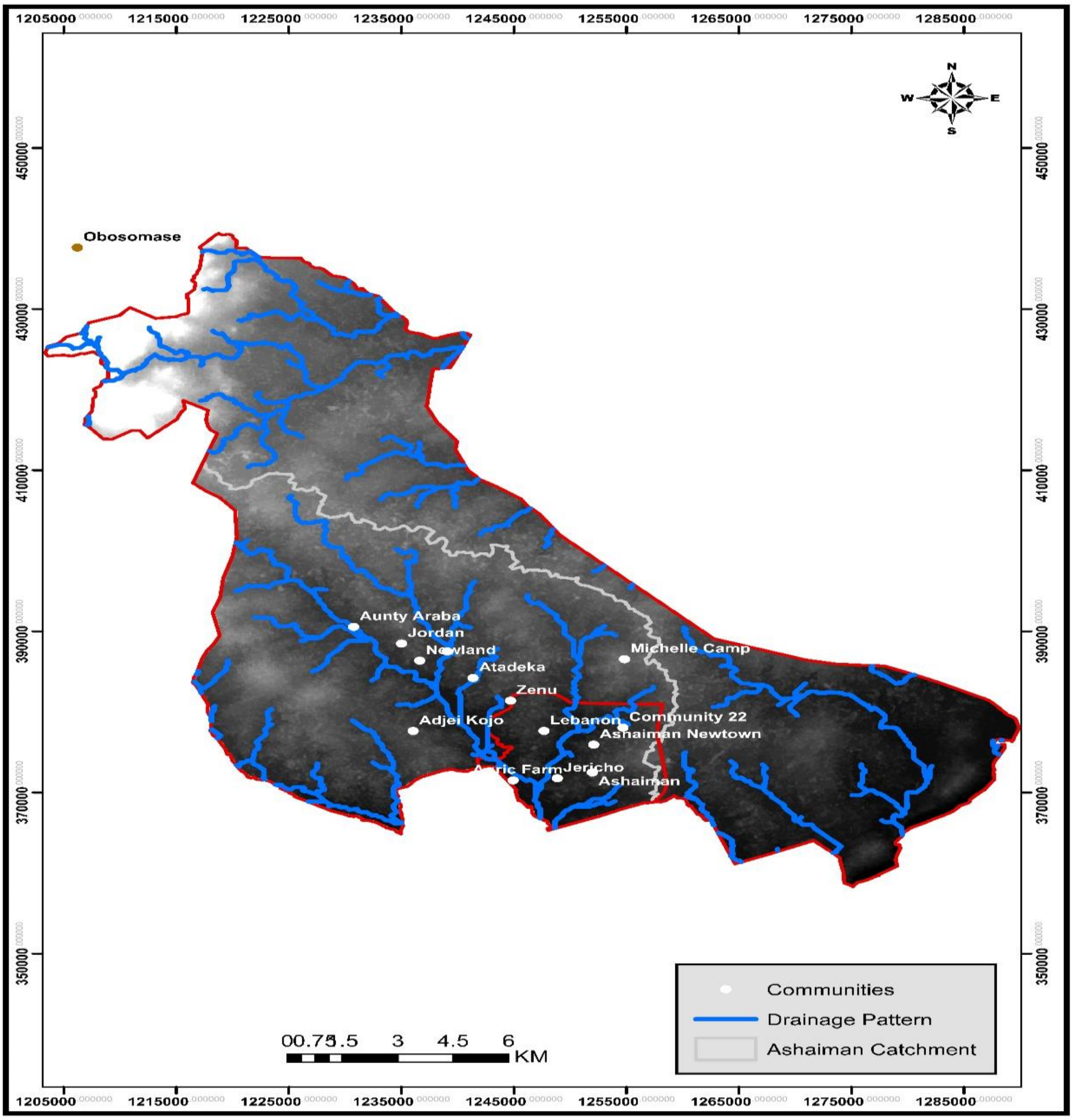


Figure 4.6 Drainage Pattern of Ashaiman Catchment Area

This objective is to delineate the drainage pattern of the Ashaiman catchment area and to show all the water bodies (Rivers, Lakes, and Lagoons) and their borders in the municipality. From (Figure 4.6), it can be seen that the catchment area of the municipality is from the Aunty Araba area, down to the rice farm, Ashaiman New town and community 22. This means that storm water from all these areas accumulates within the Ashaiman municipality. Technically the Aunty Araba, Jordan, Newland and some parts of Attadeka are all outside the Ashaiman municipality but water from all these areas passes through Ashaiman. Also, there is some evidence of the water coming the from Aburi Mountains (Jamaica, Daween and Obosomase Waterfalls) in the Eastern region which meets up with the waters at Aunty Araba area and possibly they all contribute to the amount of water that pile up in Ashaiman during rainfall. This means that if it rains at Aburi and Ashaiman at the same time, the volume of runoff within the municipality will increase.

Within the catchment area as shown in (Figure 4.6 and 4.7)), the earth drains at Zenu, Lebanon and somewhere around Adjei Kojo are the main receptacle for the municipality. This means should there be a heavy downpour; these are the areas that receive water from neighbouring areas into the municipality. The main Ashaiman Dam (IDE) and the Agric farm are also a major catchment for the surrounding communities.

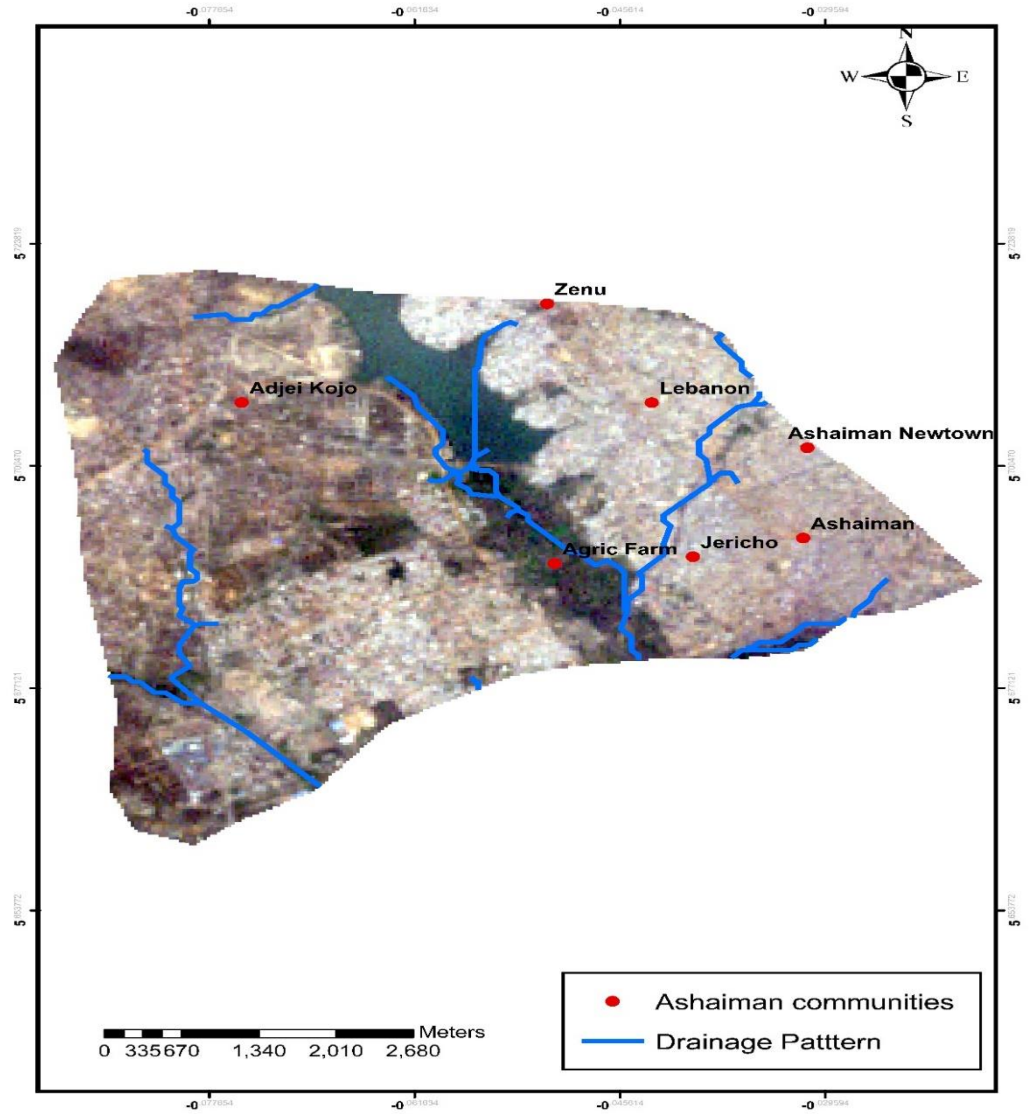


Figure 4.7 Ashaiman Municipality Main Earth Drain Pattern

4.2.5 Obejective Five

To determine the extent of flooding in the Ashaiman catchment area, the level of water measured in meters during heavy downpour or low-down pour and the water in terms of spread in the area

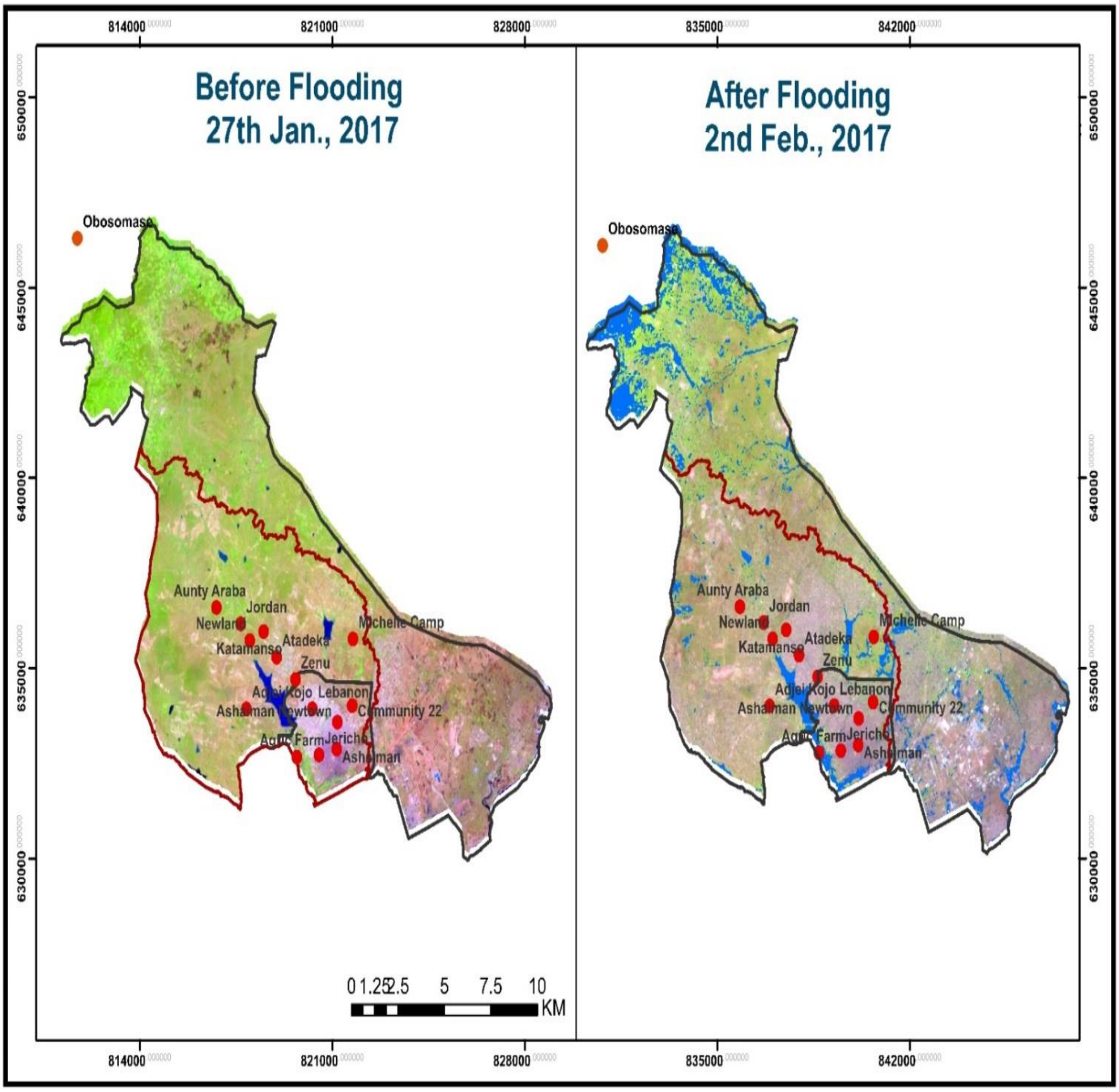


Figure 4.8 A &B, A Map Showing Coverage of Ashaiman Catchment Area Before and After Flooding

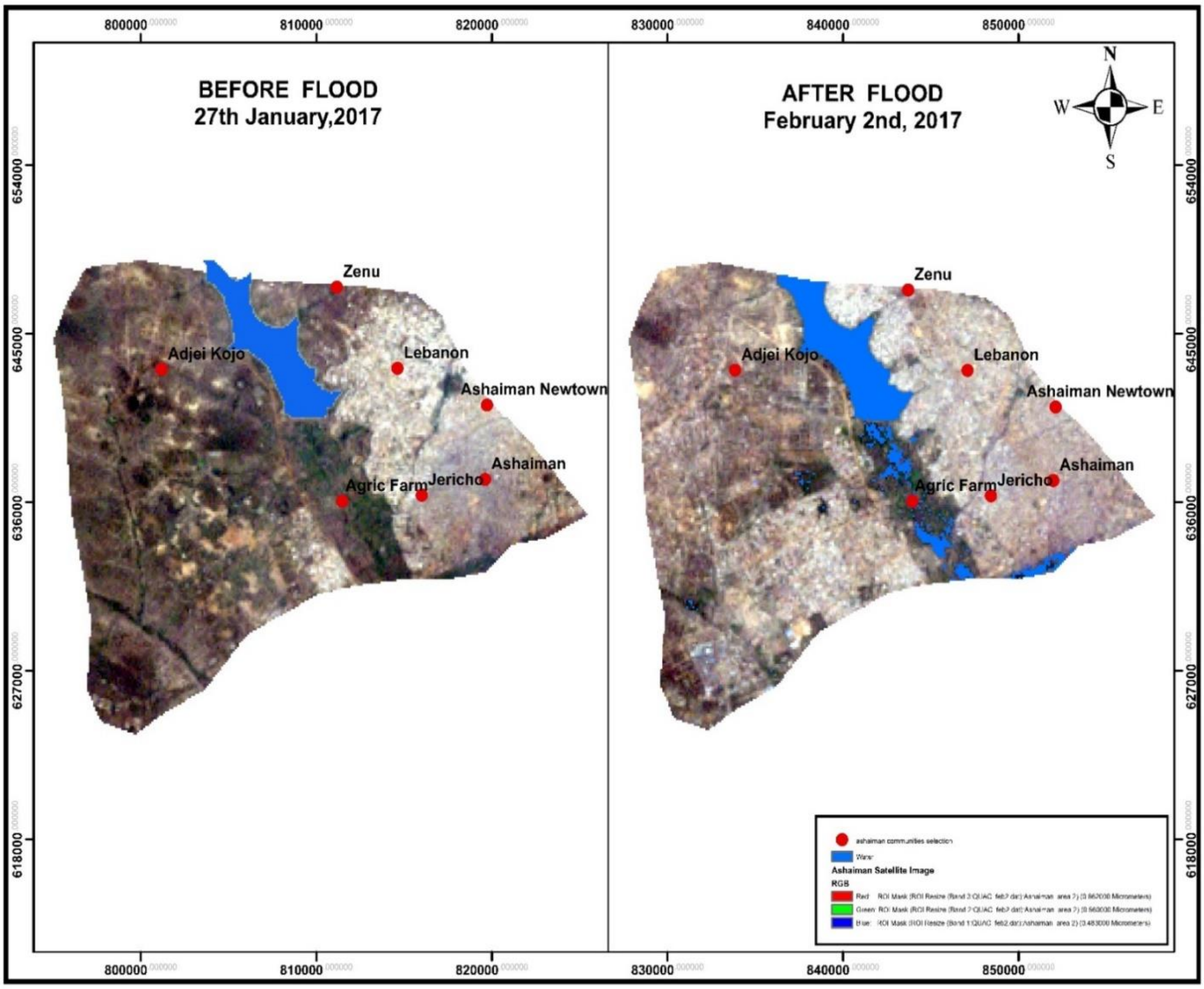


Figure 4.9 A&B, Flood Situation in Ashaiman Municipality

One of the intentions was to determine the extent of flooding in the Ashaiman catchment area, as to the level of spread during heavy downpour. In the recorded history of flooding in Ashaiman, forty-five (45) minutes downpours on the 31st of January, 2017 caused flooding where about 143 people were affected and several properties were destroyed (*NADMO HQ, ACCRA*). To be able to ascertain this, data was taken a few days before heavy down pour (that is 27th January, 2017) and after the downpour (that is 2nd February, 2017), with the intention of assessing the situation of flooding against the baseline of situation on 31st January, 2017. From (figure 4.9A), it can be seen that only the Dam was visible from the satellite image. However, two days after the rainfall (Figure 4.9B) there still seem to be a lot of water of the surface of the Ashaiman area especially around the rice farm, Jericho and other areas. The stagnant water all over those areas two days after the flooding incident shows the extent or the impact of the flooding in the area after the downpour. Such waters on the surface is enough to cause damage to some property and are obviously the breeding ground for mosquitos and other insects hence an increase in malaria cases in the region.

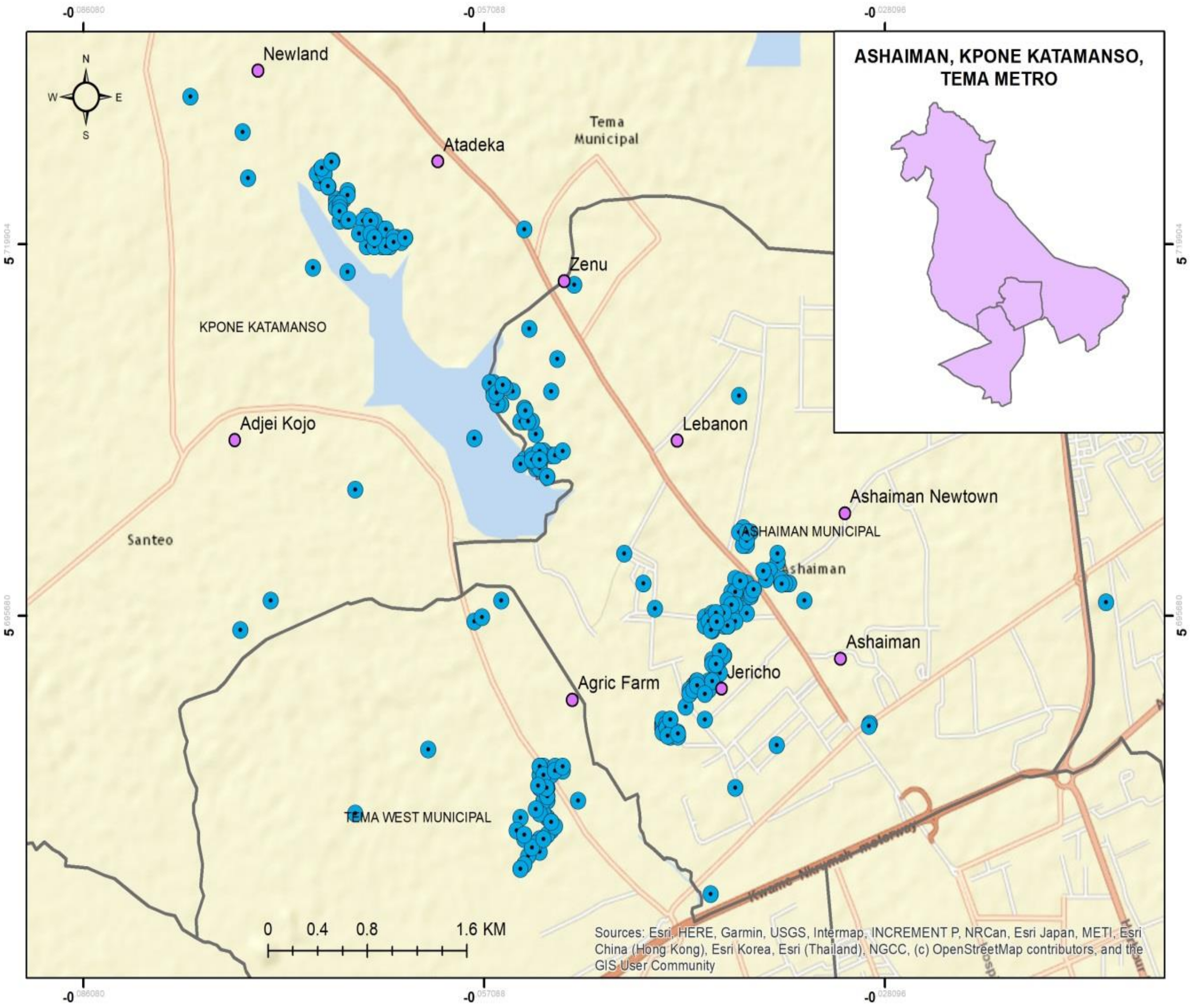
Table 4.2 The Level of Water Before and After Flooding in Ashaiman Municipality

Dataset	Date	Plane Height	Reference	Z-factor	Area size (2D)	Area (3D)	Volume (m^3)
Ashaiman Municipal	27/1/2017	75	Below	1	53346600	53346733.21	3895611300
Ashaiman Municipal	2/2/2017	75	Below	1	53346600	53347527.88	3966577200

Quantitatively, to determine the volume of water that was within the Ashaiman area two days after the flooding incidence, 3,895,611,300m^3 was subtracted from 3,966,577,200m^3. A difference of about 70,965,900 m^3 (see table 4.4) was realized. This volume of water is large enough to cause flooding if the drainage system is bad. If a forty-five (45) minutes rainfall can leave this volume of water after two (2) days, then how will be the impact of flooding in Ashaiman area be if there should be a two (2) or more hour continuous and intense downpour.

4.2.6 Objective Six

A total of 410 questionnaires were administered to individuals at the Ashaiman municipal area especially those along the waterways. These areas were chosen because people in these areas directly or indirectly experience the effects of flood during flood events. The GPS coordinates location for the places where the questionnaires were administered was also recorded.



Map 4.3 The GPS mapping of the various locations the questionnaires were administered

4.3 Descriptive Statistics

This section presents graphs and summary tables that describes the demographics of the respondents in terms of age, gender, educational background, etc. A total of 410 questionnaires were administered during primary data collection. However, about 400 questionnaires were successfully retrieved accounting for a response rate of 97.6%.

4.3.1 Gender of Respondent

The study categorizes gender into male and female. The outcome of the finding indicates that more than half (60%, n = 239) of the respondents were male while female constitutes 40% (n = 161) of the sampled population.

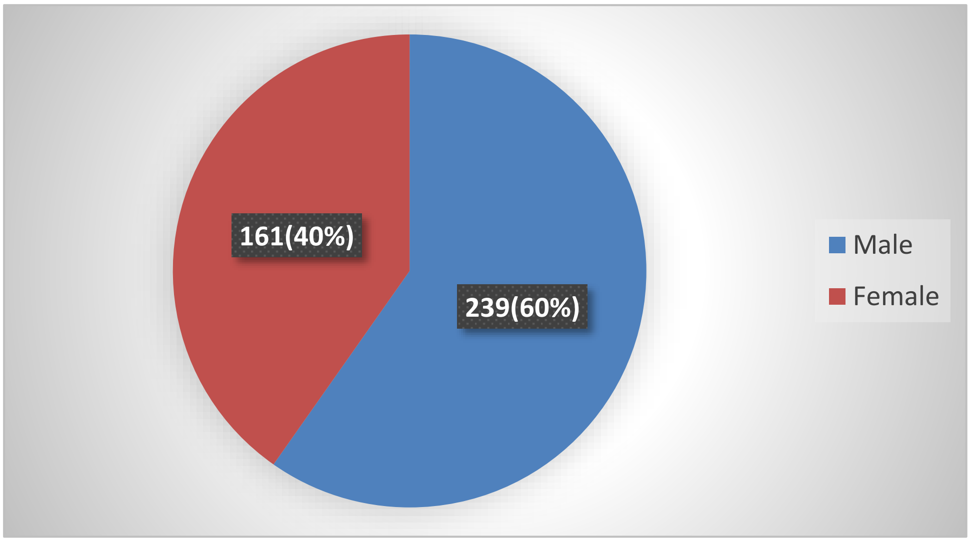


Figure 4.10 Gender of Respondent

4.3.2 Age of Respondent

Also, the study explored the age distribution of the respondents, which was categorized into ages between 18 and 30 years, between 31 and 45years, between 46 and 55 years, between 56 and 65 years, and 66 years and above. The study results revealed that majority of the respondent were between 31 and 45 years which constitutes more than half (57%, n =228) of the sampled respondent. In addition, the respondent between 18 and 30 years, between 46 and 55 years, between 56 and 65 years and 66 years and above constitutes 18% (n = 72), 18% (n = 72), 5% (n = 20) and 2% (n = 8) respectively.

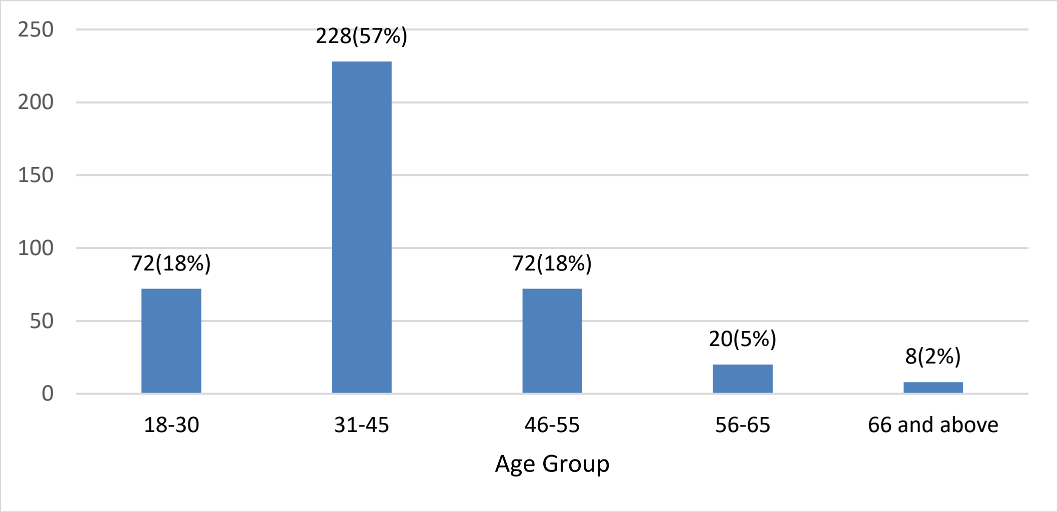


Figure 4.11 Age of Respondents

4.3.3 Marital Status

Moreover, the study investigates the marital status of the respondent. The outcome of the results indicates that majority of the respondent were married which constitutes more than two-third (79.06%, n =253) of the sample respondent. The respondent that were single, divorce and widow constitute 16.9 % (n = 54), 2.9% (n =9) and 1.25% (n = 4) respectively.

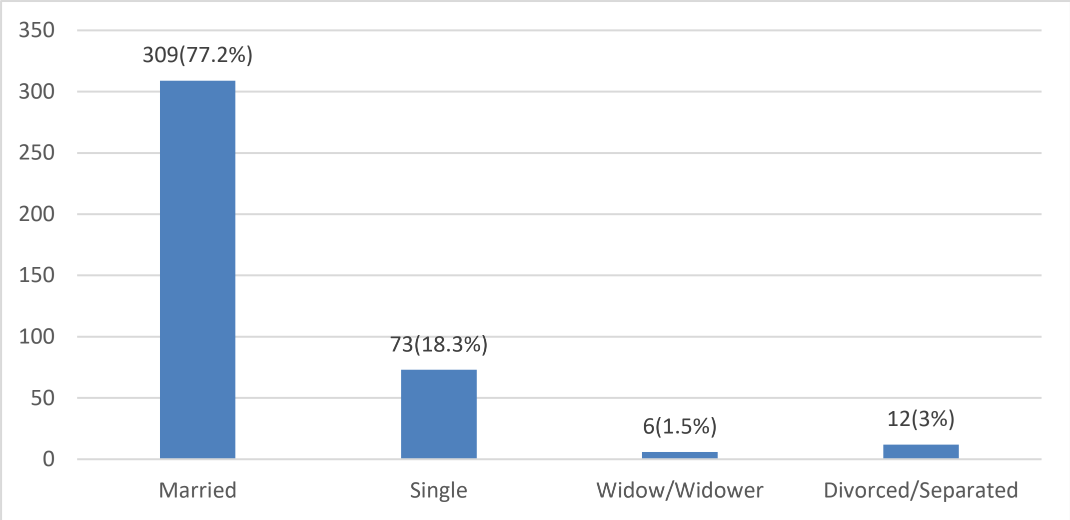


Figure 4.3 Marital Status of Respondent

4.3.4 Educational Background

The study investigates the educational background of the respondent. The outcome of the results indicates that majority (28%, n =112) of the respondent were had only up to JHS level. The respondents that had only up to No Formal Education, Primary, SHS and Tertiary constitute 26 % (n = 104), 12% (n =48), 22% (n =88) and 12% (n = 48) respectively.

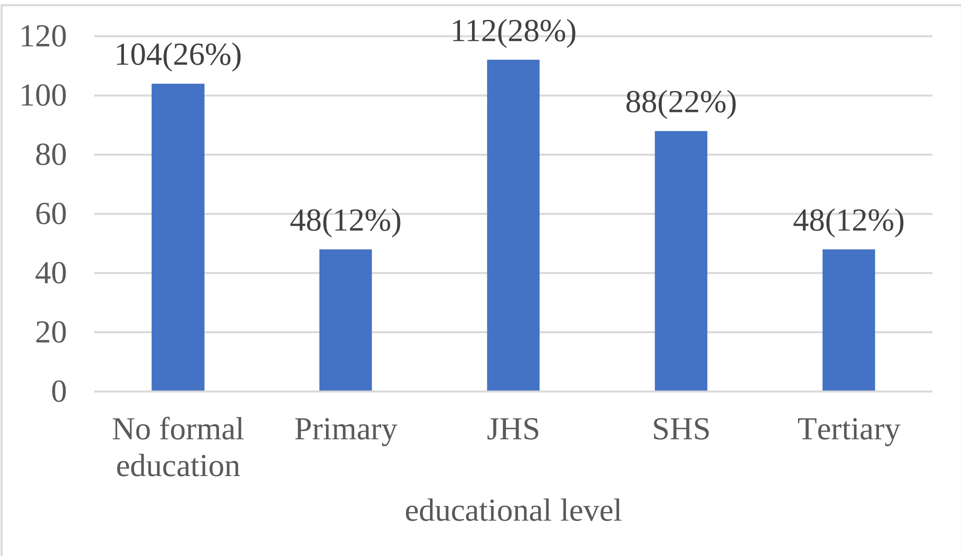


Figure 4.13 Educational Background of Respondent

4.3.5 Occupation

The study examined the occupation of the respondents. The study purposely classified into no occupation, trader/business, carpentry, driver, teacher, Mason, farmer and others. The findings of the study revealed that most of the respondent were trader/business which constitutes 49.75% (n = 199). This is followed by no occupation and driver which constitutes 13.5% (n = 54) and 10% (n = 40) respectively. In the case of their background, the outcomes portray that most of the respondent had attained basic education (Junior high school).

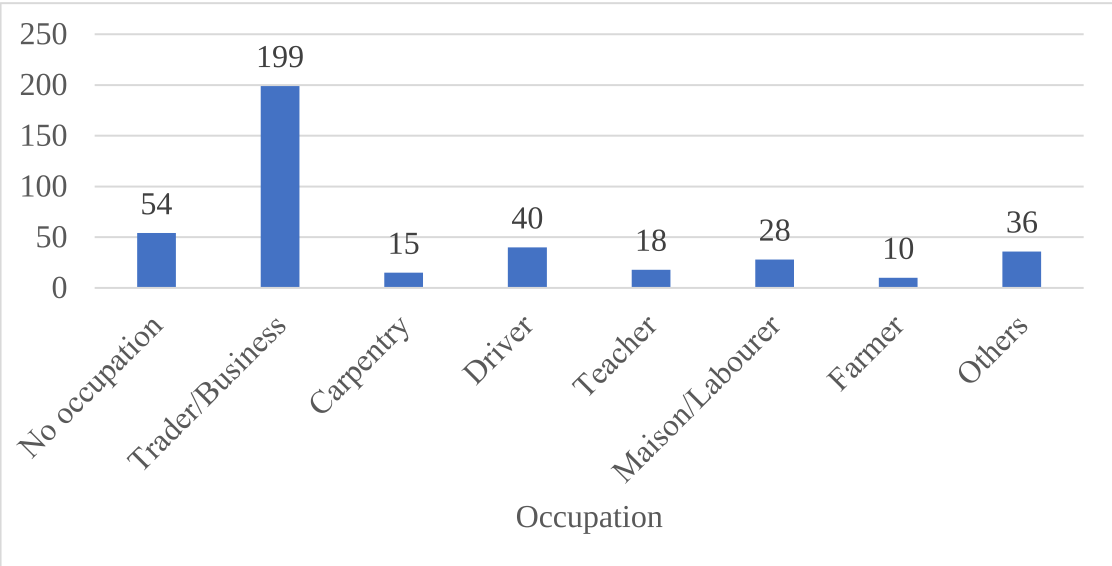


Figure 4.4 Occupation of Respondent

4.3.6 Household Size

In addition, the study explored number of household member and was categorized into 1 to 3, 4 to 6 and above 6. The result revealed that most of the household member numbered 4 to 6 which constitutes 48.5 % (n =194). Also, those respondent of who household members numbered above 6 represent a 30.25% (n =121) whiles those numbered 1 to 3 accounted for 21.25% (n = 85) of the sample respondent.

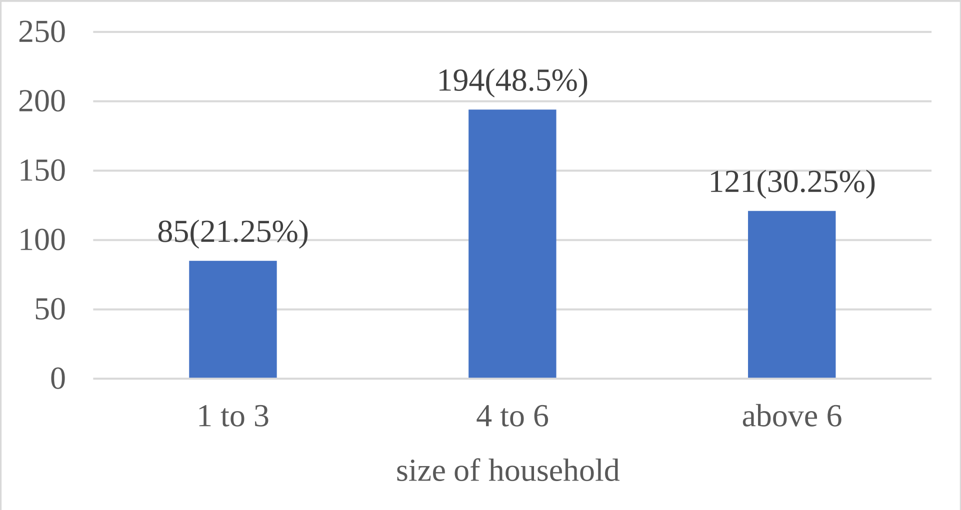


Figure 4.5 Household Size of Respondent

4.3.7 Years Lived in The Community

In another development, the study researches on the number of years spent in the community. The study categorizes the number of years spent into below 5 years, between 6 and 10 years, between 11 and 15 years, between 16 and 20 years and those above 20 years. About one-third (32.5%, n = 130) and (29.3%, n =117) of the respondent had live in the community between 11 and 15 years and between 6 and 10 years respectively.

Lastly, the study explored on the types of house the respondent. The respondent residential status was categorized into compound, detached, semi-detached and others. The study result revealed that more than half (57.5%, n=230) of the respondent reside in a compound house. The detached, semi-detached and other represent 27.8 % (n = 111), 10.3% (n =41) and 4.5% (n =18)

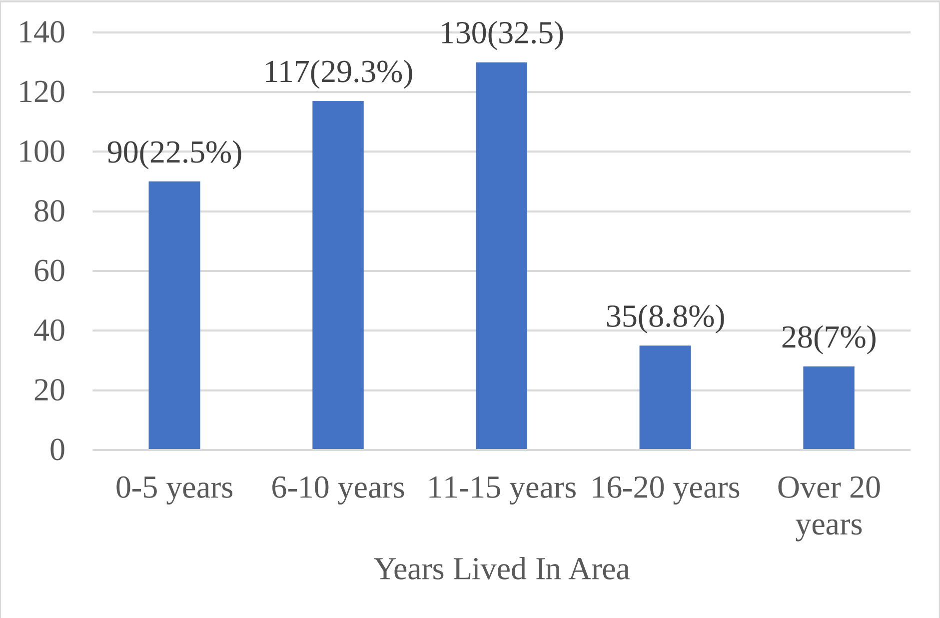


Figure 4.6 Educational Background of Respondent

4.3.8 Building Information

The study focused on the build information within the catchment area of study. Thus, the study explored the predominant use of land in the area, main material type used for the walls of the building in the area, main material type used for the wall of the building, type of floor of the house and the type of roof of the house. To begin with, the predominant land use of the area was categorized into residential, commercial and industrial and slum areas. Based on the findings, most of the respondent reside at commercial area (32.5%, n =130) and this followed by residential (32%, n =128). Also, some of the respondent live with in slum (31%, n =124) and few of the respondent reside at industrial (4.5%, n=18). Also, the main material type used are mostly concrete brick in cement (86.8%, n = 347). The study result indicates that four-fifth (86.8%, n = 347) of respondent reside in concrete brick in cement. In addition, most of the floor in their houses are made of concrete which constitutes (52.3%, n = 209). Lastly, the roof of the houses mad of Corrugated aluminium sheets (82.8%, n = 331).

Table 4.5 Building information

Variables		Frequency	Percentage
Predominant land of the area	Residential	128	32.0
	Commercial	130	32.5
	Industrial	18	4.5
	Slum	124	31.0
Main material type used for the walls of the building in your area	Concrete brick in cement	347	86.8
	Brick with mud	17	4.3
	Wood	36	9.0
Main material type used for the wall of your building	Concrete brick in cement	347	86.8
	Brick with mud	21	5.3
	Metal	2	0.5
	Wood	30	7.5
Floor in your house made of	Mud	107	26.8
	Wood	28	7.0
	Tiles	40	10.0
	Concrete	209	52.3
	Terrazzo	10	2.5
	Others	6	1.5
The roof of your house mad of	Corrugated aluminium sheets	331	82.8
	Asbestos	35	8.8
	Concrete	21	5.3
	Thatched/straw	11	2.8
	Others	2	0.5

4.3.9 Occupants in the Building

The study investigates the occupants in the building of resident using a descriptive statistic (minimum, maximum, mean and standard deviation). On average, the number of adults (18-65 years) that occupy the building is 3.37 with standard deviation of 3.12. Also, the number of older people (65 years) that occupy the building and number of children (1-17 years) that occupy the building were over-dispersed with Mean = 0.56 (SD = 2.27) and Mean= 2.79 (SD =3.44). ln addition, workers occupy the building, people who stay in the building during the day and during the night have a respective mean and standard deviation of 2.34 (SD = 2.18), 2.09 (SD = 1.74) and 5.78(SD= 7.37).

Table 4.6 Occupants in the building

Variables	Minimum	Maximum	Mean	Std. Deviation
How many adults (18-65years) occupy the building	1.00	30.00	3.37	3.12
How many older people (65 years) occupy the building	0.00	33.00	0.56	2.27
How many children (1-17 years) occupy the building	0.00	45.00	2.79	3.44
How many workers occupy the building	0.00	20.00	2.34	2.18
How many people stay in the building during the day	0.00	10.00	2.09	1.74
How many people stay in the building during the night	1.00	98.00	5.78	7.37

4.3.10 Experience with Flood on 8th April, 2019

In this section, the study examined the experience of flood within the community. The result in Table 4.7 indicates that there was experience of flood on 8th April 2019. This assertion was made by more than four-fifth (88.3%, n = 353) of the respondent claiming they experience flood on the said date. The flood affected these community, Lebanon (24.08%, n = 85), Dam site (21.81%, n = 77), Adakupe and Attadeka (21.25%, n= 75), Jordan (20.96% n =74), Agyei -kojo (20.40%, n = 72). New town (19.26%, n = 68), Jericho (18.98%, n =67), Jerusalem (16.71%, n = 59) and Valco Flat (15.30%, n =54). Furthermore, to ascertained the water level; most of the respondent said that it reached their ankle and knee which represent a proportion of 48.2% (n =170) and 22.9% (n 81) respectively. In addition, more than three-fourth of the respondent stated that their room properties were destroyed. All in all, on the average about 37.72 (SD=31.26) accounted for the extent of damaged.

Table 4.7 Experience 8th April 2019 flood

Variables		Frequency	Percentage
Experience 8th April 2019 flood	Yes	353	88.3
	No	47	11.8
Areas were heavily affected (n=353)	Adakupe	75	21.25
	Dam site	77	21.81
	Jordan	74	20.96
	Jerusalem	59	16.71
	Agyei Kojo	72	20.40
	Lebanon	85	24.08
	Valco flat	54	15.30
	New town	68	19.26
	Attadeka	75	21.25
	Jericho	67	18.98
Water level(n=353)	No flood	24	6.8
	Ankle	170	48.2
	Knee	81	22.9
	Hip	41	11.6
	Breast	21	5.9
	Head	14	4.0
	First floor	2	0.6
Specify the damage	Wall cracked	24	14.55
	Wall collapse	26	15.76
	Building collapse	29	17.58
	Room properties destroy	86	52.12
	Mean	**st. dev.**	**Range**
Percentage of damage	37.72	31.26	(0,100)

4.3.11 Experience of 14th April 2019 flood

The result in Table 4.8 indicates that there was experience of flood on 14th April 2019. This assertion was made by more than two-third (76.5%, n = 306) of the respondent claiming that they experienced flood on the said date. The flood affected communities such as Lebanon (12.42%, n = 38), Dam-site (9.8%, n = 30), Attadeka (6.48%, n= 29), Jordan (14.38% n =44), Agyei kojo (9.8%, n = 30). New town (10.46%, n = 32), Jericho (13.4%, n =41), Jerusalem

(8.5%, n = 26) and Mali (7.2%, n =10). Furthermore, to ascertained the water level; most of the respondent said that it reached their ankle and knee which represent a proportion of 42.16% (n = 129) and 19.61% (n = 60) respectively. In addition, more than half (50.9%, n =58) of the respondent stated their room property were destroyed. All in all, on the average about 32.30 (SD = 32.89) accounted for the extent of damaged.

Table 4.8 Experience 14th April 2019 flood

Variable		Frequency	Percentage
Do you remember the 14th April 2019 flood	Yes	306	76.5
	No	56	14.0
Areas is heavily affected (n=306)	Adakupe	38	12.42
	Dam site	30	9.80
	Jordan	44	14.38
	Jerusalem	26	8.50
	Agyei Kojo	30	9.80
	Lebanon	38	12.42
	Mali	30	9.80
	New town	32	10.46
	Attadeka	29	9.48
	Jericho	41	13.40
Water level (n=306)	No flood	69	22.55
	Ankle	129	42.16
	Knee	60	19.61
	Hip	24	7.84
	Breast	11	3.59
	Head	12	3.92
Own house or other houses (n=306)	Yes	114	37.25
	No	192	62.75
Specify the extent of damage (n=114)	Wall cracked	15	13.2
	Wall collapse	23	20.2
	Building collapse	18	15.8
	Room properties destroy	58	50.9
	Mean	**st. dev.**	**Range**
Percentage of damage	32.30	32.89	(0,98)

4.3.12 Experience of 31st January 2017 flood

The result in Table 4.9 indicates that there was experience of flood on 31th January 2017. This assertion was made by more than two-third (62.0%, n = 248) of the respondent claiming they didn't experience flood on the said date. The flood affected communities such as Adakupe and New-town (24.3%, n = 37), Dam-site, Jordan and Mali Estate (21.1%, n = 32), Adjei-kojo (19.7%, n = 30), Jericho (19.1%, n =29), Lebanon and Attadeka (18.4%, n = 28) and Free town (17.1%, n = 26). Furthermore, to ascertained the water level; most of the respondent said that it reached their ankle and knee which represent a proportion of 35.5% (n = 54) and 10.5% (n =16) respectively.

In addition, few of the respondents stated that their room properties were destroyed. All in all, on the average about 35.31 (SD = 32.20) accounted for the extent of damaged.

Table 4.9 Experience 31st January 2017 flood

Variable		Frequency	Percentage
Experience 31st January 2017 flood	Yes	152	38.0
	No	248	62.0
Area is heavily affected(n=152)	Adakupe	37	24.3
	Dam site	32	21.1
	Jordan	32	21.1
	Jerusalem	26	17.1
	Agyei Kojo	30	19.7
	Lebanon	28	18.4
	Mali	32	21.1
	New town	37	24.3
	Attadeka	28	18.4
	Jericho	29	19.1
	Free town	26	17.1
Water level(n=152)	No flood	55	36.2
	Ankle	54	35.5
	Knee	16	10.5
	Hip	12	7.9
	Breast	8	5.3
	Head	7	4.6
Own Building or other House	Yes	31	20.4
	No	121	79.6
specify the extent of damage (n=31)	Wall cracked	2	6.45
	Wall collapse	2	6.45
	Building collapse	4	12.90
	Room properties destroy	23	74.19
	Mean	**st. dev.**	**Range**
Percentage of damage	35.31	32.20	(2,98)

4.3.13 Experience 15th July 2015 flood

The result in Table 4.10 indicates that there was experience of flood on 15th July 2015. This assertion was made by more than half (51.8%, n = 207) of the respondent claiming they experienced flood on the said date. The flood affected communities such as Lebanon (19.8%, n = 41), New town (17.9%, n = 37), Jericho (10.6%, n =22), Free town and Adjei-kojo (8.7%, n = 20), Dam site and Jordan (14.0%, n = 29), Mali Estate and Attadeka (21.3%, n=44) and Jerusalem (11.1%, n = 23). Furthermore, to ascertained the water level; most of the respondent said that it reached their ankle and knee which represent a proportion of 36.7% (n = 76) and 27.1% (n = 56) respectively. In addition, more than two-third (n =60) of the respondent stated that their room property was destroyed. All in all, on the average about 40.57 (SD = 30.77) accounted for the extent of damaged.

Table 4.10 Experience 15th July 2017 flood

Variables		Frequency	Percentage
Experience 15th July 2015 flood	Yes	207	51.8
	No	193	48.2
Area is heavily affected(n=207)	Adakupe	26	12.6
	Dam site	29	14.0
	Jordan	29	14.0
	Jerusalem	23	11.1
	Agyei Kojo	20	9.7
	Lebanon	41	19.8
	Mali	44	21.3
	New town	37	17.9
	Attadeka	44	21.3
	Jericho	22	10.6
	Free town	20	9.7
Water level(n=207)	No flood	11	5.3
	Ankle	76	36.7
	Knee	56	27.1
	Hip	43	20.8
	Breast	13	6.3
	Head	8	3.9
Your building itself or other building damaged	Yes	80	25.0
	No	113	35.3
Specify the extent of damage(n=80)	Wall cracked	7	8.8
	Wall collapse	5	6.3
	Building collapse	8	10.0
	Room properties destroy	60	75.0
	Mean	**st. dev.**	**Range**
Percentage of damage	40.57	30.77	(2,100)

4.3.14 Experience of the 2010 flood

The result in Table 4.11 indicates that there was flood experience in 2010. This assertion was made by more than half (58.3%, n = 233) of the respondents claiming they experienced flood on the said date. The flood affected communities such as Adakupe and New-town (18.0%, n = 42), Jordan and Mali Estate (15.9%, n = 37), Agyei kojo (15%, n = 35), Jericho (14.6%, n =34), Lebanon and Attadeka (14.2%, n = 33). Furthermore, to ascertained the water level; most of the respondents said that it reached their hip and head which represent a proportion of 25.3% (n =59) and 23.6% (n =55) respectively. In addition, few of the respondents stated that their room properties were destroyed. Generally, the average about 58.89 (SD = 30.32) accounted for the extent of damaged.

Table 4.3 Experience 2010 flood

Variable		Frequency	Percentage
Experience 2010 flood	Yes	233	58.3
	No	167	41.8
Area is heavily affected(n=233)	Adakupe	42	18.0
	Dam site	37	15.9
	Jordan	37	15.9
	Jerusalem	31	13.3
	Agyei Kojo	35	15.0
	Lebanon	33	14.2
	Mali	37	15.9
	New town	42	18.0
	Attadeka	33	14.2
	Jericho	34	14.6
	Free town	31	13.3
Water level(n=233)	No flood	7	3.0
	Ankle	39	16.7
	Knee	31	13.3
	Hip	59	25.3
	Breast	38	16.3
	Head	55	23.6
Own House or Other House	Yes	31	9.7
	No	127	39.7
specify the extent of damage(n=31)	Wall cracked	9	29.0
	Wall collapse	6	19.4
	Building collapse	5	16.1
	Room properties destroy	11	35.5
	Mean	**st. dev.**	**Range**

Percentage of damage	58.89	30.32	(0,100)

4.3.15 Risk factors for Flooding in your Community

In Table (4.13) provide information about the causes of food within the study catchment area. The causes of flood were mainly; poor drains, choked drains, topography of the land, building on water ways, impervious ground, overflow of water bodies and poor waste management. Most (55.6%, n = 178) of the respondent stated that choked drain was the major cause of flood. Also, the study result revealed that slight less than half (49.1%, n =157) of the entire respondent claimed that building on water ways. In addition, poor drains (47.8%, n =153), overflow of water bodies (47.8% n =153) and topography of the land (36.6 %, n=117) causes flood in the community.

Table 4.4 Risk factors of Flooding in your Community

Causes of Flood	Frequency	Percentage
Poor drains	153	47.8
Choked drains	178	55.6
Topography of the land	117	36.6
Building of water ways	157	49.1
Impervious ground	72	22.5
Overflow of water bodies	153	47.8
Poor waste management	94	29.4

4.3.16 Ways of Solving Flooding Problems

Table 4.14 revealed the ways of solving flooding problems; these include construction of proper and big drains, clear choked drains, clear building on water ways, stop constructions on water ways, build far from water ways, build far from water bodies and clear building. Most of them claims that the construction of proper and big drains (72.5%, n =290), clear choked building on water ways (56%, n =224), build far from water bodies (46.25%, n =185), clear building on water ways (39.25%, n =157), stop constructions on water ways (35%, n = 140) and clear building close to water (17.5%, n =70) can solve the flood problems. Generally, the way to solve flood problem will be construct proper and big drains in the community to ease whenever its rains.

Table 4.5 Ways of Solving Flooding Problems

Ways of Solving Flooding Problems	Frequency	Percentage
Construct proper and big drains	290	72.5
Clear choked drains	224	56.0
Clear buildings on water ways	157	39.25
Stop constructions on water ways	140	35
Build far from water bodies	185	46.25
Clear buildings close to water	70	17.5

4.3.17 Effects of Flooding

The study assessed the health conditions of the respondent in the study catchment. In the case of disease, most of the respondent claimed that they experience diseases in the community. The study results posited that 85.25% (n = 341) of the sampled respondent accepted the claims. The affected diseases include Cholera, Malaria, Typhoid and Bilharzia. On a large extent, the respondent rank Malaria (n =235) as highly affected, this is followed by Cholera (n =216), Typhoid (n =39) and Bilharzia (n=8). Also, majority of the respondent posited that they did not experience injuries (67%, n = 268) and death (74%, n = 296). In another development, most of respondent posited that they experienced pests in the community. The pests were mosquitoes, worms, termites, rats, frogs and cockroaches. The most predominate pest was mosquitoes (58.25%, n=233) and least was rat/mouse (6.25%, n= 25).

Table 4.6 Health Conditions

Health conditions	Frequency	Percentage
Types of diseases		
No disease	59	14.75
Cholera	216	54.00
Malaria	235	58.75
Typhoid	39	9.75
Bilharzia	8	2.00
Injuries		
Yes	132	33.00
No	268	67.00
Pests		
No pest	29	7.25
Mosquitoes	233	58.25
Worms	106	26.50
Termites	51	12.75
Rats/mouse	25	6.25
Frogs	26	6.50
Cockroaches	21	5.25
Death		
Yes	104	26.00
No	296	74.00

4.4 Inferential Analysis

4.4.1 ANOVA Test for Type of House and Damaged Cause by Flood

The study examined the statistical difference between type of house and damage caused by flood using Analysis of Variance (ANOVA).

In the percentage of damage in 8th April 2019, 14th April 2019, 31st January 2017, 15th July2015 and 2010 flood have statistically significant difference between type of house (Compound, Detached, Semi-detached and others). In all flood experienced, people living in detached houses experienced the most damage caused by the flood.

Table 4.7 ANOVA Test for Type of House and Damaged Cause by Flood

	Types of House	Mean	Std. Deviation	df1, df2	F-statistics	p-value
Percentage of damage (8th April, 2019)	Compound	35.27	26.36	3,307	11.68	0.0000
	Detached	52.00	35.44			
	Semi-detached	24.45	35.80			
	Others	12.33	17.13			
Percentage of damage (14th April, 2019)	Compound	26.57	29.62	3,231	17.28	0.0000
	Detached	53.84	33.16			
	Semi-detached	19.90	29.36			
	Others	5.00	0.00			
Percentage of damage (31st January, 2017)	Compound	29.62	24.94	3,112	43.137	0.0000
	Detached	73.43	23.97			
	Semi-detached	5.00	0.00			
	Others	5.00	0.00			
Percentage of damage (15th July, 2015)	Compound	39.94	29.62	3,198	10.39	0.0000
	Detached	58.75	32.05			
	Semi-detached	14.71	15.56			
	Others	20.00	0.00			
Percentage of damage (2010)	Compound	63.13	27.44	3,208	4.79	0.0030
	Detached	53.45	38.01			
	Semi-detached	40.50	16.93			
	Others	80.00	0.00			

4.4.2 Building Information and Damaged Cause by Flood

The study examined the statistical difference between building information and damage caused by flood using Analysis of Variance (ANOVA).

In the percentage of damage in 8th April 2019, 14th April 2019, 31st January 2017 and 15th July 2015 have statistically significant difference between main materials used in building (Concrete brick in cement, brick with mud and wood). However, with regards to 2010 flood there was no significant difference between main materials used in building. This was because the flood experienced in 2010 was heavy and as a result caused damaged regardless of the materials used in building.

Table 4.8 Test for Building Information and Damaged Cause by Flood

	Main materials used	Mean	Std. Deviation	df1, df2	F-statistics	p-value
Percentage of damage (8th April, 2019)	Concrete brick in cement	34.91	29.90	2,308	29.84	0.0000
	Brick with mud	13.00	11.12			
	Wood	72.97	22.58			
Percentage of damage (14th April, 2019)	Concrete brick in cement	29.19	31.96	2,232	15.47	0.0000
	Brick with mud	10.00	0.00			
	Wood	64.46	25.58			
Percentage of damage (31st January, 2017)	Concrete brick in cement	37.06	32.67	2,113	3.37	0.0390
	Brick with mud	15.00	0.00			
	Wood	2.00	0.00			
Percentage of damage (15th July, 2015)	Concrete brick in cement	37.66	29.91	2,199	9.05	0.0000
	Brick with mud	36.36	30.79			
	Wood	66.57	26.04			
Percentage of damage (2010 flood)	Concrete brick in cement	59.18	29.11	2,209	0.051	0.9510
	Brick with mud	56.91	35.48			
	Wood	57.67	37.44			

4.4.3 Correlation between Number of People in a Building and Damaged Cause by Flood

The study evaluates the Correlation between number of people living in a building and damaged caused by flood using Pearson correlation.

To start with number of adults (18-65years) that occupy the building and percentage of damage in 8th April 2019, 14th April 2019 and 31st January 2017. It found that there is a positive relationship between the number of adult and percentage of damage. This implies that as the number of adults living in a building increase, the percentage of damages causes by flood also increases. The number of older people (65 years) that occupy a building, number of children (1-17 years) that occupy a building and number of people that stay in a building during the night were all having a significant relationship with the percentage of damages caused by the flood. This also means that as the number of people living in a building increases the chances of damages caused by the flood also increases.

However, numbers of older people (65 years) that occupy a building, number of children (1-17 years) that occupy a building, number of people that stay number of people stay in a building during the day has no significant relationship with percentage of damage in 15th July2015. This can be explained that when the degree of flood is high, it does not matter the numbers of people living in a building, the percentage of damage are similar.

Table 4.9 Correlation of Number of People in the Building and Damaged Cause by Flood

		Percentage of damage				
		8th April, 2019	14th April, 2019	31st January, 2017	15th July, 2015	2010
Number of adults (18-65years) occupy the building	Corr.	.251**	.225**	.265**	0.122	.216**
	p-value	0.000	0.001	0.004	0.083	0.002
Number of older people (65 years) occupy the building	Corr.	.191**	.200**	.210*	-0.008	0.084
	p-value	0.001	0.002	0.024	0.911	0.221
Number of children (1-17 years) occupy the building	Corr.	.225**	.158*	.278**	0.028	0.097
	p-value	0.000	0.015	0.003	0.691	0.160
Number of people stay in the building during the day	Corr.	.304**	.262**	.324**	0.102	.255**
	p-value	0.000	0.000	0.000	0.148	0.000
Number of people stay in the building during the night	Corr.	0.075	0.070	.317**	0.102	-0.024
	p-value	0.185	0.285	0.001	0.147	0.734

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This section discusses the results of the analysis presented in chapter four. The discusses are done with respect to extant literature relative the specified objective of this study. The discussion is presented in two parts; discussion on the qualitative geological fieldwork, discuss on the analysis of questionnaire results.

5.2 Specific Objectives

5.2.1 Objective One: Aerial view of the Ashaiman main natural waterway

The Ariel view of the area with the mechanical Drone shows clearly that most of the settlements are on and immediately around the waterway. An overflow of some of these watercourses is a potential risk factor for flooding (Picture 5.1). From the aerial view of the Ashaiman main natural waterway, it can be seen that there are three dams all with outflows down towards the direction of the sea through the channels and streams that meander through Ashaiman. The Ashaiman dam is visibly the largest among all the dams in the Ashaiman Municipality; it is the largest dam. It receives inflows downhill from the Akuapem Ridge which flows at significant volumes when there is a downpour, however, from the map, it is seen that only one narrow channel may have been purposed for excess water to flow when its volume capacity is exceeded. Along its path, the water in the Rivers and Streams serves as a receptacle to receive water from secondary and tertiary drains and also storm water from its environs which makes the buffer zones soaked with water. Also, around these dams, especially the Ashaiman dams are populated communities, Zenu, Attadeka among those and communities and human activities around water bodies are known to significantly affect flood and increases the risk of flooding, as was reported by (Karley, 2009).

5.2.2 Objective Two: Assessing the Trend Pattern in Ashaiman Catchment Area Using Bayesian Time Series

The results of the time series analysis indicated that though there was fluctuation of the intensity of rainfall and that most of the floods that occur in the catchment were between the months of May to August each year, a posterior distribution of rainfall pattern in Ashaiman show that the municipality does not experience heavy rainfall frequently and so the continuous flooding is not as a result of heavy downpour. This implies that the flooding experienced could be due to defective and or inadequate drainage system and other anthropogenic effect.

5.2.3 Objective Three: Compute flood return period of the Ashaiman catchment areas.

From the results of the Gumbel Extreme Value Probability Distribution for flood return period of Ashaiman catchment area which tells us about the probability of extreme flooding event, it can be inferred from the trend equation (fig. 4.5) that the Ashaiman municipality is expected to experience/ witness more increasing levels of flooding events with its damaging effects. From predictions by this distribution and with factors remaining as there are, in about 100 years, flood discharge will be expected to be around $250m^3$ with the Ashaiman municipality and this obviously will bring along significant damaging effects.

5.2.4 Objective Four: Determine the borders of the water bodies before and after floods

The Remote Sensing images show that the whole Kpone-Katamanso area gently slopes towards the sea (Fig. 4.6). It also demonstrates the topography (high and low grounds) of the general area and in particular the Ashaiman Municipal area that aid the flow of water. Regardless of the Dzorwulu River coming all the way from the Aburi Mountains, the catchment area for storm water that is likely to cause flood in the Ashaiman Municipality starts from Aunty Araba community and the surrounding communities. This means that it is only in extreme cases that water from the mountains cause flood in the Ashaiman municipality.

From the aerial map and drainage patterns of the water bodies in the Ashaiman municipality it can be inferred that several water bodies streaming from various communities as far as the Aburi Mountains flow into those in the municipality through to the sea and this results in a widening of the natural borders on waterways and dams in the Ashaiman. Hence, flooding in Ashaiman Municipality is highly probably whenever there are simultaneous events of rainfall in Ashaiman and those communities uphill the water channels. And this is similar to results obtained by Codjoe, S. N. A., & Afuduo, S. (2015) that flood risk in areas is compounded by drainage systems, silting and choking of drains, and land-use change.

5.2.5 Objective Five: Determine the extent of flooding in the Ashaiman catchment area during heavy rains.

From the pre rainfall and post rainfall satellite image of the Ashaiman community around the waterbodies, it is visible that there is significant amount of surface flooding clearly sighted. Furthermore, the difference in the quantitative measurements of pre rainfall and post rainfall measurements is about 70,965,900 m^3. The gathering or pooling of this amount of water in the waterbodies and lagoons is indicative of the flood prone nature of the Ashaiman, as also reported by Twumasi, et al. (2002) of low-lying flood-prone that experience flood hazards.

5.2.6: Objective Six: The perception of the residents of Ashaiman on the risk factors, the effects and possible management of flooding in the area

On the perceived risk factors, it can be inferred from the analysis that majority of the respondents from Ashaiman thought choked drains or building on waterways were the common significant risk factors for floods in the Ashaiman community. This can be inferred that; the community members are of the opinion that human activities but domestic and economic play a significant impact on flooding risk in communities and this is in line with several extant studies such as reported by (Karley, 2009).

On the perceived effects of flood, it can be inferred from the analysis that most of the respondent reported suffering from physiological effects of insect infestation and its related illness of malarial but discounted fatalities or significant injuries as an effect of flooding. Again, on the proposed solutions on managing floods, it can be inferred from the analysis that most of respondents suggested human infrastructural changes and changes in social behaviours especially around the waterways and drainage facilities and these are in line with findings of by (Arnold et al., 1996; Yeboah 2000; Afeku 2005). The effectiveness of mitigation measures depends on among other things, the prevailing hydrological and environmental circumstances. These measures can be categorized as either structural or non-structural.

5.2.7 Objectives seven: To interview experts on issues of flood and flood control; the risk factors, effects and management of flood.

Experts from the Head of Geography Department, University of Ghana, Legon, the Chief Operation Officer, National Disaster Management Organization (NADMO) Headquarters and the Head of Hydromet at the Hydrological Department were interviewed for their expert knowledge and views on the issues of flooding, risk factors, effects and flood management efforts.

At the interview with the expert, the Head of Geography Department, University of Ghana, Legon, (2020), "the whole of Accra is a lowland basin that stretches from the surrounding mountains to the Sea (Gulf of Guinea) so prone to flooding". This assertion was shared by the Chief Operation Officer, NADMO Headquarters (2020) and supported by Mr Seth Kudzordzi, the Head of Hydromet at the Hydrological Department. The primary reason for most of the floods in the Greater Accra Region is that Accra is general a lowland below sea level with a relatively high-water table' and this corroborate findings of (Nyarko, 2002). "This makes the ground easily saturated with water whenever it rains heavily thereby increasing the surface runoff water that cause flooding, affecting human lives, livestock and physical properties" (See Map1.1). Speaking on the Remote Sensing Images, "the Ashaiman general area also has a gentle slope towards the sea though there are some flat and undulating areas. The land was originally waterlogged, marshy, salty and porous with most areas having clay soil. It is one of the typical natural land reserves which should have been left untouched to ensure the growth of the ecosystem. Such lands are usually neither for crop cultivation nor major engineering works" (see Fig 4.6, Fig 4.7 & Fig 4.8B).

Again, in an interview with the Head of Hydromet , Ghana Hydrological Department,(2020), "in addition to the Municipality being waterlogged, the Ashaiman general area also serves as a passage-way or a natural course for the waterfall and surface runoff or storm water (Rivers, Streams) from the Akuapem Range precisely the Aburi Mountains and storm water from neighbouring town all the way to the Sea" (see Map 5.2 & Map 5.3 in appendix). "This is called the SAKUMONO BASIN. Large volume of water gushes out of the rocks during the rainy seasons, together with the storm water in the Sakumono basin and that from the Ashaiman catchment area increases the volume of water that pries the Dzorwulu River and the Gbemi Stream. This phenomenon causes the water to sometimes overwhelm or overflow the banks of the primary and secondary drains and potentially cause flooding to settlements in the buffer zones and beyond.

Water naturally flows through very lowlands or valleys with a gradient into a receptacle (Lake, River, Lagoon or Sea). In the Sakumo basin, the waters that flow through the municipality are the Dzorwulu River and the Gbemi Stream. The Gbemi Stream is also joined at some point by the Amatsuru Stream. They all join at the Adjei–Kojo Underbridge area and serve as the catchment or watershed for the Municipality (Fig 5.2). Due to the blockade of the flow of the River by the construction of the main Accra-Tema Motorway, the water sometimes dams at the Adjei-Kojo Under-Bridge area with the Fitaline community as its Buffer Zone".

He further added, "Over a long period of time, the movement of the water in the rivers creates large gullies and furrows which were mechanically expanded as large primary (Earth) drains to contain large volume of water. Large volume of water gushes out of the rocks during the rainy seasons, together with the storm water in the Sakumono basin and that from the Ashaiman catchment area increases the volume of water that pries the Dzorwulu River and the Gbemi Stream. This phenomenon causes the water to sometimes overwhelm or overflow the banks of the primary and secondary drains and potentially cause flooding to settlements in the buffer zones and beyond. The excess water then flows into and along the Buffer Zones which by convention is estimated to be about sixty (60) meters radius on both sides the main waterway. Some of these primary (Earth) drains have been intentionally created to divert water in order to make room for settlements. As large volume of water flows in the earth drains, nature creates reservoirs along the path of the Rivers and Streams so that excess water could be stored and later released in bits into the waterway when the water pressure is relatively low for onward movement into the Sea. The vegetative cover in the buffer zones also absorbs excess water and slows down the water current. At some points along the Sakumono Basin, the water (River and stream) was intentionally dammed during the post-colonial era for irrigation of farmlands over the years and to serves as drinking water for livestock. Tunnels have been placed under the dam to control the release of the water for the irrigation purpose. Unfortunately, most parts along the Gbemi Stream from the Michel Camp Dam have been encroached and the water diverted at some points to create more space for more settlements. The encroachment immediately along the watercourse contributes to flooding in the area as excess water easily enters people's home even with minimal rainfall".

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Introduction

This section provides a complete summary of the study, highlighting on key major findings of the study.

First of all, it is expected that the Ashaiman municipality is experience/witness more increasing levels of flooding events with its damaging effects in future generations if extant factors are to remain. Also, the inhabitants of communities along and around the Ashaiman municipality fully understand and acknowledge most risk factors of flooding such as building in waterways, poor waste management which can choke drains leading to flooding as well as the lack of proper drainage systems in their communities.

6.2 Summary of Findings

6.2.1 Hydrological Factors

Ashaiman like most communities in Accra is generally lowland below sea level with a relatively high-water table making its ground easily saturated when it rains heavily leading to flooding, affecting human lives, livestock and properties. The Ashaiman Municipality, as part of the Kpone-Katamanso Constituency in particular is lowland that lies between the Akuapem Range and the Sea. The Ashaiman general area also serves as a passage-way or a natural course for surface runoff water or storm water (Rivers, Streams) from the Akuapem Range precisely the Aburi Mountains and the surrounding Storm Water. Due to the blockade of the flow of the River by the construction of the main Accra-Tema Motorway, the water sometimes dams at the Adjei-Kojo Under-Bridge area with the Fitaline community as the buffer zone. An overflow of these water bodies is a potential for flooding.

6.2.2 Meteorological Events

Climate change has not really had a significant change in the intensity of rainfall in the Ashaiman municipality but rather a shift in the period of rainfall. Although the rainfall pattern might change in terms of intensity (frequency and volume) in the catchment area due to climate change in the future, it should not necessarily have an impact on flood situation in the area if there is proper planning and engineering of the municipality with particular attention to the watercourse and settlement areas.

6.2.3 Anthropological Activities

In order to create more space for new settlers, most parts of the waterway (the Dzorwulu River and the Gbemi Stream) and their buffer zones were encroached with buildings. Flowing water was blocked with constructions, new gutters were created to divert some streams, natural water reservoirs were filled with sand and stones, roads and concrete pavements were also constructed at certain area. After the 1980s, a little bit of planned structural layout was observed at the new settlement areas especially at the Atta-deka area and beyond. In 2000 slums dwellers began to upgrade and improve the slum constructions, Ashaiman then metamorphosed into a municipality.

Engineering works of the drainage system such as the primary (earth), secondary and road side drains, bridges and culverts on the Sakumono Basin are poorly constructed and maintained considering the volume of water that passes through this area. This is the reason why settlements close to the big gutters (primary drains) and portions of the Accra-Tema motorway and its immediate surroundings especially around the Adjei-kojo area gets flooded almost every year during the heavy rainy seasons.

6.2.4 The Effects

The respondent reports suffering from physiological effects of insect pest infestation and its related illness of malarial but discounted fatalities or significant injuries as an effect of flooding. Again, the respondents reported of structural damages to the homes and households and some amount of effects on their socioeconomic activities.

6.2.5 Physical effects

The ANOVA test performed from the data collected show a significant statistical difference between the percentage damage to houses and the type of houses (compound, detached, semi-detached and others). People in detached houses experienced the most damage. The analysis also proved that there is more damage to house built with wood than concrete houses.

Some of the people in the Ashaiman area, especially those close to the waterways are subsistent farmers who are engage in the crop cultivation and keeping livestock. There is also a major commercial rice farm at the Adjei-kojo and Ashaiman Lebanon area on the waterway. During flood situations most of the farms get submerged in the water destroying almost all of the crops. Some farm animals lose their lives. This leads to hunger and poverty among the farmers since most of them depends on the crop yield and sale of livestock to make a living. Farmers lose revenue and gets frustrated during the rainy seasons when their stored food at the various storage sites gets damaged by floods.

Most shops in flood prone areas get closed during floods situations. These shops include groceries, clothing shops, food vendors, petty traders, gas filling stations, wholesalers and retailers and the market in general. Businesses come to a standstill because water sometimes enters shops destroying or soaking most of its contents. This slows down the local business which invariably affects the local and national economy. Food vendors' stands are sometimes carried away by the water current which denies most artisans food at their work places. In the year 2010 flood, Petty traders including those who operate small grocery and clothing shops had their wares soaked deep in water with damage to most of their items. This results in huge loss to the investment which invariably affected their standard of living. The manager of the gas filling station (GOIL) built along the waterway or drain at New-Town and close to the vehicular bridge stated clearly that anytime it rains heavily he is not able to operate. The sale of fuel and transport services is thereby affected. He said that the flood water sometimes goes as far as hundred (100) meters away from the filling station destroying properties and commercial ventures. Carpentry shops and other artisanal shops also suffer similar fate.

Currently, none of the roads and bridges in the municipality has suffered massive damage by floods only that bits and pieces of asphalt break off due to poor constructional works or weakened by flood water and continual usage. However due to the poorly engineered road network, deficient drainage system and haphazard settlements the storm drains (secondary and tertiary drains) are not able to contain the storm water when there is heavy and continuous rainfall. The roads therefore become flood with large volume of water making the roads immovable creates thick vehicular traffic. This is reason for the vehicular traffic experienced on the main Accra-Tema motorway around the Adjei-kojo area whenever it rains. Vehicles, kiosk and container are sometimes carried away. The vehicle of the two soldiers who perished on the motorway was carried away by the flood water.

6.2.6 Environmental Effects

The areas in Ashaiman that flood the most are settlements along the Gbemi Stream and the Dzorwulu River such as Newtown, Jericho, Lebanon Zone 5 and many other. Most of the houses that record floods are mainly in the slum areas. Apart from the loss of lives as a result flooding, properties of people get damaged, the environment get filthy, houses collapse especially wooden structures, and mud houses, people lose money, food shortage, water contamination, destruction of farm lands, clothing get wet or spoil, books also get damage and many more. Flood also may result in population displacements. Anxiety, neurosis and depression are some of the mental torture people go through.

Floods normally bring lot of filth into the Ashaiman communities. This is because the water brings up and out some of the garbage thrown into the drains. The garbage and filth invite lot of houseflies and other insects that aids in the transmission of diseases. Malaria is one such disease that increases weeks after flood because of the numerous breeding sites for the vectors. During flood situations some of the septic tanks get damaged with resultant release of faecal matter that contaminates our water bodies. Due to these faecal pollution typhoid, cholera and other diarrheal diseases are common during flood situation. The risk of epidemic outbreak of communicable diseases is proportional to population density and displacement. These conditions increase the pressure on water and food supplies and the risk of contamination, the disruption of pre-existing sanitation services and failure to maintain or restore normal public health programs in the immediate post disaster period.

Flood water may potentially contaminate the local water (dam, river) and sources of food supply (farm produce) and damage the sewage system resulting in contamination and increase the potential for communicable diseases. Contaminated water source may result in waterborne disease transmission including E. coli, Shigella, Salmonella, and hepatitis A virus. Faecal contamination of livestock and crops also may lead to the spread of infectious disease. The flood or irrigation with contaminated water represents a risk to farm and other workers

Another potential hazard is that flood water may result in the spread of chemical. Industrial sites may become flooded unleashing chemicals and other contaminants into the water. Hazardous materials that cause fire or explosions, toxic gas emissions, spills from damaged equipment and pipes carrying toxic substances, punctured tanks and vessels can also release their content into floodwater. This has the potential to negatively affect human when the contaminated water is drunk or used for household chores.

Food shortages observed in the immediate aftermath may arise from food stock destruction within the disaster areas and this may reduce the absolute amount of food available. The disruption in the distribution system caused by the flood may curtail access to food. It may be necessary to institute an emergency feeding program to victims or vulnerable people.

6.3 Management

Floods are natural phenomenon and sometimes inevitable no matter how much measures are put in place against it. Floods can therefore not be prevented but can be managed and its effects mitigated. The effectiveness of measures depends on among other things hydrological and environmental circumstances. These measures can be categorized as either structural or non-structural.

6.3.1 Non-Structural Interventions

Nothing proper and comprehensive within the Ashaiman municipality can be done without the involvement of key stakeholders within the local communities. This includes the opinion leaders, the chiefs and their traditional governing council, the religious bodies (Christianity, Islam and others), civil society organizations and the citizens. The people must also be well abreast and understand the various effects of flooding so that they can appreciate the various interventions that may be brought to the municipality.

A comprehensive planning of the whole municipality especially around and along the waterway is very important to the solution of the perennial flooding. This will include planning for new settlements, recreational centres, industrial and commercial hubs for the municipality so as to allow the streams and rivers to flow unhindered.

It has been observed over the years that some governmental integrated projects and policies are usually suspended and not continued to completion. Several reasons can be attributed to such unfortunate observation. It is therefore important to draw or laydown concrete plans and policies backed by the necessary laws so that projects will be followed through to their completion. It is also imperative that projects (such as roads, bridges and drains under construction or completed) are strictly maintained and monitored.

Flood information should be disseminated early and actively, not just on request and should be accompanied by the envisaged action and procedures for public participation should flood event occur. The people of Ashaiman should become aware of the need to restrict and specify land use for certain purposes such as industry, agriculture, tourism and for settlements especially in flood prone areas so as to leave the waterway alone in order to reduce the potential for flooding.

Climate change and its effects in the future further emphasizes the need for an effective early warning and forecasting of perennial rainfall which can eventually result in flooding and its harmful effects. An effective national and local flood disaster management team with the requisite resources and adequate contingency plans is needed to respond to flood events and should be properly prepared and maintained in operational readiness at all times.

6.3.2 Structural Management

It is important therefore that the waterways (rivers and streams) in addition to their buffer zones are left alone (without development) so as to facilitate free flow of the water. It is absolutely necessary for the state and the municipality to legislate against settlements and the construction of structures within and around the waterway and the buffer zones. All structures; settlements, industrial, commercial buildings within and along the Dzorwulu River and the Gbemi Stream and the buffer zones should be demolished.

Since most of the natural retention ponds or reservoirs along the Dzorwulu River and the Gbemi Stream and the Amatsuru Stream have been destroyed by human activity, it is important to create artificial detention ponds along the buffer zones of the river and the stream or dam the flowing water at some point along its path. These reservoirs or dams serve to collect and keep excess water when the waterways are overwhelmed by large volume of water from either upstream or heavy storm water.

It is important that the Town and Country Planning (T&CP) and Urban Roads within the municipality collaborate to draw a comprehensive plan or layout for drains and to construct tertiary and secondary drainage system for the various communities within the Municipality based on the topography of the area, settlements and available lands.

Drainage is all about the gradient of the ground or passage way so as the earth drains are being de-silted or dredge, the cleaners with the help of excavators should to create a gradual slope of the drains towards the sea so that the water can flow easily otherwise there will be ponding of the water at certain areas. The embankment of the earth drains should also be shaped regularly to avoid landslide of sand or soil into the drains.

The indiscriminate disposal of garbage into the drains and surroundings must stop. This requires an effective and efficient waste collection and management services.

6.4 RECOMMENDATION

Firstly, the waterways (the Dzorwulu River, the Amatsuru and the Gbemi Streams) plus the buffer zones should be left alone; illegal structures along these areas should be demolished. The area should be well demarcated and possibly fenced so as to restrict movement within the area.

Secondly, the law regarding education of and the application of effective and efficient land-use; settlement areas, commercial and industrial centres should be enforced. Offenders should be severely punished to deter others.

Thirdly, the drainage system including the earth drains should be properly engineered or re-engineered; construction of retention dams/ponds in the buffer zones, enough secondary and tertiary drains should be well-laid out and properly constructed so as to receive and drain large volume of storm water.

Fourth, the primary, secondary and the tertiary drains should be regularly dredged and de-silted respectively. The earth drains should be dredged at least twice a year while the secondary drains de-silted monthly and that of tertiary drains de-silted weekly.

Fifth, the municipality should ensure proper waste collection and management services; both public and private services. At least every community should have one dump site. The management at the Kpone Landfill Site should always be ready to receive refuse from the refuse collectors.

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APPENDICES

Appendix 1 Table of Reduced Mean and Standard Deviation Vs. Record Length (Object 3)

n	$\bar{y}_n$	σ_n	n	$\bar{y}_n$	σ_n	n	$\bar{y}_n$	σ_n
8	0.4843	0.9043	35	0.5403	1.1285	64	0.5533	1.1793
9	0.4902	0.9288	36	0.5410	1.1313	66	0.5538	1.1814
10	0.4952	0.9497	37	0.5418	1.1339	68	0.5543	1.1834
11	0.4996	0.9676	38	0.5424	1.1363	70	0.5548	1.1854
12	0.5035	0.9833	39	0.5430	1.1388	72	0.5552	1.1873
13	0.5070	0.9972	40	0.5436	1.1413	74	0.5557	1.1890
14	0.5100	1.0095	41	0.5442	1.1436	76	0.5561	1.1906
15	0.5128	1.0206	42	0.5448	1.1458	78	0.5565	1.1923
16	0.5157	1.0316	43	0.5453	1.1480	80	0.5569	1.1938
17	0.5181	1.0411	44	0.5458	1.1499	82	0.5572	1.1953
18	0.5202	1.0493	45	0.5463	1.1519	84	0.5576	1.1967
19	0.5220	1.0566	46	0.5468	1.1538	86	0.5580	1.1980
20	0.5236	1.0628	47	0.5473	1.1557	88	0.5583	1.1994
21	0.5252	1.0696	48	0.5477	1.1574	90	0.5586	1.2007
22	0.5268	1.0754	49	0.5481	1.1590	92	0.5589	1.2020
23	0.5283	1.0811	50	0.5485	1.1607	94	0.5592	1.2032
24	0.5296	1.0864	51	0.5489	1.1623	96	0.5595	1.2044
25	0.5309	1.0915	52	0.5493	1.1638	98	0.5598	1.2055
26	0.5320	1.0961	53	0.5497	1.1653	100	0.5600	1.2065
27	0.5332	1.1004	54	0.5501	1.1667	150	0.5646	1.2253
28	0.5343	1.1047	55	0.5504	1.1681	200	0.5672	1.2360
29	0.5353	1.1086	56	0.5508	1.1696	250	0.5688	1.2429
30	0.5362	1.1124	57	0.5511	1.1708	300	0.5699	1.2479
31	0.5371	1.1159	58	0.5515	1.1721	400	0.5714	1.2545
32	0.5380	1.1193	59	0.5518	1.1734	500	0.5724	1.2588
33	0.5388	1.1226	60	0.5521	1.1747	750	0.5738	1.2651
34	0.5396	1.1255	62	0.5527	1.1770	1000	0.5745	1.2685

Source: (Selaman et al., 2007)

Appendix 2: Methods Used for Objectives 4 & 5

The electromagnetic radiation (solar radiation) is normally used as an information carrier in remote sensing. The output of a remote sensing system is usually an image (digital pictures) representing the objects/events being observed. The images of the flood prone areas were integrated with other geospatial technologies such as Geographic Information System (GIS) for analysis and interpretation.

Aster Digital Elevation Model (DEM) was obtained from https://search.earthdata.nasa.gov. The ASTER Digital Elevation Model (AST14DEM) product is a generated image acquired by the Visible and Near Infrared (VNIR) sensor. The VNIR subsystem includes two independent telescope assemblies that facilitate the generation of stereoscopic data. The band three (3) stereo pair is acquired in the spectral range of 0.78 and 0.86 microns with a base-to-height ratio of 0.6 and an intersection angle of 27.7 degrees. The accuracy of the DEMs is certain. It is more accurate than 25 meters Root Mean Square Error (RMSE) in xyz dimensions. The ASTER DEM is a single band product with 30-meter horizontal postings that is geodetically referenced to the UTM coordinate system and to the Earth's geoid using the EGM96 geo-potential model. Larger water bodies are detected and typically have a single value, but they no longer are manually edited. Any failed areas, while infrequent, remain as they occur. Cloudy areas typically appear as bright regions, rather than as manually edited dark areas.

To create an accurate representation of flow direction and, therefore, accumulated flow, it is best to use a dataset that is free of sinks. That is a Digital Elevation Model (DEM) that has been processed to remove all sinks. A sink is a cell or set of spatially connected cells whose flow direction cannot be assigned one of the eight valid values in a flow direction raster. This can occur when all neighbouring cells are higher than the processing cell or when two cells flow into each other, creating a two-cell loop. Sinks are considered to have undefined flow directions and are assigned a value that is the sum of their possible directions. Sinks in elevation data are most commonly due to errors in the data. These errors are often caused by sampling effects and the rounding of elevations to integer numbers. Naturally occurring sinks in elevation data with a cell size of 10 meters or larger are rare (Mark 1988), except in glacial or karst areas, and generally can be considered errors. As the cell size increases, the number of sinks in a dataset also often increases.

Due to this error, the Aster DEM was filled using the ArcGIS 10.7 fill tool. Normally, when a sink is filled, the boundaries of the filled area may create new sinks that need to be filled. So, the filled process was run on the DEM covering the whole of the Tema Municipal, and then

Ashaiman was extracted from bigger municipal area to avoid the tendency of including the boundaries errors introduce during the fill process.

A flow direction raster was created from each cell to its downslope neighbour, or neighbours, using the D8 methods. The D8 flow method models flow direction from each cell to its steepest downslope neighbour. ArcGIS 10.7 flow direction tool was employed in this process. The flow direction raster was then used as an input for creating a drainage basin. The drainage basins are delineated within the analysis window by identifying ridge lines between basins. The input flow direction raster is analysed to find all sets of connected cells that belong to the same drainage basin. The drainage basins are created by locating the pour points at the edges of the analysis window where water would pour out of the raster, as well as sinks, then identifying the contributing area above each pour point. The result led to identifying all the drainage basins within the District. The flow direction raster was again used as an input to create an accumulated raster of accumulated flow to each cell, as determined by accumulating the weight for all cells that flow into each downslope cell using the flow accumulation tool in ArcGIS Desktop 10.7. From the flow accumulation data value ranges between 0 – 22988.

Using the raster calculator, all flow accumulation cells greater than 1000 were identified creating the drainage catchment for the Ashaiman Municipality. This drainage catchment raster was converted into vector data using the raster to Polyline tool in ArcMap creating a nice continues drainage catchment of Ashaiman.

Among the flooding events that have occurred in the Ashaiman municipal area, one of the significant is the 45minutes downpour that caused about 143 people to be affected on the 31 January 2017. This was used as a backdrop for estimating the level of water in the catchment area and the coverage in times of flooding. Satellite data of the Ashaiman catchment taken was taken four (4) days before the flooding and another data two (2) days after the flooding to access the coverage, and measure the water in the area.

These satellite data were level 1 Landsat data (details in table 2), so they were calibrated to correct for radiometric errors and the atmospheric error using ENVI 5.3 software. The boundary shape file of the Ashaiman area was then used to extract the catchment area. Supervise classification was then performed using two classes i.e. Land and water. The algorithm used was Maximum Classification. Maximum likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. This led to a classification of only land and water. The water pixels were then extracted from the land using the ArcMap software. Google earth was used to estimate the elevation of the water body and the surface volume tool was then used to calculate the volume of water below the surface layer.

Appendix 3 Objective Six

Questionnaires were administered in the Ashaiman Municipality especially areas that virtually record flood annually. The questionnaires were administered in these areas; Adjei-Kojo, Lebanon, Jericho, New-Town, Dam-Site and Atta-Deka general areas. To have a representative sampling, most of the communities within these areas were covered. Respondents were selected from houses and also at centres of commercial activities within these communities. These people were chosen because individuals in these areas directly or indirectly experience flood and it’s the effects during flood events.

Due to the haphazard nature of the settlements within some communities, the community leaders were identified who furnished us with a fair idea of the total number of houses. Most of the houses are compound houses that contain one, two, three or more households depending on the size of the house and the number of rooms available.

According to Mr Seth Kudzordzi, Head of Drainage at the Ghana hydrological service, the buffer zone for every primary waterway is about sixty meters on both sides. Houses within the buffer zone were separated from houses beyond. The houses immediately along the primary drains were counted (within about two-hundred-meter diameter) for each community and a Systematic Random Sampling approach was applied to select the house for the questionnaires. Convenient and Snowball Sampling was also applied to select the houses within the buffer zone and beyond that directly or indirectly experience floods. Within each house, any person above eighteen years (18) and of sound mind was interviewed. GPS coordinates were taken at every location the questionnaires were administered. This is to map out the areas covered.

Appendix 4 Objective Seven

Structured questions were used as a guide during the interview to sample the views key officials concerned with floods and how floods can be mitigated. The structured questions used for the interview captured the following headings: the demographic characteristics, the possible risk factors associated with the development of floods, possible effects of floods on the people and how to manage flood in the area.

An exploratory review of literature of journals and academic repositories on flood and flood control mechanisms were explored. The paper also examined literature from some relevant internet sources. Studies on flood and flood control mechanisms were reviewed to understand some risk factors of flooding and some remedial measures to mitigate flood situation. Further examination on the challenges in addressing flood situation was also explored.

Empirical verification was done via observation on attitudes and behaviours of people in the flooded area. This was so, because, a descriptive statement is regarded as true if and only if it is found to correspond with observed reality. The ultimate test of the truth or falsity of an empirical statement is the test of observation (Anderson, 1971).

The researcher in this study concealed his real identity and interacted with members of the community while activities of people were observed. The researcher employed a "rapport" alongside to get first-hand information. This is because some important facts or information about the attitudes and behaviours of people in the flooded area cannot be obtained from questionnaire or interview. This enhanced the researcher's knowledge on the study since almost every year pockets of flooding were recorded in Ashaiman. The importance of this method was that, it ascertained and verified the other sources already employed to collect the information. In other words, it was used to cross check the data already gathered and analysed

Appendix 5: Informed Consent

RISK FACTORS AND MANAGEMENT OF FLOOD IN THE ASHIAMAN MUNICIPAL AREA IN THE GREATER ACCRA REGION, GHANA

My name is ISAAC AMPADU, a student at Ensign College of Public Health, Kpong**.** I am conducting a research on the risk factors and management of flood in the Ashaiman municipal area. This is an academic exercise which could be used to formulate a policy to help reduce flooding within the municipality. I would very much appreciate it if you could spare some time to answer this questionnaire.

Flooding is a natural danger and disaster which displaces people by destroying their lands, houses and other valuable properties (Hague, 1997) and in many cases claiming human lives. Flooding may occur as an overflow of water from water bodies, such as a river, lake, or ocean, in which the water overtops or breaks levees, resulting in some of that water escaping its usual boundaries, or it may occur due to an accumulation of rainwater on saturated ground in an aerial flood.

The rationale of this study is to review and conduct a qualitative analysis into the risk factors contributing to flooding in the Ashaiman Municipality, the effects of flooding and how to effectively manage this problem. The policy recommendation drawn from the study is for the state in collaboration with the municipality to implement effective management strategies and also for people to effectively cope with the yearly floods in the long run.

Confidentiality

This information you are about to share will not be disclosed to anyone outside this research team. Your name will not be written, but a number will be assigned to your questionnaire. Every information from this research will be kept private and under lock and key.

Risks

This survey might require you to give very personal details, location of your house and your experiences with flooding. You might feel a bit awkward about some of the questions I will ask but bear in mind that you don’t have to answer any question if you don’t want to. You should also bear in mind you don’t have to explain or answer any questions you are not comfortable with. Additional information may or will be provided on request to facilitate your willingness to participate if you so wish.

Benefits

You will not be given anything to motivate you to partake in this survey. However, your participation might assist us to find out more about the causes and effects of flooding in the municipality and to find ways and means to educate people in order to reduce the harmful effects of flooding in the area.

Duration

The interview might take 15 to 20 minutes to complete. It will involve some questions about your perception and experiences about the causes and effects of flooding in the Ashima municipality. It is not compulsory to partake in this survey and you are not obliged to answer any or all of the questions.

Do you have any questions to ask about the interview?

Do you want to partake in it? **YES** ☐ **NO** ☐

ANSWER ANY QUESTIONS AND ADDRESS RESPONDENT'S CONCERNS.

RESPONDENT <u>*AGREES*</u> TO BE INTERVIEWED [1] -- - - - → BEGIN

RESPONDENT <u>*DOES NOT AGREE*</u> TO BE INTERVIEWED [2] - - - - → END

Name of Interviewer ____

Date: ________________

Respondent's Signature: ____________________ **or** ……………………..

THUMB PRINT

Appendix 6

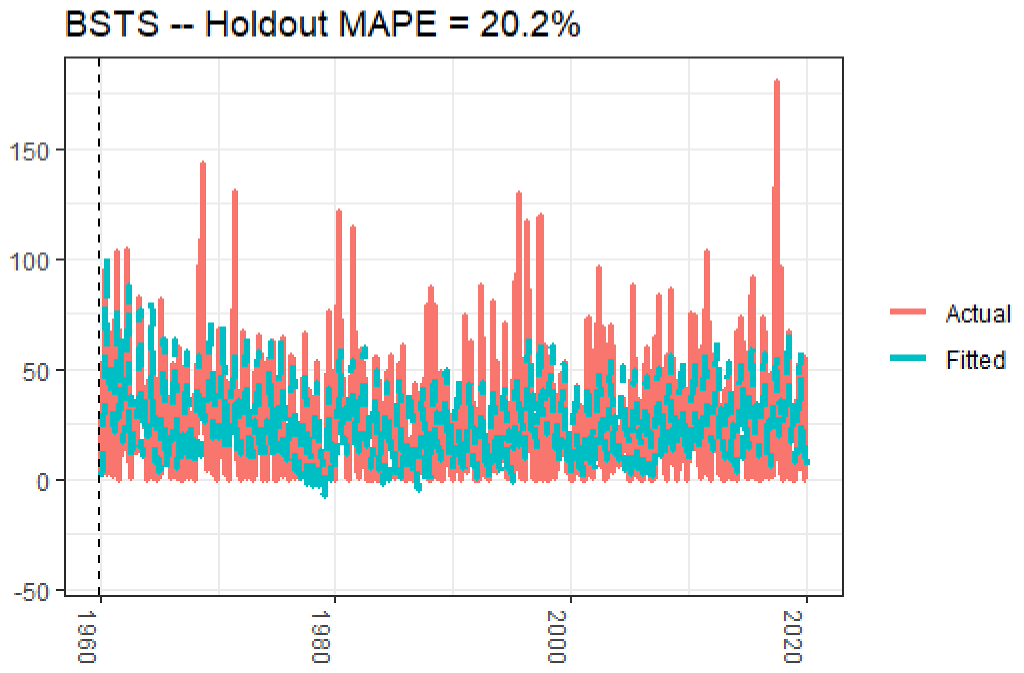


Fig 4. 7 Actual against Fitted Rainfall Pattern of Ashaiman Catchment Area

Appendix 7

Detention/Retention Ponds

Since most of the natural retention ponds or reservoirs along the Dzorwulu River and the Gbemi Stream have been destroyed by human activity, it is important to create artificial detention ponds along the buffer zones of the river and the stream or dam the flowing water at some point along its path. These reservoirs or dams serve to collect and keep excess water when the waterways are overwhelmed by large volume of water from either upstream or heavy storm water. The reservoirs will reduce the water current and reduce the volume of water flowing per unit space per time in the drains hence mitigating flood and its devastating effect.

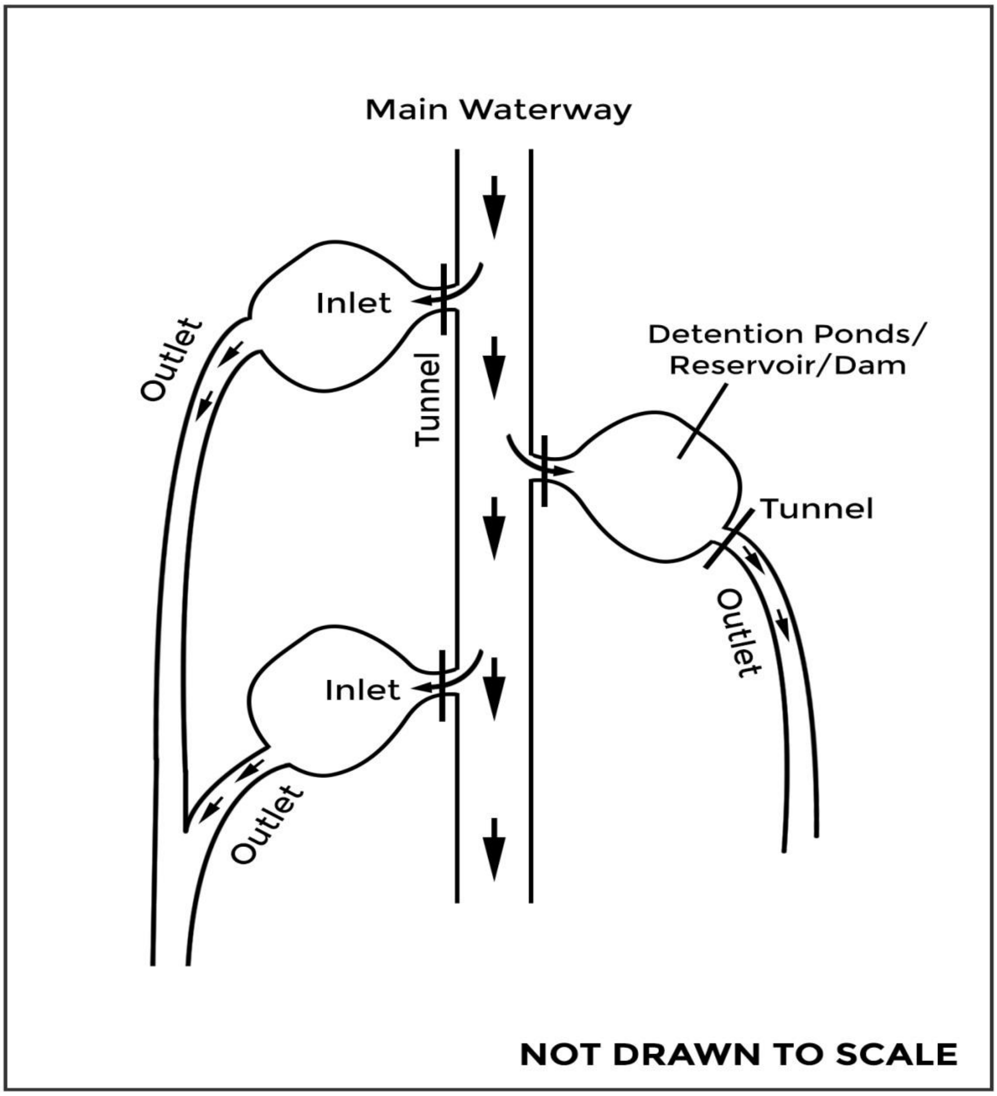
The water in the retention pond can then be channelled out through another drainage system or be allowed to gradually flow through the main waterway when the water current is low. The ponds/reservoirs should be alternated on each side of the river and be constructed such that the excess water flows into them by gravity. Tunnels may be fitted to control the volume of water that flows into and out of these ponds. It is suggested that, in addition to the Dam (IDE) at Ashaiman Lebanon, two more reservoirs or retention ponds could be constructed on the stretch of the Dzorwulu River at Ashaiman, one at Ashaiman New-Quarters and the other one at Ashaiman Under-Bridge general area. It is also suggested that retention ponds be constructed in the various communities along the Gbemi Stream. The retention ponds and their outlets may be cemented, covered or open to embank the water properly and also be constructed such that it will be easy for periodic de-silting or dredging. The number, size and depth of these reservoirs on a particular stretch of water basin depend on the size of the river or stream, the volume and speed of water flowing per unit area and the slope of the area. If the mentioned parameters are high, then several detention ponds may be required at regular intervals.

In order to slow down the speed of excess water on the buffer zones, green grasses, elephant grasses or other flowering plants could be planted along this zone. The buffer zones could also be used for some crop farming. Water current is known to decrease in areas where there is enough vegetative cover because the plants, green grasses and fallen leaves trap the water and prevents its free flow.

Some benefits or advantages could be derived from the detention ponds though they may be purposely design to mitigate flooding and its consequences. The water in the reservoir could be used for fishing and irrigation, could be harvested for constructional work (concrete works), could serve as drinking water for livestock. It could be treated to provide potable water for residents and even be used for small scale electrical power generation. The disadvantages include; the breeding of some insects and vectors of diseases such as mosquitoes.

The massive settlement in the area has increased the impervious layer of the ground causing a decrease in the infiltration of water to the ground. Most of the water then flows and overwhelm the inadequate and poorly constructed drains. The water then runs into people's homes and cause damage even with little rain. To reduce this phenomenon, individuals can adopt certain strategies at homes by planting green grasses and constructing fish ponds instead of concreting the whole compound in their houses. This will allow enough water to seep deep into the soil. The roofs could also be constructed such that some amount of water could be harvested whenever it rains for household chores.

It is important that the whole waterway including the buffer zones and the detention ponds is well demarcated, possibly well fenced and strictly monitored so as to prevent unusual encroachment for settlement, commercial and industrial activities. Movement in and out of this area should be restricted including grazing or overgrazing by animals.

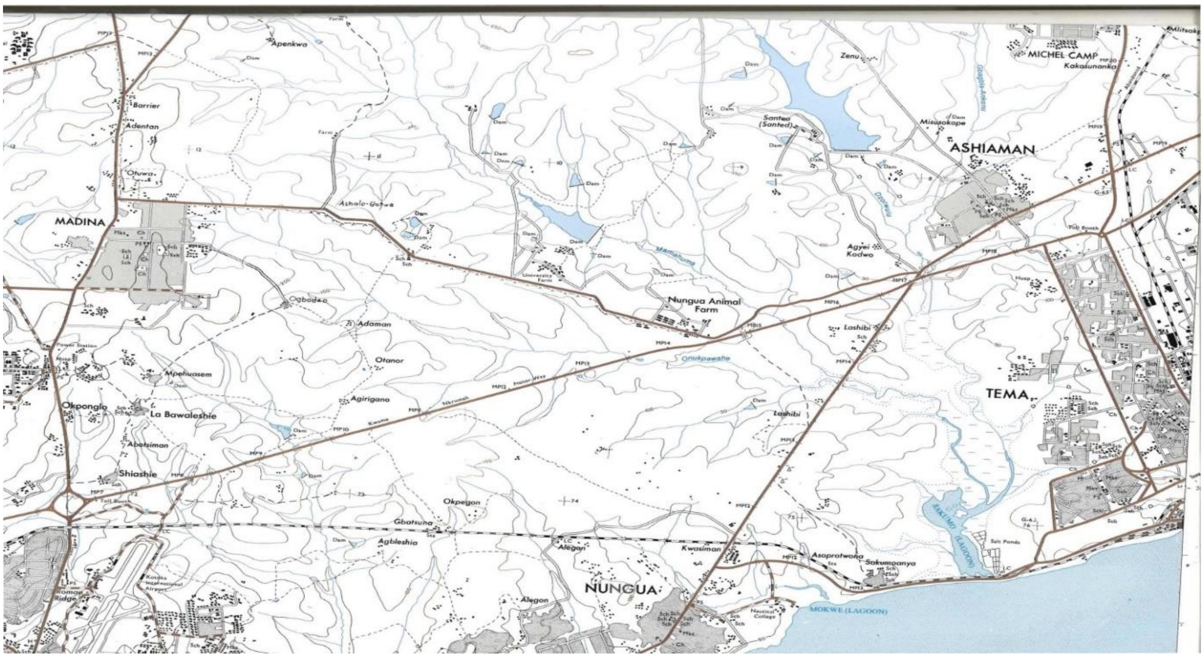


A Sketch of Detention Ponds along a Waterway

Appendix 8 Pictures

Map 5. 1 Aerial view of the Dzorwulu River and the Gbemi Stream that passes through the Ashaiman Municipality.

Source: Google Earth Image



Map 5. 2 Topographical Map of The Ashaiman Municipality and Tema general area showing the waterways

Source: Ghana Survey Department, Lands Commission


Picture 5. 1 Natural waterways within the Ashaiman Municipality and settlements

Source: Ampadu's Library


<u>Inadequate and Poorly Managed Drainage System</u>



Picture 5. 2   Poorly managed earth drains at Ashaiman (Silted with Sand and Solid Waste)

Source: Ampadu's Library

Picture 5. 3   Accumulation of garbage in the Drains at Ashaiman

Source: Ampadu's Library

Picture 5. 4   Some physical effects of flooding

Source: The Internet

Picture 5. 5 Environmental filth as a result of flooding.

Source: The Internet

QUESTIONNAIRE PERSONAL INFORMATION

1. Sex of Respondent Male ☐ Female ☐

2. Age A) 18-30 ☐ B) 31-45 ☐ C) 46-55 ☐ D) 56-65 ☐ E) 66 and above ☐

3. What is your occupation? …………………………………

4. Marital status

   a. Married ☐
   b. Single ☐
   c. Cohabiting ☐
   d. Window/widower ☐
   e. Divorced/Separated ☐

5. Number of household members…………………..

6. Educational level

   a. No formal education ☐
   b. Primary ☐
   c. JHS ☐
   d. SHS equivalent ☐
   e. Tertiary ☐

7. Which Community do you reside in? ……………………………………..

8. Geographic Coordinates: N……………………….., E……………………………

9. How long have you been living in this community? ………

0 – 5 years ☐ 6 – 10 years ☐ 11 – 15 years ☐ 16 – 20 years ☐ over 20 years ☐

10. What type of house do you live in (observe)

   a. Compound ☐
   b. Detached ☐

c. Semi- detached ☐
d. Others………

SECTION B: BUILDING INFORMATION

11. What is the predominant land use of the area?

Residential ☐ commercial ☐ industrial ☐ slum ☐ institution ☐ others please specify ……………………………………..

12. What is the main material type used for the walls of the buildings in the area?

Concrete brick_in_cement ☐ brick_in_mud ☐ metal ☐ Wood ☐ others please specify ……………………………..

13. What is the floor in your house made of? Mud ☐ Wood ☐ Tiles ☐ Concrete ☐

Terrazzo ☐ Others….

14. What is the roof of your house mad of? Corrugated aluminum sheets ☐ Asbestos ☐

Concrete ☐ Thatched/straw ☐ others…..

15. What is the number of floor? 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ others specify……..

16. Which area is the building located? ....

17. How many adults (18 – 65 years) occupy the building? ....……………………..

18. How many older people (> 65 years) occupy the building? ....

19. How many children (1 – 17 years) occupy the building? …………………………

20. How many workers occupy the building? ....

21. How many people stay in the building during the day? ....

22. How many people stay in the building during the night? ....

23. What is the livelihood of the occupants of the building? Laborers ☐ Artisans ☐ Traders

☐ Skilled workers ☐ Unemployed ☐ Others please specify ☐

SECTION C: EXPERIENCE WITH RECENT FLOOD HAZARD

24. Do you remember the 8th April 2019 flood? Yes ☐ No ☐

25. Which areas were heavily affected? …………………………………………………..

26. If yes, what was the water level? No Flood ☐ Ankle ☐ Knee ☐ Hip ☐ Breast ☐

Head ☐ First floor ☐ Second floor ☐ third or higher floor ☐

27. What was the percentage damage to the content of the building? ....

28. Was the building itself damaged? Yes ☐ No ☐

29. If yes, please specify the extent of damage…………………………………………

30. Do you remember the 14th April 2019 flood? Yes ☐ No ☐

31. Which areas were heavily affected? …………………………………………………..

32. If yes, what was the water level? No Flood ☐ Ankle ☐ Knee ☐ Hip ☐ Breast ☐

Head ☐ First floor ☐ Second floor ☐ Third or higher floor ☐

33. What was the percentage damage to the content of the building? ....

34. Was the building itself damaged? Yes ☐ No ☐

35. If yes, please specify the extent of damage…………………………………………

36. Do you remember any other flood event in the community in the past since the year 1990? Yes ☐ No ☐

37. If yes, in which year/s was/were this/these flood/s? ....

38. What was/were the water level/s? No Flood ☐ Ankle ☐ Knee ☐ Hip ☐

Breast ☐ Head ☐ First floor ☐ Second floor ☐ Third or higher floor ☐

40. What was/were the percentage damage/s to the content of the building?...

41. Was the building itself damaged? Yes ☐ No☐

42. If yes, please specify the extent of damage/s……………………………………

43. Do you remember the 2015 flood? Yes ☐ No ☐

44. Which areas were heavily affected? ………………………………………………..

45. If yes, what was the water level? No Flood ☐ Ankle ☐ Knee ☐ Hip ☐ Breast ☐

Head ☐ First floor ☐ Second floor ☐ third or higher floor ☐

46. What was the percentage damage to the content of the building? ....

47. Was the building itself damaged? Yes ☐ No ☐

48. If yes, please specify the extent of damage…………………………………………

49. Do you remember the 2009 flood? Yes ☐ No ☐

50. Which areas were heavily affected? …………………………………………………..

51. If yes, what was the water level? No Flood ☐ Ankle ☐ Knee ☐ Hip ☐ Breast ☐

Head ☐ First floor ☐ Second floor ☐ third or higher floor ☐

52. What was the percentage damage to the content of the building? ....

53. Was the building itself damaged? Yes ☐ No ☐

54. If yes, please specify the extent of damage…………………………………………

55. Do you remember the 2007 flood? Yes ☐ No ☐

56. Which areas were heavily affected? …………………………………………………..

57. If yes, what was the water level? No Flood ☐ Ankle ☐ Knee ☐ Hip ☐ Breast ☐

Head ☐ First floor ☐ Second floor ☐ third or higher floor ☐

58. What was the percentage damage to the content of the building? ....

59. Was the building itself damaged? Yes ☐ No ☐

60. If yes, please specify the extent of damage………………………………………

61. Do you remember the 2005 flood? Yes ☐ No ☐

62. Which areas were heavily affected? ………………………………………………..

63. If yes, what was the water level? No Flood ☐ Ankle ☐ Knee ☐ Hip ☐ Breast ☐

Head ☐ First floor ☐ Second floor ☐ third or higher floor ☐

64. What was the percentage damage to the content of the building? ....

65. Was the building itself damaged? Yes ☐ No ☐

66. If yes, please specify the extent of damage………………………………………

67. Do you remember the flood event in the Ashaiman municipality in the year 2001?

Yes ☐ No☐

68. Which areas were heavily affected? ………………………………………………..

69. What was/were the water level/s? No Flood ☐ Ankle ☐ Knee ☐ Hip ☐

Breast ☐ Head ☐ First floor ☐ Second floor ☐ Third or higher floor ☐

70. What was the percentage damage to life and property? …………………….

71. What do you think is the cause of flooding in your community?

Poor drains ☐ choked drains ☐ topography of the land ☐ building on water ways ☐

impervious ground☐ Overflow of water bodies☐ poor waste management ☐

72. What do you think can be done to solve the flooding problem in your community?

Construct proper and big drains ☐ clear choked drains ☐ clear buildings on water ways ☐

stop constructions on water ways ☐ build far from water bodies ☐ clear buildings close to water bodies ☐

72. Are you aware of any health effects of flooding in your community with regards to;
a. Diseases ………………………… B. Injuries…………………………

C. Pests …………………………… D. Death …………………………

73. What are the effects of flood on the social life of citizens in the communities in terms of;

a. Transportation ………………………. B. Markets, …………………

C. Recreation, …………………………... Healthcare, …………………………

Sample questions for the interviews

1. What type of soil is predominantly present in the Ashaiman area?
2. What is the general land topography of the Ashaiman area?
3. What type of vegetation is present in the general area that may contribute to flooding?
4. How many water bodies can be found in the Ashaiman municipal area?
5. What type of water bodies is present in the Ashaiman general area? (Rivers, Lakes, Lagoons, Sea etc.)
6. Do these water bodies sometimes overflow their banks?
7. How far do these water bodies overflow their banks during heavy downpours?
8. What type of rainfall is experienced in the Ashaiman general area?
9. What is the rainfall pattern in the Ashaiman municipality?
10. How often does it rain in the general area within a year?
11. How much of rain water is normally experienced in the general area?
12. How many flood spots have been identified in the Ashaiman general area?
13. Do you think that the water does not penetrate the earth due to surface constructions or developments?
14. How long does it take rain water especially during flood water to dry?

15. Per history or records has flooding been recorded in this area over the years or the floods are recent development?
16. What do you ascribe the flooding in this area to?
17. What can be done to reduce flooding and its effects in this area?
18. What do you think is the cause of flood in the municipality?
19. What are the effects of flooding in the municipality?
20. In your assessment how can we manage or prevent flood in the Ashaiman municipality?