

Addis Ababa
University
(Since 1950)



COLLEGE OF SOCIAL SCIENCES

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL
STUDIES**



URBAN HOUSEHOLDS' VULNERABILITY TO FLOODING

HAZARDS IN ADDIS ABABA

A CASE STUDY FROM GINFLE STREAM

BY

SELAMAWIT BIREHANU AYELE

DECEMBER 2018

ADISS ABABA

**ADDIS ABABA UNIVERSITY
COLLEGE OF SOCIAL SCIENCES
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL
STUDIES**

**URBAN HOUSEHOLDS' VULNERABILITY TO
FLOODING HAZARDS IN ADDIS ABABA
A CASE STUDY FROM GINFLE STREAM**

**BY
SELAMAWIT BIRHANU AYELE**

**ADVISOR
TEBAREK LIKA (PHD)**

AN MA THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF
ADDISABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR DEGREE OF MASTER OF ARTS IN GEOGRAPHY AND
ENVIRONMENTAL STUDIES (SPECIALIZATION IN CLIMATE CHANGE AND
ADAPTATION)

**DECEMBER 2018
ADISS ABABA**

DECLARATION

I, **Selamawit Birhanu Ayele**, do hereby declare to Addis Ababa University School of Graduate Studies that this thesis is a product of my original research work, and it has not been submitted to any other university for any academic degree. Materials and information other than my own are dually acknowledged.

Name: **Selamawit Birhanu Ayele**

Signature: _____

Date of Submission: _____

Supervisor's approval

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge as an advisor.

Approved by: _____

Thesis Advisor Signature

Date

**URBAN HOUSEHOLDS' VULNERABILITY TO
FLOODING HAZARDS IN ADDIS ABABA
A CASE STUDY FROM GINFLE STREAM**

SELAMAWIT BIRHANU AYELE

Approved by:

_____	_____	_____
Thesis Supervisor	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
External Examiner	Signature	Date
_____	_____	_____
Chairperson, Department of GeES	Signature	Date

Table of Contents

Contents	Page
Table of Contents	i
List of Tables	iv
List of Figures	v
Abbreviations and Acronyms	vi
Acknowledgements.....	vii
Abstract.....	viii
CHAPTER I: INTRODUCTION.....	1
1.1 Background of the study	1
1.2 Statement of the problem	3
1.3 Objectives of the study	5
1.3.1 General objective.....	5
1.3.2 Specific objectives.....	5
1.4 Research questions	5
1.5 Scope and Limitation of the Study	6
1.6 Significance of the Study	6
1.7 Definition of keywords/phrases	7
1.8 Outline of the thesis.....	8
CHAPTER II: REVIEW OF RELATED LITRATURE	9
2.1.The concept of flooding	9
2.2.Causes and Consequences of Flooding	10
2.3.Urban Flooding	13
2.4.Management of Urban Flooding	14
2.5.Empirical Related Literatures.....	15

2.6 Analytical Framework of the Study	20
CHAPTE III: DESCRIPTION OF THE STUDY AREA AND THE RESEARCH METHODS	22
3.1. Description of Addis Ababa.....	22
3.1.1. Location	22
3.1.2. Climatic conditions of Addis Ababa	25
3.1.3. Land Use, Vegetation and Ecosystem Service in/around Addis Ababa.....	28
3.1.4. Socioeconomic profile of Addis Ababa.....	29
3.1.5. Water Supply and Sanitation	31
3.2. Methods and Materials	31
3.2.1. Research design	31
3.2.2. Sources of Data	31
3.2.3. Sampling design	32
3.2.4. Tools of primary data collection.....	33
3.2.4.1. Document review:	33
3.2.4.2. Focus Group Discussions:.....	33
3.2.4.3 Key Informant Interview.....	33
3.2.4.4 Field observation.....	34
3.2.5 Techniques of data analysis.....	34
3.2.5.1. Analysis of causes of flooding along Ginfile River.....	34
3.2.5.2. Analysis of peri-urban Addis Ababa land use/land cover changes.....	35
3.2.6 Ethical Considerations.....	37
CHAPTER IV: RESULTS AND DISCUSSIONS	38
4.1. Introduction	38
4.2. Topography, slope and LU/LC as causes for flooding hazards in Addis Ababa	39

4.3 Causes and impacts of flooding hazards in Ginfile Catchment: Community perception.....	46
4.3.1 The environmental and ecological impacts of the Ginfile River.....	46
4.3.2. Social impacts of the Ginfile stream.....	50
4.3.3. Health impacts of the Ginfile stream.....	51
4.3.4. Psychological impacts of Ginfile stream.....	52
Chapter v: CONCLUSION AND RECOMMENDATIONS.....	54
5.1. Conclusion	543
5.2. Recommendations	609
REFERENCES	60
Appendices	

List of Tables

	Page
Table 3.1: Landsat imagery used for the study	35
Table 4.1: The current LU/LC status of Addis Ababa.....	39
Table 4.2: Classification of Ginfile catchment in slope.....	42
Table 4.3: The 2002 and 2018 LULC of the study area	43

List of Figures

	Page
Figure 2.1: A simplified diagram indicating the causes and consequences of flooding.....	12
Figure 2.2: DPSIR Framework for flood assessment	21
Figure 3.1: Addis Ababa: Major, sub-cities and its national settings	22
Figure 3.2: Mean Monthly Temperature (Minimum and Maximum) and Rainfall (1990 - 2014).....	23
Figure 3.3: Ginfile river catchments.	26
Figure 3.4: Long term Mean Annual temperature (Minimum and Maximum) (1985-2014)	27
Figure 3.5: Long term and Total Rainfall of Addis Ababa in millimeters (1985-2014)	27
Figure 3.6: Methodological flow of LULC analysis of uplands in peri-Addis Ababa	36
Figure 4.1: Current LU/LC situations of Addis Ababa	38
Figure 4.2: Elevation of Ginfile Catchment	40
Figure 4.3: Land slope in Ginfile Catchment	41
Figure 4.4: Land Use Land Cover in Ginfile Catchment	44
Figure 4.5: Flooding vulnerability of Ginfile catchment	45
Figure 4.6: Flooding due to heavy rainfall.....	47
Figure 4.7: Flooding affected homes and disposal systems.....	49

Abbreviations and Acronyms

AAFEPPRA:	Addis Ababa Fire And Emergency Prevention and Rescue Authority
AARRDPO:	Addis Ababa River and River Side Development Project Office
ACCCRN:	Affairs Under Climate Change Resilience Network
AMSL:	Above Mean Sea Level
AARRDPO:	Addis Ababa River and River Side Development Project Office
GIS :	Geographical Information System
CFES:	Centers For Environmental Science
CSA:	Central Statical Agency
DBF:	Data Base File
DEM:	Digital Elevation Model
DPPA:	Disaster Prevention and Preparedness Agency
EEA:	European Environment Agency
EMA:	Ethiopian Mapping Agency
ENVI:	Environment For Visualization of Images
ERCS:	Ethiopian Red Cross Society
ERDAS:	Earth Resource Data Analysis System
ESCS:	Erosion and Sediment Controls
ETM+:	Enhanced Thematic Mapper Plus
EWS:	Early Warning System
FAO:	Food and Agricultural Organization
FGD:	Focus Group Discussion
GCPS:	Ground Control Points
GIS:	Geographic Information System
GLCF:	Global Land Cover Facility
GPS:	Global Positioning System
IDP:	Integrated Development Plan
KII:	Key Informant Interview
ISDR:	International Strategy For Disaster Reduction
LDAO:	Land Development and Administration Office
LULCC:	Land Use Land Cover Change
MaDGIC:	Map Data And Geological Information Center
MWR:	Ministry of Water Resource
NGOS:	Non Profitable Organizations
NHC:	National Health Center
NMA:	National Meteorological Agency
MS:	Microsoft
OLI:	Operational Land Imagery
RS:	Remote Sensing
SRTM:	Shuttle Radar Topography Mission
TM:	Thematic Mapper
USACE:	United States Army Corps of Engineers
USGS:	United States Geological Survey
WMO:	World Meteorological Organizations
WWDSE:	Water Works Design And Supervision Enterprise

Acknowledgements

The accomplishment of this thesis would have been impossible without the encouragement and assistance of many individuals. First and foremost, my appreciation and gratitude goes to my research advisor, Dr. Tebarek Leka for his valuable advice, comments and unreserved guidance. I greatly acknowledge him for allocating me adequate time for careful advisement from the inception to the conclusion of my research work. Without his encouragement, inspiration and professional support, the thesis work would have not been completed. His contribution to the completion of this study is priceless. Thank you, Dr. Tebarek for your impartiality, objectivity and uninterrupted supervision from the inception to the end of this research. Furthermore, I would also like to thank Dr Messay Mulugeta, Associate Professor and Head of Center for Food Security Studies, Addis Ababa University, and for the vital resources he shared me for this research. I witnessed Dr Messay's kindness, selflessness and his impartiality at large. I am also grateful to the examination board of my thesis: Dr Asnake and Dr Yohannis. I'm forever grateful to my beloved family, Sami and friends for their continually supports and encouragement throughout my study and in all activities of my thesis work.

Selamawit Birhanu Ayele

December 2018

Abstract

The prime objective of this study was to investigate urban households' vulnerability to flooding hazards in Addis Ababa with more emphasis to the households and areas along Ginfile Stream. To achieve this objective a two-time series satellite image of 2002 TM and 2008 were analyzed by using Arc GIS 10.3.1 mainly meant for analyzing the status and dynamics of land use land cover (LU/LC) as a cause for flooding hazards, and the level of inundation. Additionally, the main adverse impacts of the flooding hazards were analyzed by using key informant interview (KII), focus group discussion (FGD) and field observation. Five land use classes were identified along the stream such as built-up areas, vegetation lands, open lands, water bodies and agricultural lands. The LULC dynamics in the area was found to be very high, leaving the area vulnerable to flooding. The open land had decreased by 10.44% from 2002 to 2018. Both agricultural and vegetation lands have also shown decreased by 74.27% and 35.19%, respectively; whereas the built up area increased by 36.65%. The result of the purposely selected informants and discussants reveal that flooding in Ginfile catchment and its adverse impacts are very high due to high urbanization which changed the vegetation cover in to buildings and industries as most of the time manufacturing industries built along the riverside. In addition to flooding hazards, the river is becoming source of pollution in the area as various types of wastes are disposed in it. This has become a serious health problem for the population along the riverside and still not given proper attention by the city administration. Based on the result of this study, the following issues are recommended: upgrading the infrastructure in the area in terms of building durable flooding barriers in the catchments or capacitating the existing barriers. Most importantly, Drainage Master Plan must be in place so as to serve Addis Ababa City and other small towns around the city.

Keywords: *Urban flooding, urban, land use/land cover, GIS/RS, Ginfile, Addis Ababa,*

CHAPTER I: INTRODUCTION

1.1 Background of the study

Natural hazards have historically substantial threat to the progress and development of human population on the surface of the earth. Some of the natural hazards include volcanic eruption, earthquake, temperature extremes, hurricane, tropical cyclones and flooding. Among the natural hazards, floods hold the dominant position in the world. This is because of the nature of the flood, its onset and occurrence and its recurrence interval. Besides, its nature and occurrence, unlike other natural disasters, floods occur in almost all parts of the world. The ISDR (2010) describes flood as one of the foremost natural disasters, which account approximately one-third of all natural disasters in the world (Mulugeta, 2016).

Flooding is one of the major environmental crises and destructive natural events. On the other hand, flood is considered as the most common natural phenomena in the world that causes a great loss on lives, property and economy than any other natural hazards throughout human history. Flood causes human suffering, inconvenience and widespread damage to buildings, structures, crops and infrastructures, as well as, it disrupts personal, economic and social activities and retard a nations security and development by destroying roads, buildings and other assets. So that the need to study the cause and effect of flooding has begun since flooding has become a problem to society when people and their valuables become affected. Historically many solutions have been proposed to mitigate the effects of flooding but knowledge on the actual cause effect relation is lacking (Manandhar, 2010; Sinafikish, 2013).

Globally, flooding is the most frequently occurring destructive natural events, affecting both rural and urban settlements as well as developed and developing countries (Santosa, 2006). But, the degree of vulnerability to natural disasters especially to flooding is high in developing countries, such as Ethiopia, where necessity tends to force the poor to occupy the most vulnerable areas. The vulnerability of developed countries to flooding increases with economic growth and the accumulation of property in flood prone areas and in

highly urbanized settings (WMO, 2009; Mulugeta, 2016). WMO (2009) stated that, approximately 70% of all global disasters are linked to hydro meteorological events especially flooding, which ranked the second highest natural disaster in causing loss of lives in the world. Each year thousands of people displaced from their homes and a millions of people lose their lives due to floods.

Over past decades, high deaths recorded in Africa due to flooding as a result of population settlement patterns than a consequence of climate change. The report showed that, floods displaced 2.5 million people in Africa in 2009 and more than a million in 2007. Besides, Overall African flood fatalities increased by a factor of ten from 1950 to 2009 and over 15,000 people died during the decade 2000-2009. On the other hand, the settlement in flood prone areas also increased by a factor of ten over the same period and the frequency and severity of floods in most parts of African country has increased considerably (Sinafikish, 2013).

Flooding in Ethiopia is mainly linked with the national topography of highland mountains and lowland plains with natural drainage systems formed by the principal river basins. On the other hand, most floods in the country occur due to the overflowing of rivers that causes runoff and inundation along their banks in lowland plains. As ERCS (2006), stated that, heavy rains across the country caused further flooding in different parts of the country including Addis Ababa. The flood duration and its appearance in Addis Ababa seem increasing over years. Due to this, the issue of flood continues to be of growing concern in Addis Ababa especially to peoples residing along river courses, such as Ginfile, as well as village located at the foot of hills/mountains, such as Entoto Hills. Flood disasters are occurring more frequently, and having an ever more dramatic impact on Addis Ababa in terms of the costs on lives, livelihoods and environmental resources. According to the data from Addis Ababa Fire and Emergency Prevention and Rescue Authority (AAFEPPRA), due to global climate change and local environmental pressures, the occurrence and frequency of flood hazards and the magnitude of destruction is increasing through time in Addis Ababa. Particularly at present, flooding is increasing and causing great loss of human lives and property.

According to <http://capitalethiopia.com/2018/05/14/new> (retrieved on 24 July 2018), the study by Addis Ababa City Fire, Emergency Prevention and Rescue Agency disclosed that 121,000 houses in Addis, including 1,000 government and private institutions are in locations vulnerable to flood disasters. A majority of the risky places are in Gullele and Nifas Silk Sub cities where houses are constructed near rivers and drainage sites. The Agency, which is notifying home owners who are at risk, initially identified 143 flood prone areas in Addis Ababa. Riversides in Addis Ababa have been a source of worry for residents in their precipices. The areas have been dogged by landslides, pollution and lack of development for ages. Addis Ababa rivers and riversides face problems which include: badly polluted segments through direct discharge of domestic waste generated mainly from households and institutions; river bank erosion; and inaccessible rivers and riversides. In 2017 alone, there were 76 floods in the city, damaging houses and properties worth 20 million birr. Flooding also claimed the life of one man who lived in Nifas Silk Lafto sub-city. The figures are increasing every year.

Even though the impact of flooding hazard is related to various external factors, the absence of proper mitigation and analysis of floods is exacerbating the problem of flooding in Addis Ababa City. Indeed this is strongly correlated with the study of the cause of flooding and scientific analysis of the status of floods at the specific location with all its characteristics and pattern of flow. That is why this study is focusing on the cause of flooding hazard and mitigation strategies in Addis Ababa City with the specific attention to the households residing along Ginfile River.

1.2 Statement of the problem

Addis Ababa is a city suffering from rainy season flooding owing to several factors such as poor urban planning and solid waste management, increasing population size, deforestation in hilly peri-urban areas, misuse of sewerage tubes, and increasing paved surfaces in urban areas. This has been causing serious environmental problem that causes a great social and economic crisis on the people of Addis Ababa. One of the big problems that increase the effects of flooding from time to time in Addis Ababa is illegal settlement along riversides, such as Ginfile. On the other hand, one of the great problems that aggravates flooding in the city are land use change on the surrounding upland catchments

and the absence of proper and coordinated watershed management practices on these catchment areas, particularly around Entoto Hill. Moreover, the city has no drainage master plan and the existing flood management structures are insufficient. Due to these, if there is maximum and concentrated rainfall happens in the upland catchments, with a very high speed, high water flow from those upland catchments down to the city of Addis Ababa and inundates part of the city along rivers. Sometimes even paved roads and low-lying areas are flooded. This also has considerable consequences on houses, public institutions, transpiration and market places.

Addis Ababa is one of the cities in Ethiopia severely hit by flooding every year. In 2017 alone, there were 76 floods in the city, damaging houses and properties worth 20 million birr. Flooding also claimed human life and the figures are increasing every year. All of these flooding events attributed to different land use change activities and absence of watershed management practices on the surrounding upland catchments of Addis Ababa. Farmlands and urbanized areas are increased from time to time that removed forest areas around hilly areas of the city. Paved surfaces are increasing; riverside settlements are rising; population density is mounting, and riversides are misused. Due to these adverse factors, high surface runoff generated and it increased the occurrence of flooding which creates severe socio-economic crises on the people of Addis Ababa.

This research, therefore, attempts to synthesize the relevant information about the causes and status of urban flooding in Addis Ababa with special reference to the households living along Ginfile River. Though this needs modern technologies like GIS and remote sensing for surface water modeling to sensitize the causes of flooding hazard and how much the underlying causes exacerbate the existing problem and make the residents susceptible to the hazard, the study tries to stick socioeconomic and environmental data to look into the issue under investigation. This study not only deals with the causes of flooding but also seasonality of flooding, flood vulnerability status of the households, the measures taken by the community, the government and NGOs, perception of the households on flooding hazards, and the way forward by bringing the problem to the

scene based on tangible information. In so doing, this study will fill the gaps that a little bit or never been touched by previous researchers.

1.3 Objectives of the study

1.3.1 General objective

The major objective of this research is to assess the vulnerability of urban households to flooding hazards in Addis Ababa with specific reference to the households residing along Ginfile stream.

1.3.2 Specific objectives

More specifically, this study planned to:

- explore the major causes of flooding for households residing along Ginfile river in Addis Ababa
- investigate the seasonality of flooding in areas along Ginfile river in Addis Ababa
- Assess the flood vulnerability status of the households residing along Ginfile river in Addis Ababa
- describe the measures taken by the community and the government in mitigating flooding hazards in the area
- investigate the flood coping strategies of the households residing along Ginfile river in Addis Ababa

1.4 Research questions

This research intended to answer the following basic questions which are derivatives of the abovementioned research objectives:

- What seem the causes of urban flooding in Addis Ababa?
- What is the trend of land use change in hilly areas around Ababa?
- What are the causes of land use/land cover change in hilly areas around Ababa?
- What is the effect of land use/land cover change on flood occurrence?
- What seems the flood inundation in Addis Ababa city?
- What are the potential consequences resulted from flooding along Ginfile river in Addis Ababa?
- What are the dominant watershed management units for the sub-watersheds of Entoto?

- What the measures taken by the community, the government and NGOs in mitigating flooding hazards in the area?
- What does the flood coping strategies of the households residing along Ginfile river in Addis Ababa?

1.5 Scope and Limitation of the Study

The study is limited to the issue of causes and consequences of flooding in Addis Ababa City. However, causes and consequences of flooding is a wide concept and it is difficult to cover the whole issues and ideas under it. So, this study focused on analyzing the causes of flooding and its impacts in Addis Ababa City with special reference to the households living around Ginfile stream. In fact, the researcher has especially faced difficulties in collecting the required secondary data and software to achieve the purpose of the study, as well as getting the required satellite images with the desirable temporal and spatial specifications and getting the right software for flood inundation modeling. The other challenge encountered in the course of the study was the expensiveness of satellite areal grid, monthly temperature and rainfall meteorological data. The unwillingness and information gaps from the selected samples during group discussion and interviews were also the challenges. However, the researcher managed the challenges in one way or another so as to keep the quality of the paper to its best level.

1.6 Significance of the Study

It is quite clear that Addis Ababa is a city suffering from rainy season flooding owing to several adverse factors. This has been resulting in a great socioeconomic damage in the city. In order to minimize and avoid the problem, there should be a research that can identify and understand the causes and consequences of flooding in the city. In general, this study provides basic information for different concerned bodies including local communities, governmental and non-governmental organizations. This helps to formulate land use policy, to control illegal settlement along riversides and catchment management in and around Addis Ababa. It also helps to identify flood-vulnerable areas to adopt early warning systems (EWS), to control potential human casualty and the damage of properties and also to control illegal settlement in the flooding zone. Moreover, this study

helps as an input for the long term watershed management planning and flood control practices in the city Administration of Addis Ababa. Finally, this study has employed different methodologies especially the GIS and Remote Sensing techniques which have an important contribution for the academic societies in making further studies and other related investigations.

1.7 Definition of keywords/phrases

- **Urban flooding:** Urban flooding is the inundation of land or property in a built environment, particularly in more densely populated areas, caused by rainfall overwhelming the capacity of drainage systems, such as storm sewers. (ACCCRN, 2016)
- **Catchment/watershed/basin:** Watershed is the area covering all the land that contributes runoff water to a common point. In other words, it is an extent of land where water from rain or snow melts drains into a body of water, such as river, lake, reservoir, sea or ocean.(USGS. 2018)
- **Inundation:** Inundation is a rising and spreading of water especially flood waters over the ground. In other words, it is an overflowing and the covering of an area with flood water. Inundation is also the total water level that occurs on normally dry ground as a result of the storm tide, and is expressed in terms of height of water, in feet, above ground level.(NHC, 2013)
- **Land use change:** Land use change is defined to be any physical, biological or chemical change attributable to management, which may include conversion of grazing to cropping, change in fertilizer use, drainage improvements, installation and use of irrigation, plantations, building farm dams, pollution and land degradation, vegetation removal and so on. (Aklile, 2014)
- **Watershed delineation:** It is creating a boundary that represents the contributing area for a particular control point or outlet. Delineation is part of the process known as watershed segmentation that is, dividing the watershed into discrete land and channel segments to analyze watershed behavior.(MaDGIC, 2014)

1.8 Outline of the thesis

This thesis consists of five chapters. **Chapter One** presents the general introduction of the thesis that includes: background of the study, statement of the problem, objectives and research questions, significance of the study, scope and limitation of the study and definition of key words. The **second chapter** devoted to a review of related literature through which various concepts relevant to the study are discussed. The **third chapter** deals with methodological issues, under which the general descriptions of the study area, the data sources and acquisition techniques as well as method of data analysis are discussed. The **forth chapter** also devoted to discussion and analysis based on the processed primary and secondary data of the study. And finally the **fifth chapter** is dedicated to conclusion and recommendation based on the findings of the study.

CHAPTER II: REVIEW OF RELATED LITRATURE

This chapter tries to present an overview of the theoretical literature, related empirical studies, the literature gap and the conceptual framework of the study. It focuses on the causes and impacts of flooding, and land use dynamics vs. flooding. The chapter then concludes by providing the analytical framework depicting the conceptual roadmap of the study in the context of Addis Ababa.

2.1. The concept of flooding

Flooding has many different definitions among which Meyer' (2004) definition is worth mentioning. Meyer (2004) defined flooding as flooding is '*the accumulation of water within a water body and the overflow of excess water on to adjacent flood plains, or it is an overflow of inland or tidal waters, unusual and rapid accumulation of runoff or surface waters from any source*'. In addition to this, flooding is an overflowing or irruption of a great body of water over land surface that temporarily inundates an area. Furthermore, Manandhar (2010), also defined flooding as '*Flooding is a general and temporary condition of partial or complete inundation of normally dry land areas from the usual and rapid runoff of surface waters which may results from rainfall, rivers, ice melt and so on*'.

According to Sinafikish (2013), flood is used in a broader sense to cover several river activities that causes damage that is inundation of floodplains and adjacent terraces, bank cutting, river channel shifting, and debris torrents during normally high discharge. There are different types of flooding such as river flooding, coastal flooding, flash flooding and urban flooding. Among these types of flooding, a flash flood could be defined as a rapid flooding of low-lying areas, rivers and streams that are caused by the intense rainfall associated with a thunderstorm and they also occur when a man-made structure, such as a dam, collapses. Flash flooding occurs when the ground under a storm becomes saturated with water so quickly that it cannot be absorbed. The runoff collects in low-lying areas and flows rapidly downhill. Grabs (2011) and Bariweniet.al (2012), cited in Sinafikish (2013), finalized the concept of flooding in this manner that flood occurs when ponds,

lakes, and riverbeds have no a capacity to hold additional water due to sedimentation or other related factors, and also it occurs when soil and vegetation cannot absorb or infiltrate all the water may come from rainfall or other sources.

2.2. Causes and Consequences of Flooding

According to Mulugeta (2016) and Sinafikish (2013), floods are caused by many factors such as heavy rainfall, highly accelerated snowmelt, severe winds over water, unusual high tide, tsunamis, or failure of dams, levees, retention ponds, or other structures that retained the water. In other way, flooding can be exacerbated by increased amounts of impervious surface or hard ground cover that not allow the water to pass thorough as well as by other natural hazards such as wildfires, which reduce the supply or the amount of vegetation cover that can absorb rainfall.

Mulugeta (2016) indicated that floods can occur due to meteorological, partly meteorological or other causes, which can exacerbate the occurrence of flooding. Meteorological causes include snowmelt, rain, and combination of rain and ice melt. Coastal storm surges and estuarine interactions between stream flow and tidal conditions entail the partly meteorological causes (Alexander, 2000). The remaining causes of floods can be attributed to other natural hazards such as earthquakes, landslides, Tsunamis and hurricanes or human-caused (technological) hazards such as dam breaks, fail levees, dykes, weirs and terraces. The cause of flooding can be described according to the water source, geography of receiving area, cause and the speed of onset. Water source-related floods can originate from the ocean (coastal floods), rivers (fluvial floods), from underground (groundwater floods) and from rain (pluvial floods). These major flood types will each be described in terms of its geography, cause, and onset speed.

Climate change and increasing need for dwellings and industrial properties have a tendency to increase the risk of flooding, and many development activities which are situated in flood plains can increase the risk and impacts of flooding (Elliott and Leggett, 2002). It is generally accepted that many land use change practices or changes in land use patterns such as expansion of settlements including road construction, deforestation, and different practices in arable and grassland management have a great contribution to

increase the frequency and severity of flooding. Land use and land cover changes have different effects on the local hydrological cycle depending on the nature of the land use cover that existed and that one which results after the changes (Wahren*et. al*, 2009; Kimaro, 2003).

According to Sinafikish (2013), land use is being dynamically shaped under the influence and interaction of two broad sets of forces human needs and environmental features and processes. Land use occurs as a result of natural process such as climatic variation, volcanic eruptions, change in river channels or the sea levels, etc. However, most of the land cover changes of the present and the recent past are due to human actions or intervention to using of the land for production or settlement. This is because of the different socio-economic drivers including demographic, social, economic, technological, market, political and institutional factors and their processes.

There are two major aspects that connect land use and flooding. The first one is the location or existence of values and key components of the economy on flood plains provides economic benefits and at the same time creates risks for the society in terms of flood loss potential. Secondly, the development of land through different construction activities has consequences on the flow of water on the one hand, either by accelerating runoff through reducing the infiltration capacity of soils or obstructing the natural drainage system as well as sediment and pollutants on the other hand. In general, human alterations of the catchment area can significantly contribute to changes to all those processes that are the hydrological processes through large scale land use changes and land use practices In addition to this, with increasing human alteration and development of the catchment area, the runoff generation process is changed, especially through decreasing the infiltration capacity of the soil and the change of soil cover. This has lead to a great concern over human beings which play a great role in increasing flood hazards through the alterations of the catchments (WMO, 2008).

Likewise, Tali (2011), cited in Sinafikish (2013), clearly stated about the relationship between land use change and flooding: 'Catchment land use/land cover changes influence the condition for transformation of precipitation into runoff by expanding impervious

surfaces which lead to decrease infiltration rate and consequently increase the amount and rate of runoff’.

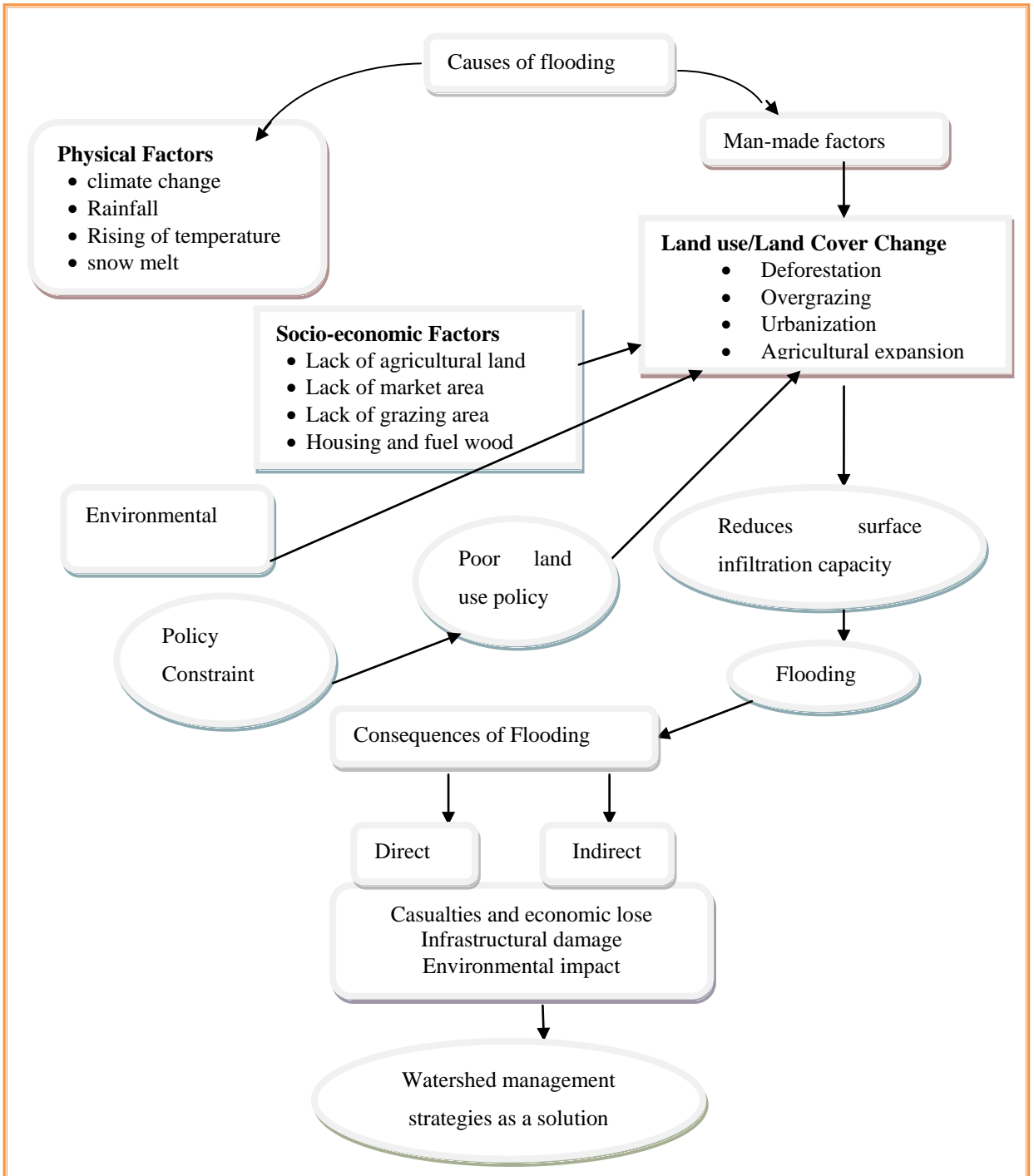


Figure: 2.1. A simplified diagram indicating the causes and consequences of flooding (Source: modified from Sinafikish, 2013).

The other important factor that causes flooding is the absence of land use policy. WMO (2007), cited in Sinafikish (2013), stated that, land use policies and regulations play an important role in catchment management and in reducing the risk due to flooding. But, due to the absence of such policy, there may be human intervention in the catchment that affects the hydrological process including illegal settlement and other restricted activities. Flooding has serious implications on the infrastructure, people and economy. That is, the adverse effects of floods often involve far reaching socio-economic and environmental consequences including loss of life and property; mass migration of people and animals; environmental degradation; and shortages of food, energy, water and other basic needs.

According to Lucena *et.al* (2006), cited in Sinafikish (2013), flooding has both direct and indirect consequences. The direct impacts of flooding concerns when damages caused by the physical contact of floodwaters or when peoples or objects directly affected by the floodwater. In addition to this, as Zein (2010), stated that, the direct losses of flooding include fatalities, injuries homelessness, collapse of buildings and infrastructures, sedimentation, pollution and so on. While, indirect losses include diseases, psychological impact, short and long-term economic loss and so on. As shown in Figure 2.1, human casualties, economic loses; infrastructural damage and adverse environmental impacts are worth mentioning in this regard.

2.3. Urban Flooding

Since this research is specific to urban households' vulnerability to flooding hazards in Addis Ababa, it is worth mention issues related to urban flooding. In this regard, Mulugeta (2016) indicated that the major causes of flooding especially in an urban environment are those drainage areas, constrictions, obstruction (bridges and culverts) debris contamination soil saturation, velocity, topography, ground cover and size are the major ones. Topographical factors are key for the genesis and evolution of the quasi-stationary convective systems (or in simplified terms slow moving rainfall cells that release large amounts of water over a relatively small area) that are often the causes of flash floods. From the hydrological point of view, on the other hand, factors that have a decisive influence on the occurrence of flash floods, apart from the intensity and duration of the rainfall, are the topography, soil conditions, and coverage of the terrain.

Disadvantageous topographical conditions such as high-exposure (steeply sloping) highland terrains, narrow valleys or ravines hasten the runoff and increase the likelihood of urban flood occurrence across the world. Saturated soil or shallow watertight geological layers increase surface runoff. Terrain coverage can have a similar effect. According to WMO (2007), urbanization processes and affiliated construction with watertight materials are thought to make runoff 2 to 6 times greater in comparison to terrains with natural coverage (fields, meadows, forests). In summary there are various factors contributing to urban flood risk, some being influenced by human intervention and others are entirely independent from human action.

According to Mulugeta (2016), riverine (fluvial), such as Ginfile stream, floods are caused by long periods of rain in the catchment area that result in an increase of the water level of the river and the overflow of river banks both in urban and rural areas. It is a slow-onset flood restricted to flood plains that is characterized by slow velocities and large inundated areas that can cause huge damages on infrastructural, the economic and human lives. Ponding (pluvial) floods are caused by the accumulation of rain water in low-lying areas with clay type soils. These floods have a slow onset and can be forecasted days ahead although they can cause major damage, especially in urban areas, but rarely with fatalities.

2.4. Management of Urban Flooding

The harsh adverse impacts of flooding usually calls for managing flood disaster through appropriate systems and strategies is necessarily required especially to predict and evaluate possible flood that may occur in a particular area. This, in turn, helps to reduce the potential damage caused by flooding hazards. It is always argued that to find out possible solutions to flooding problems, an understanding of the long-term factors that contribute to increase flooding are important including unplanned urbanization, soil erosion and deforestation. Then to mitigate flooding hazards, it is important to adopt watershed-based management practices. In addition to this, to mitigate flooding propensity, both the government and people have to adopt watershed-scale best management practices which includes floodplain zoning, planned urbanization,

restoration of abundant channels, dredging of rivers and streams, increased elevations of roads and village platforms, building of efficient storm sewer systems, establishment of buffer zones along rivers, conservation tillage, controlled runoff near construction sites, adjustment of life-style and crop patterns, good governance, and improvement in flood warning/preparedness systems (Khalequzzaman, 2006; Mulugeta, 2018; Santosa, 2006; Sinafikish, 2013).

2.5. Empirical Related Literatures

There are also various empirical studies on hazard mitigation, referring to sustained action taken to reduce or eliminate the long-term risk to human life and property from hazardous conditions Mulugeta (2016) classified the forms of mitigation of adverse impacts of runoff into: **Land use controls, erosion controls, structural and nonstructural measures.**

According to Athens (2009) and Halloway *et al.*, (2008), many municipalities have produced guidelines and codes (zoning and related ordinances) for land developers that encourage minimum width sidewalks, use of pavers set in earth for driveways and walkways and other design techniques to allow maximum water infiltration in urban settings. An example of land use control program can be seen in the city of Santa Monica, California. Erosion controls, as indicated by Büchele (2006) and Ramírez (2013), have appeared since medieval times when farmers realized the importance of contour farming to protect soil resources. Beginning in the 1950s these agricultural methods became increasingly sophisticated. In the 1960s some states and local governments began to focus their efforts on mitigation of construction runoff by requiring builders to implement erosion and sediment controls (ESCs). This included such techniques as: use of straw bales and barriers to slow down runoff on slopes, installation of silt fences, programming construction for months that have less rainfall and minimizing extent and duration of exposed graded areas. Montgomery County, Maryland, implemented the first local government sediment control program in 1965, and this was followed by a statewide program in Maryland in 1970.

Mulugeta (2016), cited USACE (1996) that flood control programs as early as the first half of the twentieth century became quantitative in predicting peak flows of riverine systems. Progressively, strategies have been developed to minimize peak flows and also to reduce channel velocities. Some of the techniques commonly applied are: provision of holding ponds (also called detention basins) to buffer riverine peak flows, use of energy dissipaters in channels to reduce stream velocity and land use controls to minimize runoff.

WMO (2007) indicates that another means of flood protection could divide between structural and nonstructural measures; the latter would seem to be the key deserving particular attention in effectively limiting the damage caused by flashfloods. This does not mean that structural measures are of no assistance, but the typical procedures, like the building of reservoirs and embankments, cannot always be adopted in areas susceptible to flash floods. Small scale structural measures can, on the other hand, play an essential role in delaying the flow of water, allowing it to be locally retained, or diverting it from places where it could pose a threat to people or properties. Operations to limit the shifting of debris or to stabilize hillsides in areas at risk of landslides are important. The flood resistance of buildings potentially at risk (flood proofing) should also be secured. It should, however, be noted that flood proofing may not be considered an option where high flow velocities and associated debris loads of flood water can be expected. The dynamic forces of such conditions on structures in general and on residential buildings in particular are very uncertain and difficult to assess

Mulugeta (2016) applied GIS and Remote Sensing techniques and flood modeling software's little bit different approach by raising issues not touched by previous researchers. He integrated the rainfall runoff modeling approach by HEC-HMS software and empirical analysis models. He used the spatial and temporal change of land use/ land cover was analyzed to assess the amount of flood generated due to the change. Furthermore, Mulugeta (2016) incorporated the analysis of digital elevation model to delineate the watershed and risk area identification by analyzing flow accumulation and inundation depth.

There are different causes of flooding identified by different researchers. Orok (2011), cited by Sinafikish (2016), made an assessment of flood risk mapping in Kano City, Nigeria and the study reported that, population explosion and poverty, urbanization and climate change are the major casual factors of flooding in Nigeria. That is, higher population density especially around flood risk zones increased the extent and the damage of flooding. On the other hand, extensive urbanization and erratic climatic conditions caused destructive flooding in the study area. Among the different effects of flooding, there are some effects identified by Xuan (2011), on the study of the Effects and Opportunities of Thailand Flood. That is, the worst flood has serious implications for the infrastructure, people and economy of Thailand. Manufacturing and agriculture sectors are most affected by the flood, and the same is true on the tourism sector. On the other hand, the people of Thailand not only face disruptions of their daily lives, but also temporary unemployment as farms are damaged and factories are closed. Lastly, the disaster also dampened both consumer and business confidence, if this prolonged, it may decrease consumptions and investments.

Mutiet.al (2006), in their study on Evaluating Land Use Change Effects on River Flow in Kenya stated that, the 2000 land use/land cover dataset gave higher flood peaks compared to the 1973 dataset. That is, the hydrograph generated from the 2000 land cover dataset produced the highest peak of $877.9\text{m}^3/\text{s}$ whereas the highest peak of 1973 dataset was $827.0\text{m}^3/\text{s}$. In addition to this, the 2000 dataset peak was higher by 6% compared to the 1973 dataset and changing vegetation cover results changes in rainfall runoff response.

Dagnachew and Wubet (2009), cited by Sinafikish (2013), in their study on flood hazard and risk assessment in Fogera *Woreda* investigated that, the major flooding causative factors particularly in Fogera *Woreda* are slope condition of the area, soil type, elevation, land use type, drainage density, and rainfall. Similarly, a study taken by Daniel (2007), in his research assessment of flood risk in Dire Dawa Town depicted the same causative factors which identified by Dagnachew and Wubet (2009) that are drainage density, slope, elevation, land use type and road density.

Likewise, a study conducted by Yonas (2009), on the socioeconomic impacts of flooding in Dire Dawa, showed that high rainfall intensity accompanied by severe forest degradation has caused increased flood damage in the study area. Moreover, the result of flood inundation showed that residential areas and business centers experienced the worst socio-economic damages among the different sectors in the city. Similarly, it has also an enormous impact on the economic foundation of the city due to expenditure for rehabilitation and reconstruction of the damaged infrastructures and houses. Absence of early warning system and land-use policy highly contributed to the increment of the flood impact.

The same study have been conducted by Yonas and Girma (2010), on flood triggering factors and the efforts to mitigate flood disaster in Dire Dawa, Ethiopia, revealed that, the primary cause of flooding in Dechatu River is unusually high rainfall and other man-induced causes, such as land degradation, deforestation, increased population density along riverbanks, poor land-use planning and zoning and a progressive loss of flood risk perception due to the periodic occurrence of flash floods, play a significant role as well. In addition, analysis of the rainfall data for the Dechatu catchment indicates an uneven distribution of precipitation and though the area is undergoing a general decreasing trend for both rainfall amount and rainy days exceeding 24 mm, peaks of rainfall surprisingly higher than usual may still occur and generate destructive flash floods.

Samson (2008), as cited by Sinafikish (2016), made an assessment of the effects of floods specifically on health in Gambella, Ethiopia in relation to the strength and weakness of coping strategy. The study reported that the main impacts of flooding on human health in Gambella region were deaths, injuries, and diseases such as malaria and diarrhea. Another notable consequence of flooding was crop destruction and subsequent malnutrition.

Land use and land cover dynamics are widespread, accelerating, and significant processes driven by human actions but also producing changes that impact humans. Shiferaw (2011), in his study evaluating the land use and land cover dynamics in Borena *Woreda*, central Ethiopia, stated that the main causes of land use land cover changes in the study

area was population growth due to the demand of land for cultivation and settlement, forests for fuel, and construction purposes. In addition to this, natural factors such as climate change and other human factors including over intensification of land use, farm size, land tenure status and policies on land use are the major causes of land use land cover changes in the study area.

According to Shiferaw (2011), flooding is the main implications of land use land cover change in Borena *Woreda*. Similarly, Yonas and Girma (2010), investigated that, the upland catchment of Eastern Harerge has experienced great pressure of population settlement and land-use change. A comparison between the 1985 and 2006 land use maps showed that a remarkable change occurred in the area, namely urbanized area + 44%, bare land +3%, cultivated land +16 %, shrub land -78% and open woodland -38%. In general, expansion of agricultural land and the reduction of shrub land and open woodland have a direct correlation with surface runoff generation potential that increased the flood frequency and the resultant damage in Dire Dawa. Ashagrieet.al (2006) also identified a significant relationship between flooding and land use change on the study detecting the influence of land use change on floods in the Mesuse river. The result showed that, surface runoff was most susceptible to land use changes, while it is observed that afforestation demonstrated a significant reduction in discharge. That is, the main reason for torrential destructive flood in Mesuse River is the destruction of the upstream land cover or the reduction of the forest lands that increased the run off coefficient from 10 to 15 percent. Floods are resulted from factors such as the human intervention in the natural hydrologic cycle, destruction of vegetation of the river basins, and expansion of impermeable surfaces through the urbanization processes (Alijaniet. al, 2010). During the last decades the natural cover of the land, especially the forest lands, has decreased all over Iran. As a result, the torrential floods increased ten times during the past 50 years.

All the reviewed empirical literatures in Ethiopia and elsewhere indicate that the researchers have made a detail investigation on the different causes and consequences of flooding in various areas. This on *Ginfle* Stream in Addis Ababa study too investigated some of the causes and consequences of flooding with the inclusion of a little bit new research approaches and issues that are not touched by the previous researches especially

researches in the study area. That is, the study will demonstrated the inundated areas and the resultant damages on people and property with the GIS environment, and looked into the causes of flooding by looking into the landscape and the ideas from the informants. For the purpose of filling the gap, this study investigated the cause of flooding by using GIS techniques, key informant interview, focus group discussion and observation. Satellite images were used to look into the seasonality and status of the inundation. Photographs were captured and analyzed. Interviews and discussions were carried out to

2.6 Analytical Framework of the Study

The most appropriate analytical framework for this study seems DPSIR framework. This is because, as indicated by Sinafikish (2013), Mulugeta (2016), and Morris and Posthumus (2007), it is significant for the purpose of flood study to show the diverse interaction between the causes and effects of flooding. This model indicates that the main driving forces and pressures that induce floods and their impacts are climate change; change in catchment and in flood plain land use, population growth, urbanization and increasing settlement. This best explains the current situation in Addis Ababa particularly related to unplanned urbanization, urban sprawl, rapid population increase, clumsy and careless settlement along rivers in the city. Impacts are the consequence of the pressures which causes flooding or runoff that includes both socioeconomic and environmental impacts. In the model *response* includes different measures like structural and non-structural as well as policies that can protect *drivers* and *pressures* are said to be improving the state of the environment and reduce the impacts of flooding in a given area.

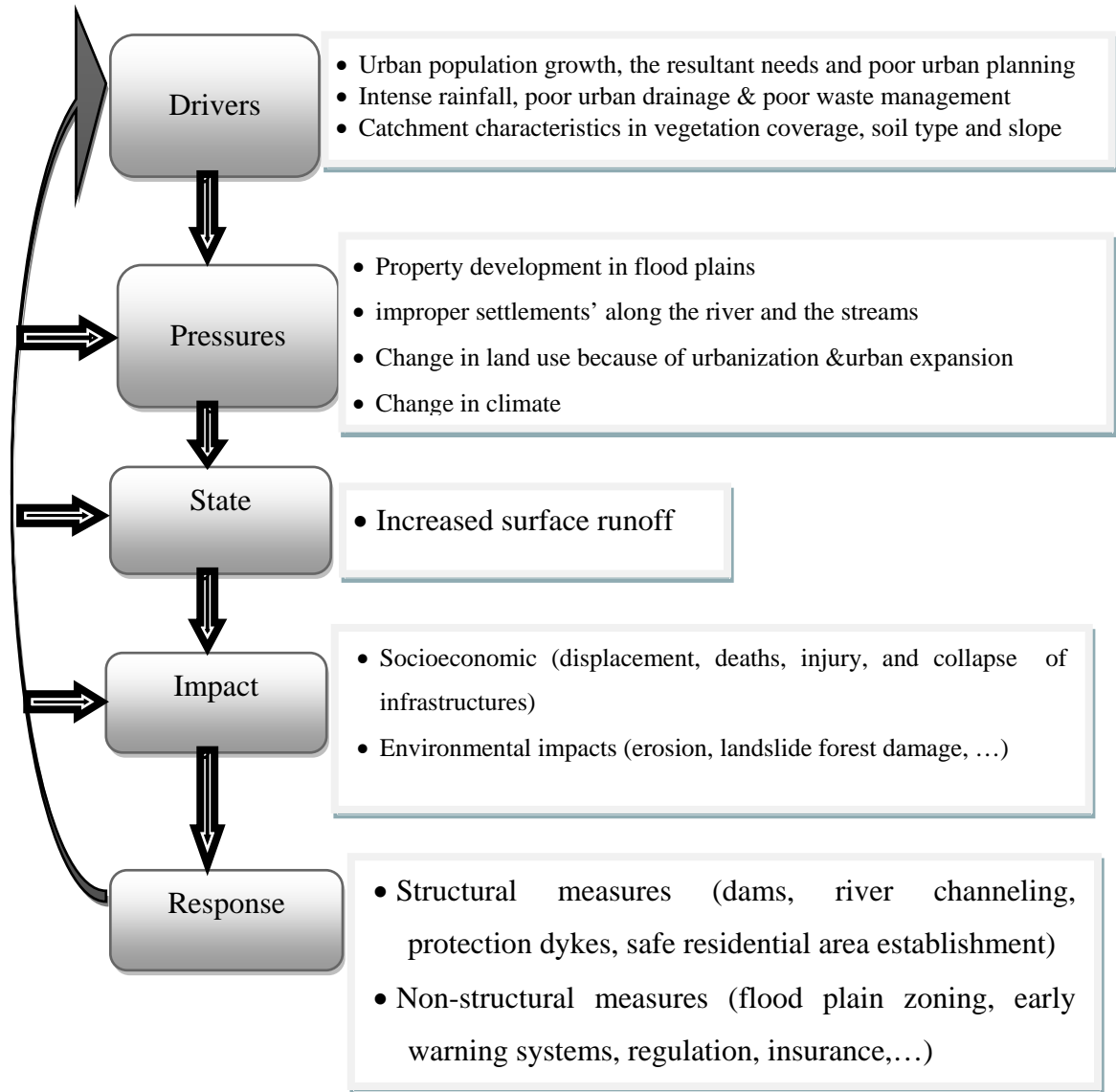


Figure 2.2: DPSIR Framework for flood assessment (source: Modified from European Environment Agency (2001), Sinafikish (2013) and Mulugeta (2016).

CHAPTE III: DESCRIPTION OF THE STUDY AREA AND THE RESEARCH METHODS

3.1. Description of Addis Ababa

3.1.1. Location

This section is justifiable for discussion because the study area, Ginfile stream, is located in Addis Ababa. Founded in 1886, Addis Ababa is the capital City of Ethiopia, and it is located at 9°2'N latitude and 38°42' East longitude with altitude ranging from 2,100 meters at Akaki in the south to 3,000 meters at Entoto hill in the North (CFES, 2017a). According to the population projection of the Central Statistical Agency (CSA) /2013/, the population of Addis Ababa is estimated to be about 3.5 million with a growth rate of 2.9% per year. This will be more than double by the year 2030. Its geographic area has grown quickly over the last decade, expanding from 11,000 hectares in 1995 to the current built up area of the City lying within the Big and little Akaki river basins which has a catchment area of about 540 square kilometers (CFES, 2017a).

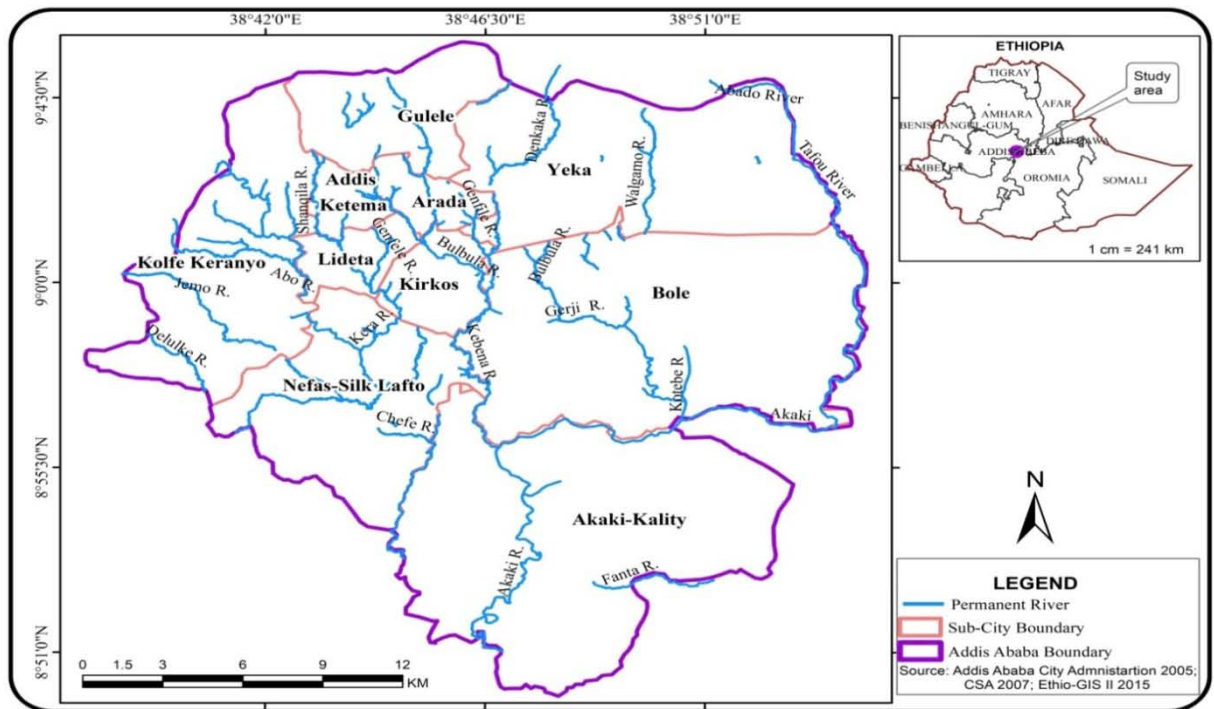


Figure 3.1: Addis Ababa: Major, sub-cities and its national settings (Source: compiled by the researcher)

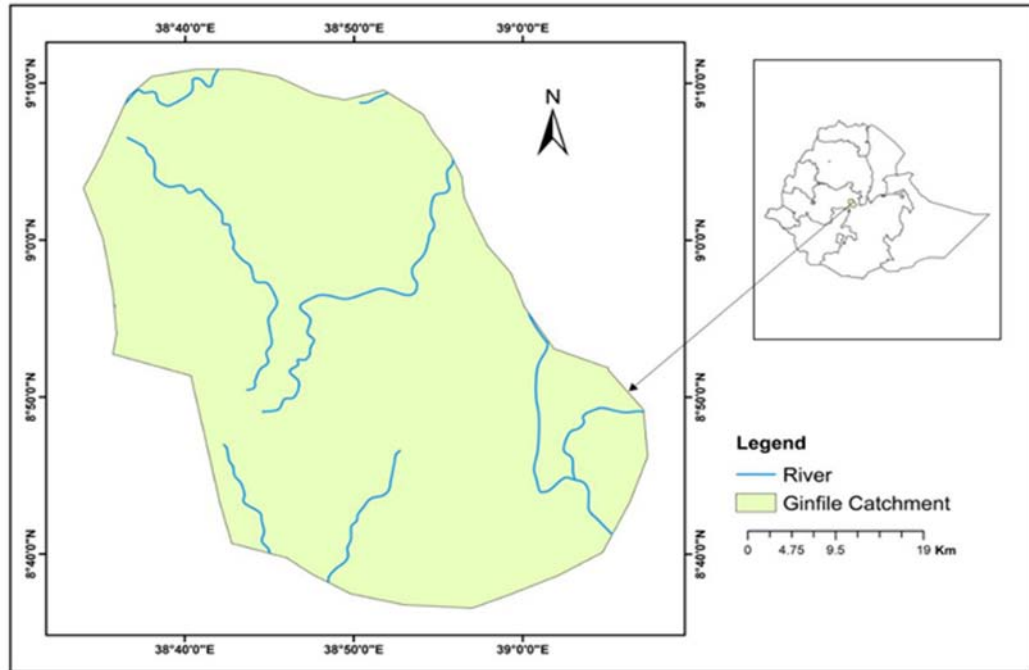


Figure 3.2: Ginfile river catchments. (Source: completed by the researcher)

There are strong correlations between rainfall amount and river discharge several of the primary streams in this part are known as kebena from the source to the middle zone. The primary streams draining the western part of the upper catchment include Denkaka (from ankorcha hills), Gelana (central hills) and Ginfile (middle catchment). Kebena and Banteyiketu are third order streams in the middle zone and form a fourth order stream called big kebena at the peacock junction.

The surface water resources in the Big-Kabana sub-watershed exist in the form of stream flows formed by network of primary, secondary, tertiary and quaternary streams. The upper catchment is the source of the primary streams, and the primary streams are formed from perched aquifers or base flows in the catchment before forming secondary streams in the middle zone.

The first major networks of streams are formed by Kurtumi and Kechene rivers draining the eastern part of the upper and middle catchment zones. The primary tributaries for Kurtumi River include Chefe, Kostre, Fendo and Gordeme originating from the eastern parts of the upper catchment. For Kechene River, the primary tributaries are Metakosha,

Kera and Demissie originating from the eastern parts of the upper catchment. Kechene and Kurtumi rivers are second order streams and together form a third order stream called Banteyiketu at Ambassador Junction.

The second major network of streams of the sub-watershed is formed by the Kabana River. The primary streams of Kabana River draining the middle part of the upper catchment include little Kebena, Gashe and Bahitawi Gedel (tinishu, fuafuate). Several of the primary streams in this part are known as Kabana from the source to the middle zone. The primary streams draining the western part of the upper catchment include Denkaka (from Ankorcha hills), Gelana (central hills) and Ginfile (middle catchment). Kabana and Banteyiketu are third order streams in the middle zone and form a fourth order stream called Big-Kabana at the Peacock Junction.

At the end of the middle catchment zone and beginning of the lower catchment zone, Big-Kabana joins Big-Akaki at a junction called Worku sefer, forming a fifth order stream named Akaki before entering the Aba-Samuel reservoir. The Big-Akaki River is formed by several primary, secondary and tertiary streams from the Legedadi and Tafo rivers catchments. In addition to the flow from Big-Akaki and Big-Kebena, the lower catchment zone is drained by primary streams of Kilinto, Dido and Tulu Dimtu. The Overflow of Ginfile River found in the Middle, west joint of 4kilo to Urael -Aware. (CFES, 2017b)

In Addis Ababa the increasing trend in population growth, urbanization and industrialization puts an extreme pressure on City's urban environmental management. Liquid waste discharge into the river including sewer line, municipal solid waste dumping on the river banks. Almost all the drainage system opens their outlet to the river system in Addis Ababa. Hospital wastes discharge into the river open defecation on the banks of the rivers surface runoff from municipal, agricultural land and vegetable farming. Discharge of animal wastes from cattle sheds located along the river banks. The inappropriate practices of dumping domestic and industrial wastes into the river catchments have resulted in turning the rivers into sewer line services.

Open green areas in general and rivers and riversides in particular, have been placed under extreme pressure, thus threatening their ability to maintain basic ecological, social and economic functions. The findings by (CFES, 2017b) revealed that the pollution level of the river is higher than not only the permissible limits used by various bodies for surface water quality parameters but also it is by far higher than the wastewater characteristics for typical untreated domestic wastewater. Due to existing poor waste management technology, domestic, commercial and industrial waste disposal systems along the riverbanks, City Rivers are seriously suffering from pollution and classified as badly polluted rivers. The main surface water system and the most impacted rivers in the city include Banteyiketu, Kechene, Qurtumie, Kebena, and little Akaki rivers (CFES, 2017a).

3.1.2. Climatic conditions of Addis Ababa

Addis Ababa has a subtropical highland climatic condition. The city has a complex mix of highland climate zones, with temperature differences of up to 10°C depending on elevation and prevailing wind patterns. The high elevation moderates temperatures year-round, and the city's position near the equator means that temperatures are very constant from month to month. As such the climate would be maritime climate if its elevation was not taken into account, as no month is above 22°C in mean temperatures.

Mid-November to January is a season for occasional rain. The highland climate regions are characterized by dry winters, and this is the dry season in Addis Ababa. According to the data from National Metrological Agency (NMA) of Ethiopia, during this season the daily maximum temperatures are usually not more than 23°C and the night-time minimum temperatures can drop to freezing. The short rainy season is from February to May. During this period, the difference between the daytime maximum temperatures and the night-time minimum temperatures is not as great as during other times of the year, with minimum temperatures in the range of 10-15 °C. At this time of the year, the city experiences warm temperatures and a pleasant rainfall.

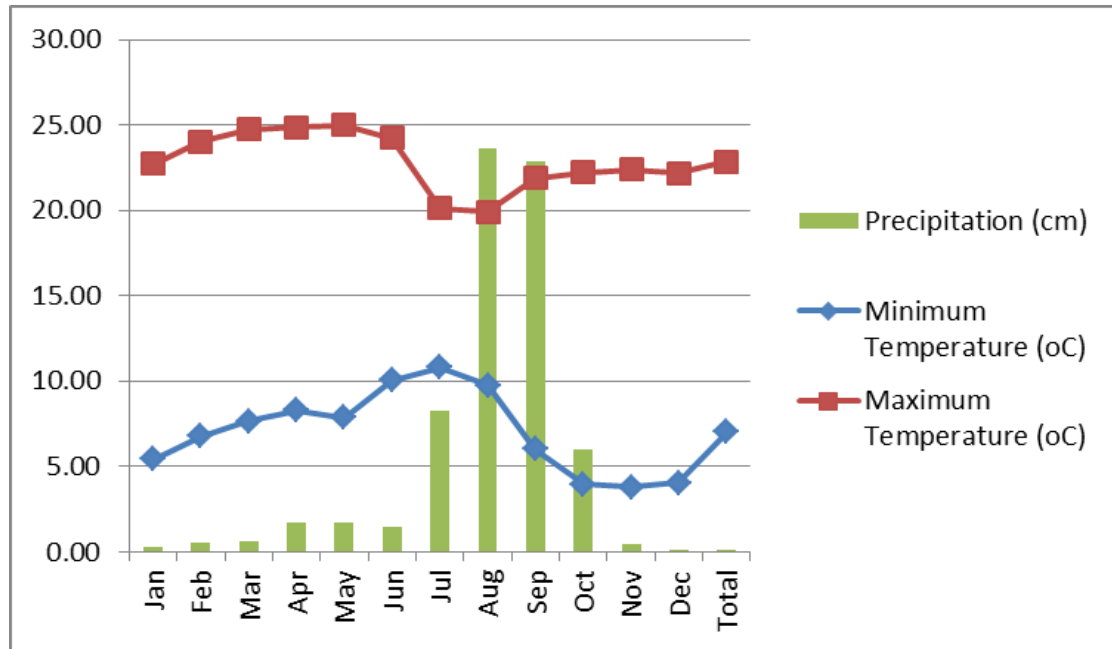


Figure 3.3: Mean Monthly Temperature (Minimum and Maximum) and Rainfall (1990 - 2014) (Source: Computed based on raw data obtained from NMA)

The data in Figure 3.3 indicates that the major wet season in Addis Ababa is from June to mid-September. It is this time (particularly in July and August) that flooding is enormous in Addis Ababa. Rivers and stream from the surrounding hilly areas (particularly from Entoto) floods roads.

Rivers overflow resulting in damages in housing units and other infrastructures across Addis Ababa this time. This period coincides with summer, but the temperatures are much lower than at other times of year because of the frequent rain and hail and the abundance of cloud cover and fewer hours of sunshine. This time of the year is characterized by dark, chilly and wet days and nights. Other seasons (winter, autumn and spring) are relatively dry. Particularly winter (December, January and February) are very dry in Addis Ababa. In fact, the autumn seems a transitional period between the wet and dry seasons.

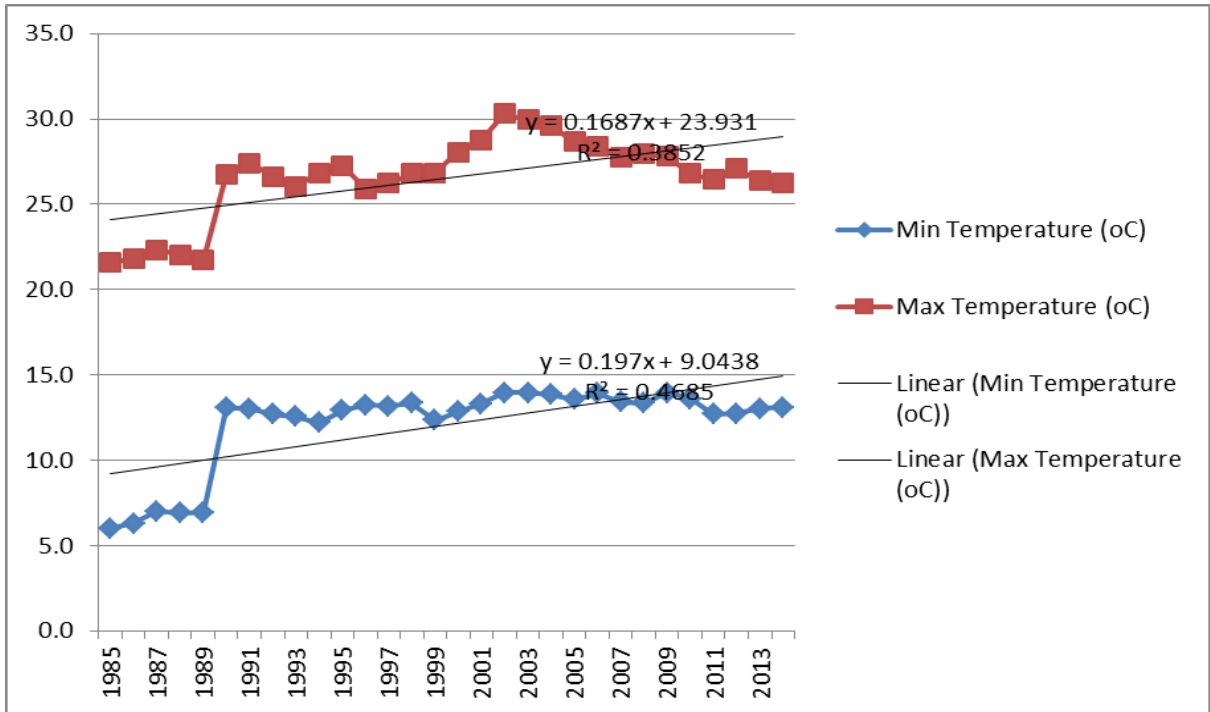


Figure 3.4: Long term Mean Annual temperature (Minimum and Maximum)(1985-2013)
 (Source: Computed based on raw data obtained from NMA).

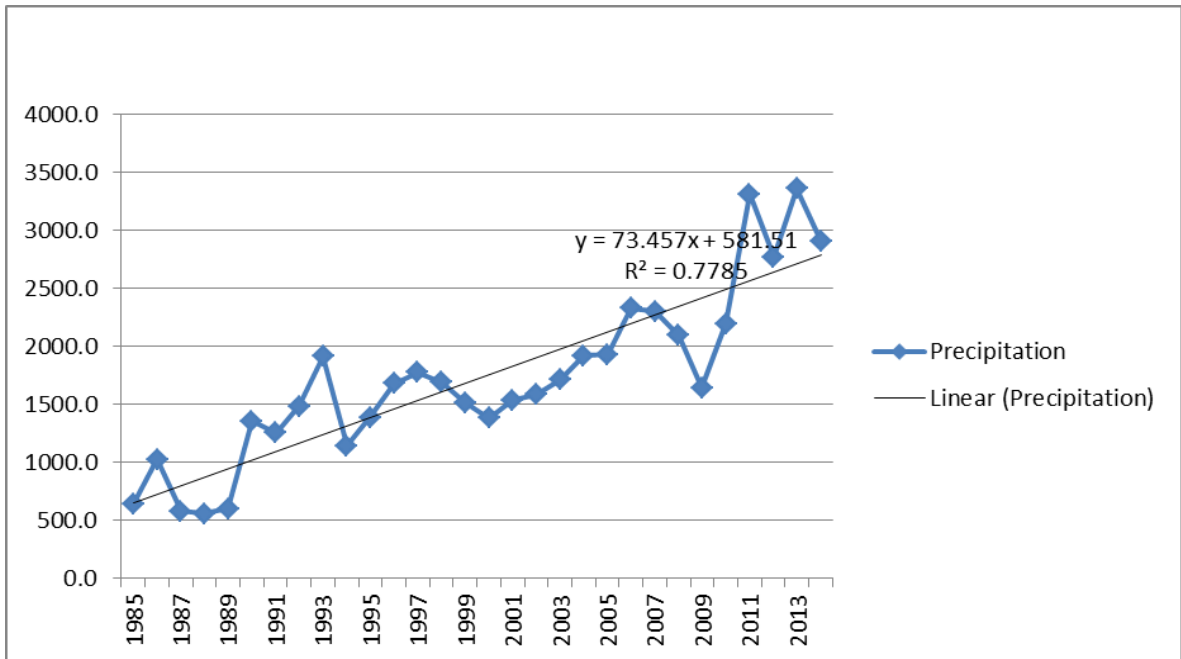


Figure 3.5: Long term and Total Rainfall of Addis Ababa in millimeters (1985-2013)
 (Source: Computed based on raw data obtained from NMA)

3.1.3.Land use, vegetation and ecosystem service in/around Addis Ababa

The Addis Ababa City is situated in the central position of the large watershed of the Aba Samuel reservoir in the Awash River Basin. The Aba Samuel reservoir is a small man-made Lake formed by a concrete dam built on the course of the Akaki River draining to the Awash River. The reservoir was established in the early 1950s as the first source of hydroelectric power for the city. The surrounding volcanic high mountain ridges such as Entoto (3200 m.a.s.l), Bereh (3228 m.a.s.l), Wechecha (3385 m.a.s.l), Yerer (3100 m.a.s.l) and Furi (2839 m.a.s.l) form the large watershed boundary and drain rain water to the Aba Samuel reservoir through a dense network of streams forming three major sub watersheds, namely Small-Akaki draining the western catchments, Big-Kebena draining the central catchments and Big-Akaki draining the eastern catchments. The Small and Big-Akaki sub-watersheds are the main sources of surface and ground water to the Addis Ababa City. Therefore, the management of the three watershed catchments is critically important for the sustainable growth and development of Addis Ababa (CFES, 2017a).

The Big-Kebena sub-watershed drains the central catchments and encompasses an estimated area of 271 km² (18%) of the watershed of the Aba Samuel reservoir. The sub-watershed extends from the Entoto mountain ridges in the north and descends down to the Aba-Samuel Reservoir after joining the Big-Akaki River. The sub-watershed crosses the central part of the city towards the southern plains separating the eastern and western catchments of the Small and Big-Akaki sub-watersheds. Big-Kebena sub-watershed is strategically important because of its important position in the city and it is the seat of the major political, historical, administrative, commercial and diplomatic establishments in the country in general and the city in particular. The parliament, the grand palace, the state house, key ministries and embassies of the major western countries iconic hotels, historical museums and Addis Ababa University are found in the urban segment of the Big-Kebena sub-watershed (CFES, 2017a).

The vegetation in/around Addis Ababa can be categorized into Eucalyptus Plantation Forest, Mixed Forest and Natural Forest. Woody plant species, herbaceous and climber species are there. The ecosystem services are an important factor in land use and land

cover management. If demand for ES exceeds supply, it is an indication of unsustainable resource use. Supply of ecosystem services is influenced by the type, condition and extent of the land use in an ecosystem. Similarly, demand for ecosystem services depends on level of socioeconomic development, climate, and urban development in urban fronts.

3.1.4. Socioeconomic profile of Addis Ababa

According to the population projection data of CSA (2013), the total population in Addis Ababa is assumed to be over 3.5 million. As of the latest 2007 population census conducted by the Ethiopian national statistics authorities, Addis Ababa has a total population of was about 2.7 million. About 662,728 households were counted living in 628,984 housing units, which results in an average of 5.3 persons to a household. Although all Ethiopian ethnic groups are represented in Addis Ababa because it is the capital of the country, the largest groups include the Amhara (56.04%), Oromo (19.00%), Gurage (16.34%), Tigre (5.18%), Siltiie (2.94%) and Gamo (1.68%). Languages spoken include Amharic (71.0%), Afan Oromo (10.7%), Gurage (8.37%), Tigrigna (3.60%), Siltie (1.82%) and Gamo (1.03%). The religion with the most believers in Addis Ababa is Ethiopian Orthodox Church with 74.7% of the population, while 16.2% are Muslims, 7.77% Protestants and 0.48% Catholic.

According to the 2007 national census, 98.64% of the housing units of Addis Ababa had access to safe drinking water, while 14.9% had flush toilets, 70.7% pit toilets (both ventilated and unventilated), and 14.3% had no toilet facilities. In 2014, there were 63 public toilets in the city, with plans to build more. Values for other reported common indicators of the standard of living for Addis Ababa as of 2005 include the following: 0.1% of the inhabitants fall into the lowest wealth quintile; adult literacy for men is 93.6% and for women 79.95%, the highest in the nation for both sexes; and the civic infant mortality rate is 45 infant deaths per 1,000 live births, which is less than the nationwide average of 77; at least half of these deaths occurred in the infants' first month of life. The city is mostly powered by drinking water Koka and Dire reservoirs.

The economic activities in Addis Ababa are diverse. According to official statistics from the Addis Ababa City Administration, some 119,197 people in the city are engaged in trade and commerce; 113,977 in manufacturing and industry; 80,391 homemakers of different variety; 71,186 in civil administration; 50,538 in transport and communication; 42,514 in education, health and social services; 32,685 in hotel and catering services; and 16,602 in agriculture. In addition to the residents of rural parts of Addis Ababa, the city dwellers also participate in animal husbandry and cultivation of gardens. According to the data from Addis Ababa Trade Office, about 677 hectares (1,670 acres) of land is irrigated annually, on which 129,880 quintals of vegetables are cultivated. It is a relatively unclean city, with the most common pollutions coming from improper solid waste management. The city has recently been in a construction boom with tall buildings rising in many places. Various luxury services have also become available and the construction of shopping malls has recently increased.

Addis Ababa has good road links with other regions, towns and Djibouti port. Public transport is through public buses and the light railway. The construction of the Addis Ababa Ring Road was initiated in 1998 to implement the city master plan and enhance peripheral development. The Ring Road was divided into three major phases that connect all the five main gates in and out of Addis Ababa with all other regions.

The city is served by Addis Ababa International Airport district is used mostly by small craft and military planes and helicopters. Addis Ababa originally had a railway connection with Djibouti City, with a picturesque French style railway station, but this route has been abandoned. The new Addis Ababa-Djibouti Railway started operation in September 2016, running parallel to the route of the original railway line. Addis Ababa opened its light rail system to the public on 20 September 2015. The system is the first of its kind in sub-Saharan Africa. The Ethiopian Railway Corporation reached a funding agreement worth millions of dollars with the Export and Import Bank of China in September 2010 and the light rail project was completed in January 2015. The route is a 34.25-kilometre (21.28 mi) network with two lines; the operational line running from the center to the south of the city. Upon completion, the east-west line will run from Ayat to

the Torhailochring-road and from Menelik Square to Merkato Bus Station, Meskel Square and Akaki

3.1.5. Water supply and sanitation

According to the data from Addis Ababa Water and Sewage Authority and (CFES, 2017a), the current total amount of water consumption in Addis Ababa (production) is 599,000 cubic meter per day. The city's water supply is powered from surface water sources at Gefersa and Dire as well as boreholes. People in the city are also reported to have using natural springs and rain water.

3.2. Methods and Materials

3.2.1. Research design

This study assessed the cause and consequence of flooding in the city of Addis Ababa with special reference to the households living along Ginfile River. To achieve this, both primary and secondary data were used. Based on the purpose and the predetermined objectives of the study, this research was carried out using mixed approaches (quantitative and qualitative). Since, all the two approaches have their own limitations, researchers felt that biases inherent in any single approach could neutralize or cancel the biases of other approaches. On the other hand, triangulating data sources a means for seeking convergence a cross qualitative and quantitative methods (Creswell, 2009). The quantitative approach encompasses the different technical approaches offered by the GIS technologies. On the other hand, qualitative approach has been used with the main aim to investigate the perceptions, feelings and experiences of the informants.

3.2.2. Sources of data

The study used both primary and secondary data sources. The primary data collected from the selected household heads living along Ginfile River in Addis Ababa, land administration experts, Addis Ababa Rivers and Riversides Development Project Officers, experts working in Addis Ababa Fire and Emergency Prevention and Rescue Agency, elders and you living along Ginfile River in Addis Ababa. According to Kitchin and Tate (2000) primary data sources are records by those who actually witnessed an

event or entail personal experience of an event itself. Whereas, secondary data sources include satellite images and written materials such as books, articles, reports, empirical findings and other related documents.

The most important sources for the secondary data were Addis Ababa Rivers and Riversides Development Project Office (AARRDPO) and Addis Ababa Fire and Emergency Prevention and Rescue Agency (AAFEPRRA). Different reputable websites are used to obtain satellite images. These are Earth Explorer, Global Land Cover Facility (GLCF) and Google Earth. Similarly, National Metrological Agency (NMA) was the most important source for meteorological data (such as temperature and rainfall data) while Central Statistical Agency (CSA) of Ethiopia was used for demographic data of Addis Ababa.

3.2.3. Sampling design

Purposive sampling is one of the sampling techniques designed and used in this study. Since, it is a type of non-probability sampling technique by which the researcher selects her/his samples based on his/her own judgment that enables the researcher to select samples that are familiar with a certain issue raised by the researcher (Kothari, 2004). So that, the researcher used purposive sampling in order to select samples who have knowledge about the purpose of the study.

The researcher carefully determined the size of the samples who conduct interview and FGD (Focus Group Discussion). To select the samples, primarily the researcher evaluated the general background including their position and knowledge, to know and to assure their ability to give adequate information about the study. So, to conduct the interview, two head officials from agriculture and rural development office and land development and administration office were selected. On the other hand, to conduct FGD, the researcher selected samples from different group of people living along Ginfile River in Addis Ababa.

3.2.4. Tools of primary data collection

To gather primary data for the study, the researcher used four tools of data collection: Document review, Key Informant Interview (KII), Focus Group Discussion (FGD), and field observation

3.2.4.1. Document review

The major sources of the documents for review were the documents of Addis Ababa Rivers and Riversides Development Project Office (AARRDPO) and Addis Ababa Fire and Emergency Prevention and Rescue Agency (AAFEPRRA). In addition to this the research to capture the status of flooding in Ethiopia in general and urban was flooding in Addis Ababa. With this in mind, any vital and reputable online sources, policies/strategies, programs and action plans will be reviewed intensively in order to come up with sounding policy roundtable output of a good reputation.

3.2.4.2. Focus Group Discussions (FGDs)

Focus group discussion was also used to get more information about the issue of the research. FGD is one of a data gathering tools in which groups of people meet to discuss their experience and thoughts about specific topics with each other and the researcher (Crang and Cook, 2007). As a result, it was used to get ample information from the discussions and idea sharing of the groups under study. Some households living along Ginfile River were selected purposively. On this ground, participants for FGDs were asked their willingness and the time for FGD was arranged at that time based on their consent. The causes of land use land cover change in upland catchment and factors of flooding effects along Ginfile River in Addis Ababa were the main topics of discussion.

3.2.4.3 Key Informant Interview (KII)

The study employed key informant interviews to get ample information on personal thought, experience and attitude. Interview is the most commonly used qualitative technique which can provide rich sources of data on people's experiences, opinions, aspirations and feelings (Kitchin and Tate, 2000). Having this in mind, in this study, higher officials of Addis Ababa Rivers and Riversides Development Project Office (AARRDPO) and Addis Ababa Fire and Emergency Prevention and Rescue Agency

(AAFEPPRA) were interviewed. The existed flood control and watershed management practices around the hilly areas in/around Addis Ababa and flood prone areas in Addis Ababa were covered during the interview. Some households living along Ginfile River as well officers were selected purposively for then interview.

3.2.4.4 Field observation

Observation entails the systematic noting and recording of events, behaviors, and artifacts in a social and physical setting (Kitchen and Tate, 2000). The researcher of this study had an opportunity to see the actual situation of the flooding zone and some parts of Ginfile River in Addis Ababa as well as the hilly areas in/around Addis Ababa that are said to be source of urban flooding in the city. Upper part of Ginfile River in Entoto Hill was also observed. Some flooding mitigation measures undertaken by AARRDPO were observed and photo'd by the researcher. Therefore, observation was used as one data collection instrument in this study. From the observation it was possible to take into consideration about the settlement and housing condition in the flooding zone, the existed flood management practices and the vegetation condition of the hilly areas in/around Addis Ababa (such as Entoto Hill).

3.2.5 Techniques of data analysis

3.2.5.1. Analysis of causes of flooding along Ginfile River

The data analysis will take the form of descriptive and interpretive methods. The descriptive technique involved describing key numerical findings, conditions, states and circumstances uncovered from the data. Numerical data from concerned offices that do have some record of flooding in Ethiopia in general and in Addis Ababa in particular were addressed quantitatively and statistical techniques will be performed in the form of descriptive analysis focusing on total numbers, frequency, averages, proportions, ratios and distribution as well as describing the prevalence and incidence of certain facts and trends. Interpretive analysis focuses on providing meaning, explanation, perceptions or causal relationship from the data obtained through document review and key informant interview.

3.2.5.2. Analysis of peri-urban Addis Ababa land use/land cover changes

Land use/land cover change in peri-urban Addis Ababa catchment and the study area was analyzed by using multi-temporal Landsat satellite images of 2002 and 2018.

Table 3.1: Landsat imagery used for the study

No	Satellite sensor	Resolution	Platform	Date
1	TM	30 m	Landsat 5	15 July 2002
2	OLI	30 m	Landsat 8	13 August 2018

(Source: Computed based on raw data obtained from Landsat image)

ERDAS imagine 9.1 and ENVI 5.3 was intensively used in the study to employ the pre-classification, classification and post classification processes. The study employed pre-classification process on the image before classifying the image to bring the image to the desirable geometric and spectral standard by removing errors and other unwanted distortions. In the classification process, the researcher employed supervised classification method by using training areas or sample points on the satellite image. In order to employ, supervised classification, the researcher was collected 36 ground truths or GCPs (Ground Control Points) from the five land use/land cover types in the field with GPS (Global Positioning System). Then, the collected points were entered into Ms-excel and processed to provide a DBF to display in ERDAS and ArcGIS software. The GCP points were integrated with the satellite image to select the training areas or sample points for supervised classification and each of the five land use/land cover types was selected from the satellite image and registered and based on their specific color. Then finally, by using the classifier algorithm in ERDAS software, the 2002 and 2018 LULC map was generated. Whereas, post classification processes was done with ENVI 5.3 software and the change detection statistics was computed and the spatial coverage of each land use classes was obtained as well as the change between 2002-2018 was detected with equivalent class pairings. On the other hand, the accuracy assessment of each LULC maps was detected based on the collected GCPs.

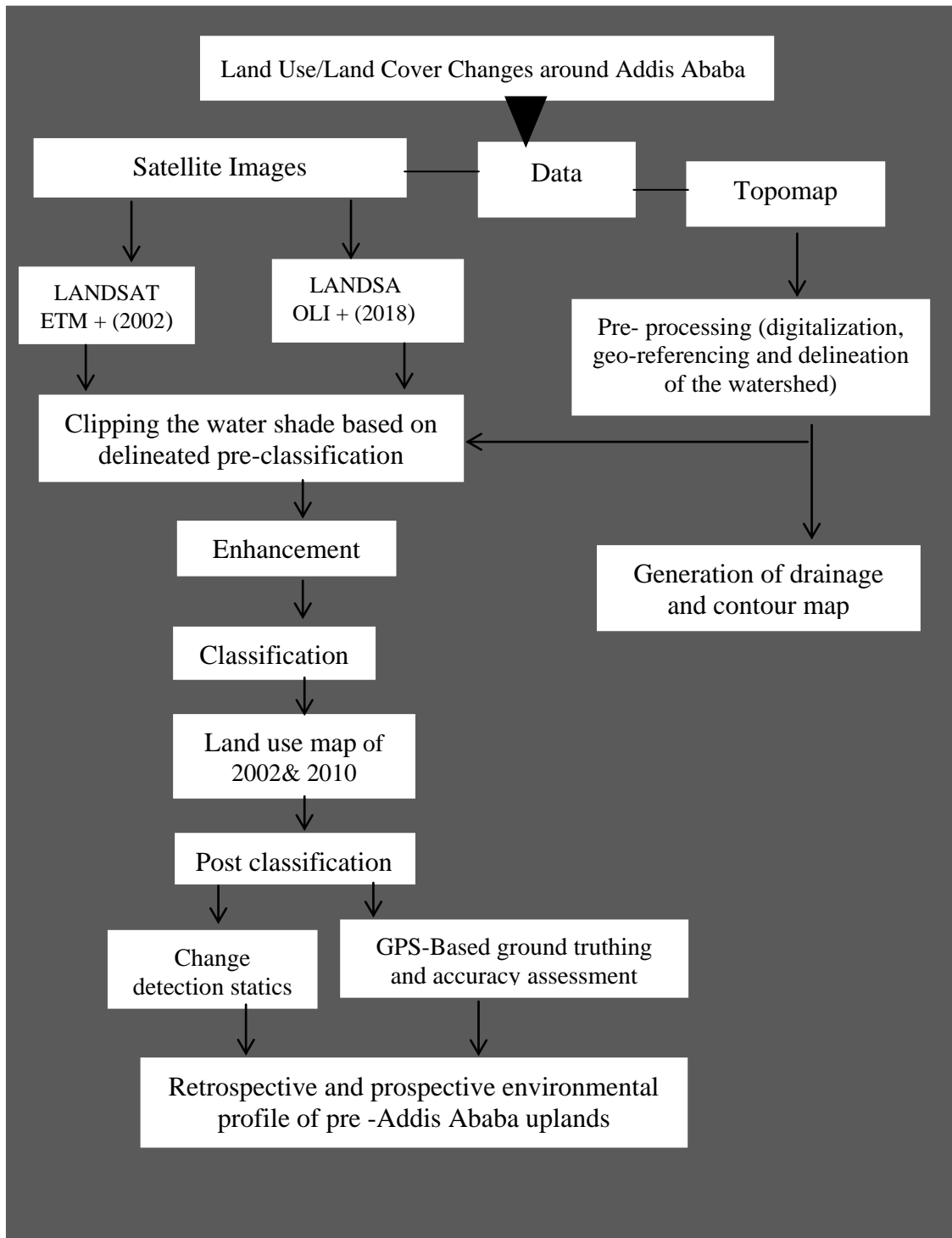


Figure 3.6: Methodological flow of LULC analysis of uplands in peri-Addis Ababa (Source: Own construction based on literatures and empirical data)

3.2.6 Ethical Considerations

In case of data collection, ethical considerations must be seriously taken into account to ensure the protection, integrity, anonymity, consents and other human elements of the informants. In this study, the respondents are not identified by names and their consent will be required during interview and discussions. As argued by Kitchin and Tate (2000) research ethics are considered with the extent to which the researcher is ethically and morally responsible to his/her participants, the research sponsors and other concerned bodies who have a contribution in his/her research. Taking this idea into consideration, before starting to conduct the study, ethical consideration has been seriously taken into account by the researcher and the researcher tried to be ethical in a manner that not disappoint the respondents and officials of different government organizations. First of all, initial contacts has made with those higher government officials and sample populations to introduce myself and explain the purpose of the research. Then after, the discussants and respondents were met and asked their willingness to conduct FGD and interview. On the other hand, during field observation and GPS data collection as well as the collection of secondary materials such as reports and other related documents, the researcher assured permission with formal letter.

CHAPTER IV: RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter presents assessment of flood risk and mapping areas in Addis Ababa in general and the study area in particular. The data collected from different sources are interpreted in this chapter. Flood hazard analysis was done based on mapping environmental factors making the area vulnerable for flood hazards. These environmental factors include terrain, slope and land use land cover (LU/LC) scenarios computed based on the data obtained from remotely sensed imageries. In fact, in order to minimize the risks of methodological errors, accuracy assessment was employed to find out those errors so as ensure reliability of the produced LU/LC maps and the overall assessment results. The classified maps were assessed and compared with a referenced data. \

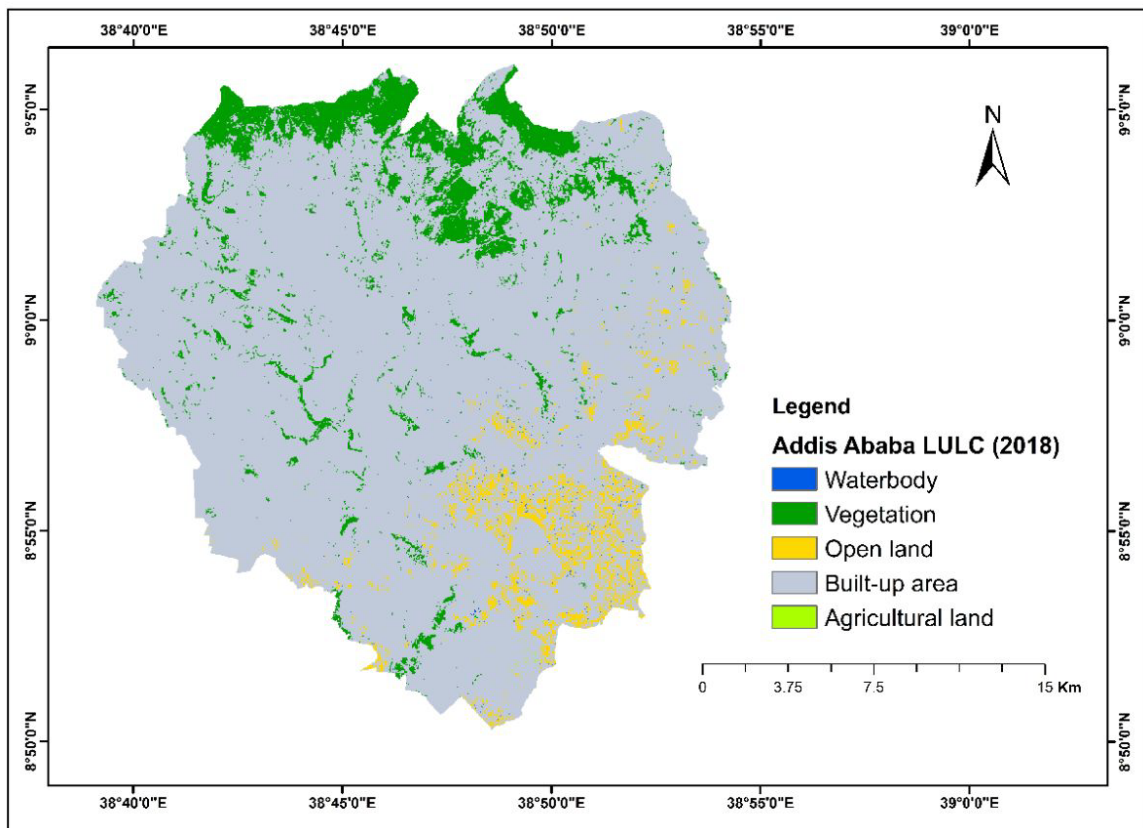


Figure 4.1: Current LU/LC situations of Addis Ababa (Source: USGS Landsat data)

Table 4.1: The current LU/LC status of Addis Ababa

LU/LC classes	Area		Percent
	In hectare	In square km	
Open land	1,931.67	19.32	3.65
Vegetation	5,272.56	52.73	9.95
Water body	47.70	0.48	0.09
Agricultural land	11.16	0.12	0.02
Built-up area	45,718.47	457.18	86.29
Total	52,981.56	529.83	100.00

(Source: Computed based on the data obtained from USGS Landsat)

The total spatial area of Addis Ababa is 52,981.56 hectares (Table 4.1). This is equivalent to 529.83 square kilometer. As the most metropolitan area in Ethiopia, most part of the city is built-up area (*i.e.* 45,718.47ha or 457.18 square kilometer) followed by vegetation land (*i.e.* 5,272.56ha or 52.7s square kilometer). At the third rank, open land constitutes 1,931.67ha or 19.32 square kilometers. Water body and agricultural land make up very small segment of the city, *i.e.* only 58.86ha or 0.6 square kilometers altogether.

4.2. Topography, slope and LU/LC as causes for flooding hazards in Addis Ababa

Topography refers to the shape the area. The topography of an area could refer to the surface shapes and features themselves, or a description of the area. Topography in a narrow sense involves the recording of relief or terrain, the three-dimensional quality of the surface, and the identification of specific landforms. In modern usage, this involves generation of elevation data in digital form a digital elevation model (DEM). It is often considered to include the graphic representation of the landform on a map by a variety of techniques including colors.

The topography of a watershed like elevation, slope, and aspect has an important contribution for the amount of surface runoff generated from it. In case of *Ginfile* Catchment (as shown in Figures 4.2 to Figure 4.5), the topography of middle catchment zone stream starts from the foothills of the Entoto and Anchorcha ridges and culminates at the junction point of the Big Kebena and Big Akaki rivers. But it is a gentler slope of 0-10 % and about 35% of the area has 10 - 30 % slope. According to the extract of a Digital Elevation Model (DEM) of the area Overflow Ginfile found in the Middle, west

joint of *Arat Kilo* to the study area located along elevation range from 2,320 meter amsl to 2,470 meter amsl. From the elevation map we can see that the study area is characterized by vigorous type of topography with noticeable elevation difference and sleepy land scope especially in the northern part. The altitude ranges from 2343 to 2545 meter amsl. The difference between the lowest and the highest is 202 meter. The highly elevated land exists in the northern while relatively lower elevation exists in the south.

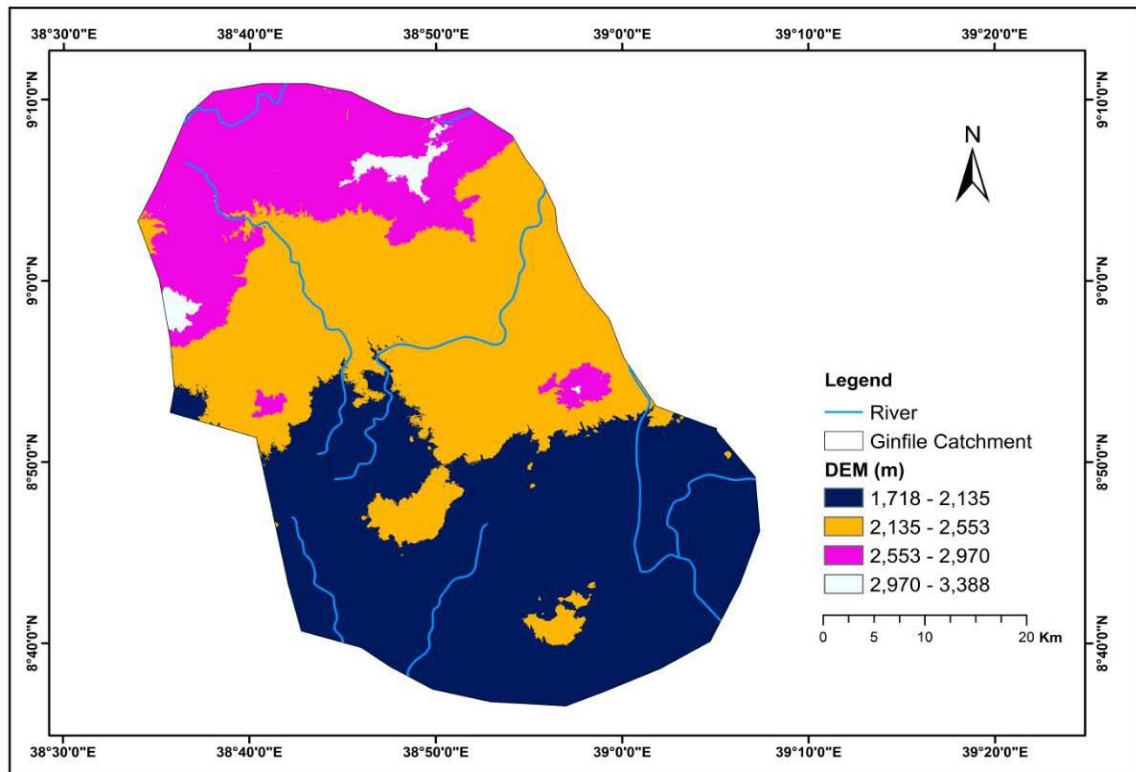


Figure 4.2: Elevation of Ginfile Catchment (Source: Computed based on the data obtained from SRTM land sat)

The highest areas of the catchment are found in the northwest part of the area, which is Entoto mountain range. This means the streams (including Ginfile River itself) flow northwest to southern and southeastern direction. The highest peak of the catchment exists in its northern area, and the altitude is about 2,545 meters amsl. The elevation of the sub-watershed drops from the highest point of 3,166 meters amsl at the tip of Entoto Mountain to the lowest point of 2,045 meters amsl at the outlet of the drainage to the Aba-Samuel reservoir. The middle catchment zone has a shorter relief of about 530 meters amsl (2,180-2,710 meters) and the agro-ecology is *dega*. According to Hurni

(1998), *dega* in Ethiopia is an agro-ecological zone ranging between 2300 to 3200 meters amsl, and where crops like barley, wheat and pulses grow widely. The landscape is undulating and crossed by fewer numbers of secondary streams including Ginfile stream and focuses the affected area of 2373-2409 meters amsl

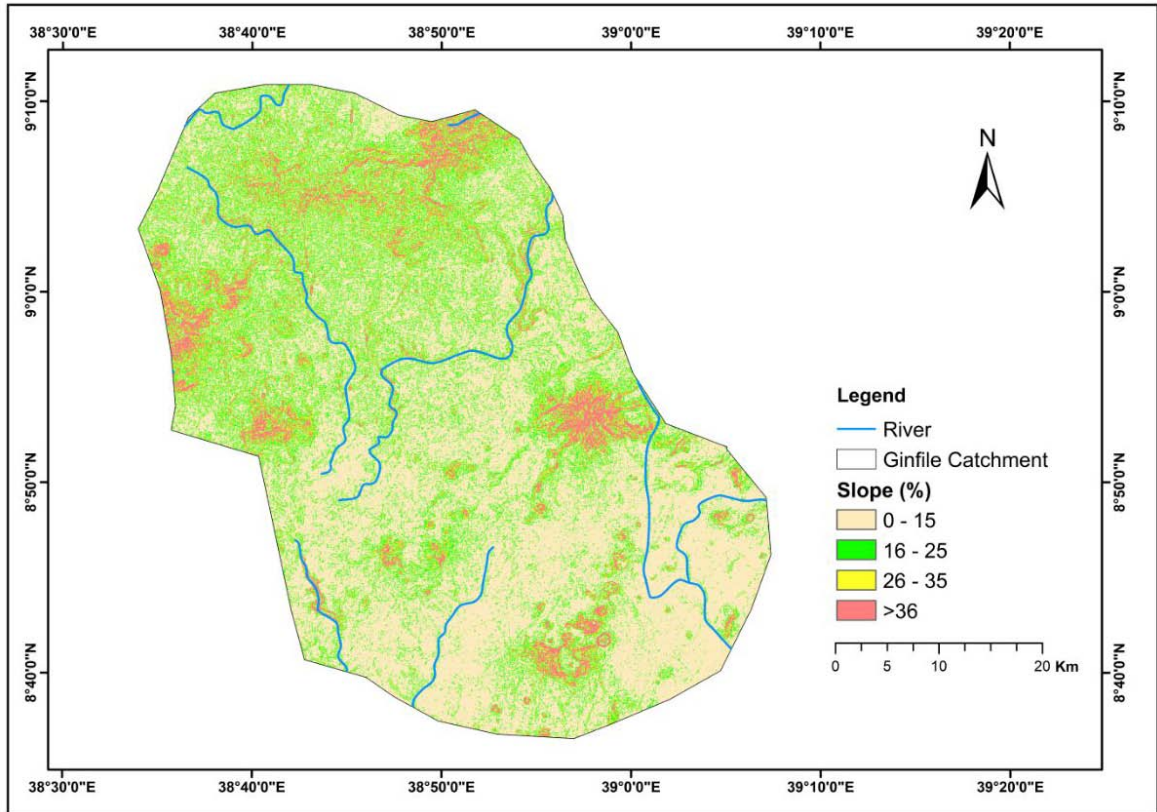


Figure 4.3: Land slope in Ginfile Catchment (Source: Computed based on the data obtained from SRTM Landsat and DEM)

Land slope is essentially the gradient or inclination of the land. A steep slope refers to a sharp incline; while a gentle slope is referring to a slight incline. Slope is a measure of terrain steepness that is, the degree to which land is not flat/horizontal. Slope affects the construction sustainability of in different area such as the place where with high slope (steep). In other word slope is another means of describing topography for a given area. It is a measure of terrain steepness that is, the degree to which land is not horizontal. The range of slope values in degree is 0 to 90. For percent rising, the range is 0 for near infinity. A flat surface is 0 percent, and as the surface becomes more vertical, the percent rises becomes increasingly larger. The categorization of an area in different slope classes can be used for different civic works such as for planning drainage, road construction,

housing and etc...in this analysis map, slope is measured as percentage rises classified in to 7 different ranges.

In case Ginfile catchment, as shown in Figure 4.3 and Table 4.2, the area is characterized by a slope ranging from 0 to over 36 degree. This is one of the physical factors making the area vulnerable for flooding. Particularly, the areas in >36 degree slope are very highly vulnerable for flooding. This adverse factor, together with other factors like paving and dumping of wastes in river courses, leads the area to the situation of high vulnerability to flooding hazards. The total area which is found to be very highly vulnerable to flooding is about 1,526.20 square kilometers, accounting for about 64% of the total area of the catchment. Moreover, the combination of Table 4.2 and Figure 4.3 show that about 22% of the catchment area is found in the highly vulnerable area with slope ranging between 16-25%. About 8% of the catchment area is found sloping environment with slope ranging between 26-35%. This area is rather vulnerable to erosion. Only about 7% of the areas are very steep slope with more than 36% slope. These are the stream valleys in the upper part of the catchment zone. This indicates a potential for large volume of surface runoff towards the streams unless there are carefully managed and well planned networks of the blue and green components in the upper part of urban zone to maximize infiltration and minimize runoff. The large coverage of the slope of the study area covered by flat and gentle slopping is between 0-15 percent, receiving water from the upper catchments of runoff, putting the area at its vulnerable position for flooding hazards.

Table 4.2: Classification of Ginfile catchment in slope

Slope class	Area		%	Vulnerability level
	In hectare	In square kms		
>36% (Steep slope)	16,336.98	163.37	7	Low
26-35% (Slopping)	19,031.22	190.31	8	Moderate
16-25% (Gentle slope)	51,494.22	514.94	22	High
0-15% (Very Gentle)	152,619.75	1,526.20	64	Very high
Total	239,482.17	2,394.82	100	

(Source: Computed based on the data obtained from USGS Landsat& DEM)

LU/LC circumstance of an area is also one of the major factors for the flooding vulnerability situation of the area. With this understanding in mind, the 2002 and 2018 LU/LC analysis was carried out for Ginfile Catchment. Table 4.2 indicates that Ginfile catchment covered 249,867.90 hectares (2,498.68square kilometers) of land of which built-up area covers the largest proportion of the total area of the catchment.

Figure 4.4 below shows that the land use characteristics in the study area is mixed with water body, vegetation, open land, built up area and agricultural land but river and riverine are not given attention to protection in revers it covers small amount but its impacts are too high. Water body covers the smallest spatial area of the catchment followed by the vegetated land. This gives us a clue about the flooding hazard vulnerability of the area in combination with other factors such as road paving and improper solid waste management.

Table 4.3: The 2002 and 2018 LULC of the study area

LULC classes	In hectare (2002)	In hectare (2018)	% change (2002 to 2018)
Open land	38,671.74	34,634.34	-10.44
Water body	718.92	985.05	37.02
Agricultural land	49,249.08	12,671.37	-74.27
Vegetation	26,085.69	16,908.03	-35.18
Built-up area	135,142.47	184,669.11	36.65
Total	249,867.90	249,867.90	--

(Source: Computed based on the data obtained from USGS Landsat and DEM)

The study area of Land use and land cover highly covered by built up area, second green vegetation and cover. This shows due to high urbanization vegetation cover are changed in to buildings and industries as most of the time manufacture and industries built along the river side to the relations of waste disposal systems, this also affected the river, stream and the propulsion along the riverside released with other, but not given attention to the protections of flood and the protections of the stream and the rivers.

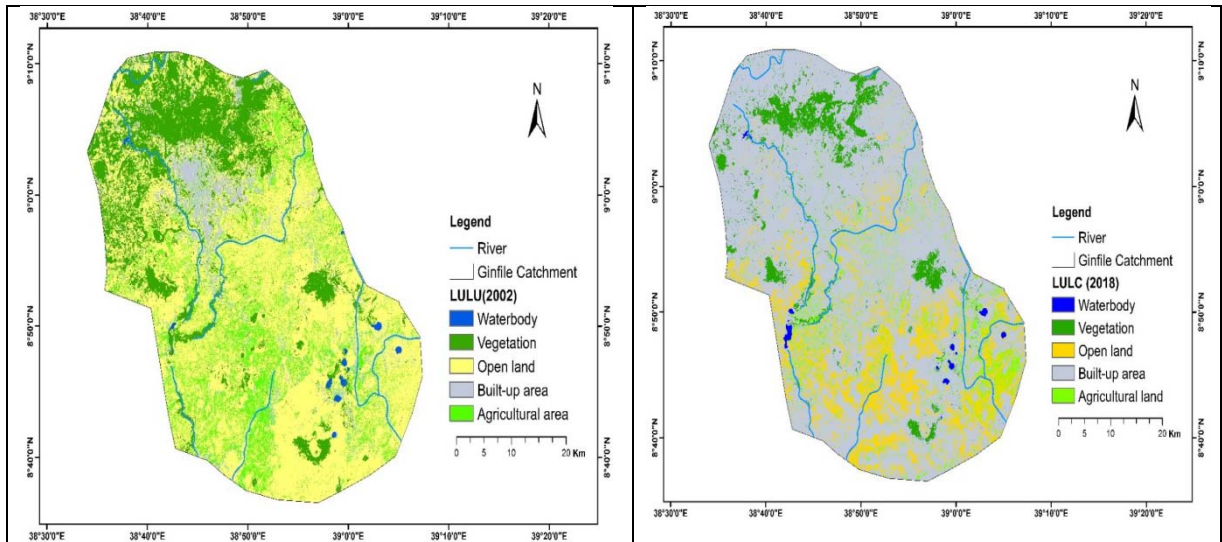


Figure 4.4: Land Use Land Cover in Ginfile Catchment (Source: Computed based on the data obtained from USGS Landsat and DEM)

The most LU/LC status of Ginfile Catchment in this research is based on the *Landsat* image of data 2018 (shown in Figure 4.4 and Table 4.3). This data shows that built-up area occupied the largest proportion of the catchment followed by open lands. Vegetation and agricultural lands have also occupied significant proportion of the area.

Table 4.3 and Figure 4.4 also show that the LU/LC dynamics in Ginfile Catchment is very high. Open land, for example, changed (decreased) by 10.44% from 2002 to 2018; whereas water body increased by 37.02% during the indicated period. An increment of the water body may be one of the indicators for the prevalence of flooding over years in the area. Because in 2002 there are different land uses that control the high rainfall and the flow of water like vegetation cover; agricultural land and open land also contribute to protect the flood disaster but in 2018 these land use classes are decrease. Both agricultural and vegetation lands decreased by 74.27% and 35.18%, respectively, between the two periods; whereas built up area increased by 36.65%.

The study area of Land use and land cover highly covered by built up area, second green vegetation and cover. This shows due to high urbanization vegetation cover are changed in to buildings and industries as most of the time manufacture and industries built along the river side to the relations of waste disposal systems, this also affected the river,

stream and the propulsion along the riverside released with other, but not given attention to the protections of flood and the protections of the stream and the rivers.

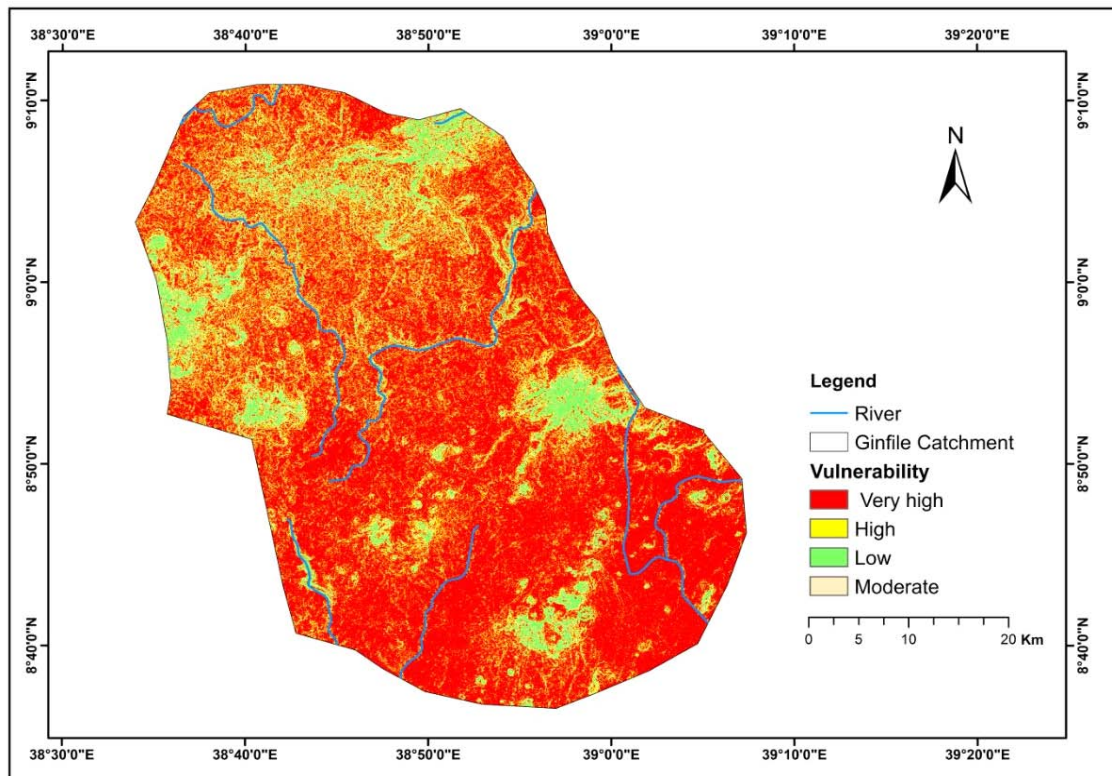


Figure 4.5: Flooding vulnerability of Ginfile catchment (Source: Computed based on the data obtained from USGS Landsat and DEM)

The vulnerability of Ginfile catchment to flooding was also analyzed by using GIS-based mapping technique (Figure 4.5). As shown in the map, the area covered by red colored is found to be very highly vulnerable. It occupied the largest part of the catchment indicating the fact that most areas of the catchment are very vulnerable. On the other hand, it is possible to conclude that the households residing in red-colored areas are very highly prone to flooding. Yellow-colored areas are highly vulnerable; whereas the vulnerability of gray-colored areas is moderate. Only green-colored areas are found to be not vulnerable for flooding in the catchment.

4.3 Causes and impacts of flooding hazards in Ginfile Catchment: Community perception

This sub-title has been addressed by using qualitative research approaches such as key informant interview, focus group discussion and observation. Interviews with persons having special practical information about flooding hazards in Ginfile Catchment have been carried out. This focuses on organizing formal interview with the aim of facilitating open interaction between the researcher and key informants.

The informants included selected residents in the catchment and experts in relevant government organizations in Addis Ababa, such as Addis Ababa Fire and Emergency Prevention and Rescue Authority (AAEPRA) and Addis Ababa Rivers and Riversides Development Project Office (AARRDPO). Besides, although the study is to be conducted at national level, selected regional level corresponding bureaus and offices will be consulted. Similarly, some bureaus of Oromia region in/around Addis Ababa and the practitioners will be assessed to hear the opinions, success and challenges from grassroots levels.

4.3.1 The environmental and ecological impacts of the Ginfile River

All the interviewed household heads living in the boundary of the catchment have the same opinion that they do you feel that they are vulnerable to flooding hazards. They feel that flooding effect in the area is one of the most hazardous, and frequent catastrophes affecting households residing along Ginfile stream, and riversides. They feel that flooding causes the disturbance of ecology and enormous impacts on environment, health risks, social disturbance, economy and financial disorder, loss of city infrastructure, and transportation systems, psychosocial disturbances and frustration. It is clearly observable that several people are living along riverside and the water is flowing washing the wall of homes (*See Figure 4.6*).

Flood is considered a significant threat to the development of the country as well as in the study area and high damaged infrastructure. In the study area floods are adversely affected both in the environmental and ecological aspects. The major environmental

impacts of the flood include deforestation, degradation of land, soil erosion, biodiversity loss, desertification, increasing food insecurity, and further degrading land due to heavy rainfall. Furthermore, out-breaks of disease is more common and air pollution and increased water stress have already intensified environmental strain on the residents along the Ginfile stream



Figure 4.6: Flooding due to heavy rainfall (Source: Photos taken by the researcher)

As to the question of the causes of flooding and pollution, the community and other key respondents have the opinion that the causes are multiple. The discharge of untreated effluent, solid wastes and wastewater from industries, households and institutions are the main sources of water pollution in Addis Ababa in general and the study area in particular. As indicated by river and river sides officer, water pollution due to fecal matter contamination and poor sanitation practice may be the major cause of the top ten

leading causes of outpatient visit, hospital admission and death among children and elderly, in Ethiopia in general and Addis Ababa City in particular.

According to a key informant from Addis Ababa Rivers and Riversides Development project Office (AARRDPO), the land use is dominantly settlement and the natural cover of the land is radically changed to non-natural and impervious features. It is a transfer or confluence zone for many of the streams and surface runoff accumulates and becomes highly erosive with a potential to cause flood risk. High load of pollutants (solid and liquid) from known and unknown sources enter into the streams from this zone. Air, water and soil pollution is hazardously high (relative to the upper catchment zone). The green and blue networks are poorly integrated. The streams in this zone are used to dispose waste from domestic, industrial and commercial sources. The buffers are poorly managed and river banks are affected by building infrastructure. The riparian vegetation is haphazardly grown and not designed to trap pollutants

Similarly, a key informant from Addis Ababa City Administration Fire and Emergency Prevention and Rescue Authority, The main environmental degradation and management problems are extreme pollution of streams and rivers due to dumping of solid and liquid wastes from domestic, commercial as well as industrial sources. Mismanagement and absence of strict control on the collection and disposal of solid waste by citizens is critical problem in the catchment zone. Although green spaces are found in different part of the catchment zone, the numbers are few and they are found in isolations. The interconnectivity of the stream networks with the green spaces is not designed and managed. Natural forest habitats and river bank vegetation are poorly managed and not developed at all. Large parts of the river banks and buffer areas are occupied by formal and informal settlements. Because of the increasing impervious surfaces, very high amount of uncommitted surface runoff is generated and causes flash floods, carries pollutant loads from non-point sources.

FGD discussants and interviewees mention, poor sanitation and sewerage coverage as well as lack of strong monitoring strategy is responsible for water quality change. The major causes of this area are increased settlement in flood-prone areas along the river banks and buffer zones , increase in flood peak volume, trend of increasing flash floods

and surface runoff, absence of flood protection structures, absence of flood risk management and rapid response body, increasing trend of runoff from the upper catchment zone, Inadequate channel width and depth of hot spot areas to accommodate increasing risk of overflow/inundation, mass loss of soil along the river banks, economic and human loss, sedimentation of downstream areas, erosion of river banks and river beds flash flood and the other is the settlements of the population are randomly settle, lack channel width and depth in high risk areas, disposal of liquid and solid waste along river banks, there is no waste trap structures in the stream.



Figure 4.7: Flooding affected homes and disposal systems. (Source: Photos taken by the researcher).

Results of interviews and FDGs as well as Figure 4.6 above indicate the fact that the river water inundates the floor of homes, wall became saturated through time it slides and the houses are suspended in the water (Figure 4.7). It transports wastes to residential areas becoming causes for respiratory disease. The area is also emits unpleasant odor. Together with wreckages of construction, households remain, and flooding debris, some areas are generally coming unsuitable to live in years after years. In fact, the prevailing less attention given to the riverside development and management is a vital problem. Moreover, the city administration hasn't given the necessary attention to the population settlements residing along the stream and the ecological, environmental, social and economic impacts of flood variability.

Though the area is very risky as per the interview and FGD data as well as observation of the area, the residents are still residing in the area as there is no better solution for them. In this regard, a key informant, for this specific research, living in *Woreda 6* of Arada Sub-city said:

'...there is no choice. We asked the administration to move us to better areas. But they didn't respond to our questions. They have no proper solution for our problems. They preferred silence. However, especially around St Mary Church the houses flooded and dilapidated. The impact is getting worse and worse over years in this area. The causes are high rate of urbanization, population growth, heavy rainfall, climate change vulnerability, poor adaptation works and wrong settlements along the streams...'

4.3.2. Social impacts of the Ginfile stream

Another key informant in the area indicates that flood in the area is becoming severely hazardous and frequent catastrophic adversely affecting the households residing along the riverside. According to this specific interviewee, he perceives that flooding causes ecological disturbances and enormous impacts on environment, health risks, social disturbance, economy and financial disorder, loss of city infrastructure, and transportation systems, psychological frustration of the current and future risks. He also indicated that in the area, the population is living along riverside, the water is passing nearest to the wall of homes and it is passing through underground. The river water infiltrate in to the ground of their homes, wall became saturated through time it slides and the houses are suspended in the water and changes the smell of the houses and causes

diseases especially respiratory disease. It seems that, according to the interviewee, the flood hazards problem is worsen in the coming years due to the massive construction of houses, buildings and roads and less attention to river side drainage and catchments. Moreover, the city does not concern about population settlements residing along the stream and the ecological, environmental, social and economic impacts of flood variability.

Results of interviews and FDGs indicate the flood sometimes takes away the trees, ditches, tunnels, walls, and houses. In addition to that the flood brings solid and liquid wastes and affects people health. The socio economic survey result revealed that residents in these areas have been heavily affected by stream overflow, rive bank erosion, and property loss. Thus, rive bank structures such as retention wall, channel reshaping and width expansion are needed to avoid the overflows and potential impacts.

4.3.3. Health impacts of the Ginfile stream

All the interviewed household heads living along the stream indicates the health effects of floods in the study area divided into, direct effects caused by the flood waters (such as drowning, injuries, and others) and indirect effects caused by other systems damaged by the flood (such as water borne infections, acute or chronic effects of exposure to chemical pollutants released into flood waters, vector-borne diseases, food shortage and others. Flood harmful affects the health status of the residents along Ginfile stream.

The number of deaths associated with flooding is closely related to the life-threatening characteristics of floods and to the behavior of victims. Injuries are likely to occur in the after math of a flood disaster, as residents return to dwellings to clean up damage and debris. Ill health, particularly in the form of psychological problems, may persist for months to years following a flood. Sub groups vulnerable to adverse health effects of floods include children and the elderly

4.3.4. Psychological impacts of Ginfile stream

The interviewed household heads indicates that the psychological impacts of the flooding hazards in the study area are showed in two ways, it is long term or short term impacts, the obvious short-term effect is emotional, and grief may also be long term. There can be longer-term responses that are interpersonal, societal and economic in nature. The psychological effects of a disaster are created by direct social and economic effects.

In the wake of a disaster, people grieve for their loved ones, treasured personal memorabilia, lost documents and lost familiar neighborhoods. Following a disaster, a wide variety of emotional disturbances occur with chronic grief, depression, anxiety or guilt. After it has happened, some people have difficulty in controlling anger, suspiciousness, irritability and hostility and others get withdrawn or avoid people. Disturbed sleeps by nightmares and flashbacks of disasters may occur in other people.

There is what is called secondary traumatization. This is when “secondary victims”, who are families of those affected, onlookers and observers, relief workers, medical and mental workers, all experience serious emotional effects. Other people that can be traumatized are journalists, human rights workers and relief workers that do need assessment. For people to have emotional trauma after a disaster has struck, might be called a “second disaster” which is the effect of the response to a disaster.

There are victims that are forced to take refuge in a shelter after a disaster has happened. They are confronted by personal and material losses, loss of privacy, community, independence, familiarity of the environment and certainty with respect to the future. Very often or always family roles and ordinary work roles are disrupted. In addition to the above, poor sanitation, inadequate shelter, contaminated water and food may produce epidemics which spread illnesses that result in death. In most cases women are raped and assaulted. All these bring distress to the victims of a disaster. Victims may show psychological effects in the hours immediately following a disaster, over weeks or even a year or two after the event. Other people show unexpected reappearance of symptoms during anniversaries of a disaster. Reactions of a disaster have to be resolved so that they

are not the source of distress and dysfunction for individuals, families and society. (Ehrenreich 2001)

Usually after the scene of a disaster and evacuation, people want to go back to resettle in the same place they were living before the disaster. This happens because of a number of reasons; some of them are that people do not have an alternative place to live or an alternative job to undertake, to protect their property which show that humans are territorial and it is not easy for them to surrender their property. (Bush 1979)

A psychological benefit is that going back to resettle at the same place and rebuild as fast as possible, makes people forget the actual event, because they are kept busy by something they are familiar with, and because their minds are kept off the disaster; they build up self- esteem and overcome feeling of hopelessness. Rebuilding is also a sign of loyalty to friends or relatives who have been called by a disaster and show respect of ancestral links, not to mention religious beliefs.

CHAPTER V: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The flood hazards problems are getting worse in the coming years due to the massive construction of houses, buildings and roads and less attention to river side drainage and catchments. Moreover, the city isn't showing enough concern about population settlements residing along the stream and the ecological, environmental, social and economic impacts of flood variability. The effects of flood hazards on urban households residing along Ginfile stream floods effects in the study area are one of the most dangerous, and frequent catastrophes assessing households residing along the stream, and river sides. Flood causes the disturbance of ecology and enormous impacts on environment, health risks, social disturbance, economy and financial disorder, loss of city infrastructure, and transportation systems, psychological frustration of the current and future risks.

River floods pose a serious threat to millions of people living in river basins worldwide. At the national level, extreme floods may bring back development by some years; the adverse impact of flood hazards in the study area involves a variety of potential environmental, ecological destructions, social, economic, health and psychological impacts. The frequency of the events and the number of people affected including losses of life and the estimated damage, because they are the most flood prone areas, this mainly happened due to population growth, urbanization and rapid expansion of built up area in most part of the city and this has changed the built-up area by (i.e. 45,718.47ha or 457.18 square kilometer), it increased by 36.65% this shows built up area has been expanding at faster rate, but open land, agricultural and vegetation areas have decreased by 10.44%, 74.27% and 35.18%, respectively from 2002 to 2018; whereas water body increased by 37.02% during the indicated period. An increment of the water body is one of the indicators for the prevalence of flooding over years in the area. Both lands between the two periods; the study has shown that most of the land has been highly covered by built up areas, open land and vegetation cover. This shows that due to high vegetation cover are changed in to buildings and industries as most of the time manufactories and

industries are built along the river sides in a relation to waste disposal systems, this also has affected the river, the stream and population those who live along the riverside, but the concerned bodies have not given it full attention to the protection of the stream and the rivers.

According to the study the vulnerability of floods residing along Ginfile stream divided the health aspects into, direct effects caused by the flood waters (such as drowning, injuries, and others) and indirect effects caused by the flood (such as water-borne infections, acute or chronic effects of exposure to chemical pollutants released into flood waters, vector-borne diseases, food shortage and others). The number of deaths associated with flooding is closely related to the life-threatening characteristics of floods and to the behavior of victims. Injuries are likely to occur in the aftermath of a flood disaster, as residents return to dwellings to clean up the damage and debris. Ill health, particularly in the form of psychological problems, may persist for months to years following a flood. Subgroups vulnerable to adverse health effects of floods include children and the elderly.

The social effects of floods in the study area are often much greater than indicated by the physical effects of floodwater coming into contact with the area losses by buildings and their contents. They can't spread well beyond the flooded in to the area and forced to losses their community area.

The study aims to reduce the harmful effects of flooding on environment, social, human health and economic infrastructure by limiting the impact of a flood before, during and after a flood event activities that have undertaken by the population at risk, by policy makers administrative bodies and by emergency workers in order to reduce flood risks by the help of fields of engineering and urban planning.

The current situations of Ginfile stream catchments and the households residing along Ginfile stream has both sided correlation effects, the stream affects the household and the households also affect the stream. The house and the river side have common wall, the

stream water pass near to the houses' wall. Due to this the residents and householders are suffering from the effects of Ginfile stream, the water enters in to the houses, the wall and the floor of the houses, and the walls cracked through time and the houses fall, the smell of the houses has also been changed by underground dam proof and others are caused by the stream but the residents also do not protect the stream and they always dispose all their wastes, connect their toilets in to the stream, they do not clean it regularly. The best management practices are done by the municipalities is replacing some houses that are highly losses and affected by the flood.

Studying the effect of flood hazards on urban households has important role in managing the adverse impact of flood hazards on urban households. The Use of mitigation measures controls the environmental, ecological, social, health and economic effects of flood. Bringing out the continuous and sustainable measures for the affected population and areas by substituting their affected houses and rehabilitating households is the best measure that can be taken. Moreover, controlling different wastage disposal system, cleaning the environment and banning the toilet wastes entering in to the stream, planting endemic plant species, aligning structural planning in urban setting with existing catchment management plans, warrants sustainable urbanization through provision of enhanced ecological, economic, cultural, aesthetic and recreational values of natural resources and ecosystems to the people. Among the important benefits of integrating catchment management plans with growth plans could increase knowledge of future infrastructural as well as resource requirements and constraints, related costs and required investments, timing and responsibilities.

Nowadays, sustainable development is widely perceived as a development pattern that improves the quality of life while protecting and enhancing the natural environment. So constructions of river and river side projection are one of the basic components of sustainable development which integrates the economic, social and environmental needs of the city. So give attention to river and river basins, improper settlements along the river, and the effects of flood hazards on residents along the stream.

The flood hazards problem is worsen in the coming years due to the massive construction of houses, buildings and roads and less attention to river side drainage and catchments. Moreover the city does not concern about population settlements residing along the stream and the ecological, environmental, social and economic impacts of flood variability. The effects of flood hazards on urban households residing along Ginfile stream floods effects in the study area are one of the most hazardous, and frequent catastrophes assessing households residing along the stream, and river sides. Flood causes the disturbance of ecology and enormous impacts on environment, health risks, social disturbance, economy and financial disorder, loss of city infrastructure, and transportation systems, psychological frustration of the current and future risks.

River floods pose a serious threat to millions of people living in river basins worldwide. At the national level, extreme floods may bring back development by some years; the adverse impact of flood hazards in the study area involves a variety of potential environmental, ecological destructions, social, economic, health and psychological impacts. The frequency of the events and the number of people affected including losses of life, and the estimated damage, because they are the most flood prone areas, this caused by population growth, urbanization and rapid expansion of built up area in most part of the city is changed in to built-up area by (i.e. 45,718.47ha or 457.18 square kilometer), in the study area also land use land cover dynamics in Ginfile catchment, built up area increased by 36.65% this shows built up area has been expanding at faster rate, but open land, agricultural and vegetation decreased by 10.44%, 74.27% and 35.18%, respectively from 2002 to 2018; whereas water body increased by 37.02% during the indicated period. An increment of the water body may be one of the indicators for the prevalence of flooding over years in the area. Both lands between the two periods the study area of land use and land cover highly covered by built up area, second green vegetation and cover. This shows due to high urbanization vegetation cover are changed in to buildings and industries as most of the time manufacture and industries built along the river side to the relations of waste disposal systems, this also affected the river, stream and the propulsion along the riverside released with other, but not given attention to the protections of flood and the protections of the stream and the rivers.

According to the study the vulnerability floods residing along Ginfile stream divided the health aspects into, direct effects caused by the flood waters (such as drowning, injuries, and others) and indirect effects caused by the flood (such as water-borne infections, acute or chronic effects of exposure to chemical pollutants released into flood waters, vector-borne diseases, food shortage and others). The number of deaths associated with flooding is closely related to the life-threatening characteristics of floods and to the behavior of victims. Injuries are likely to occur in the aftermath of a flood disaster, as residents return to dwellings to clean up damage and debris. Ill health, particularly in the form of psychological problems, may persist for months to years following a flood. Subgroups vulnerable to adverse health effects of floods include children and the elderly.

The social effects of floods in the study area are often much greater than indicated by the physical effects of floodwater coming into contact with the area losses buildings and their contents. They can't spread well beyond the flooded in to the area and forced to losses their community area. The study aim to reduce the harmful effects of flooding on environment, social, human health and economic infrastructure by limiting the impact of a flood before, during and after a flood event activities may be undertaken by the population at risk, by policy makers administrative bodies and by emergency workers in order to reduce flood risks by the help of fields of engineering and urban planning.

The current situations of Ginfile stream catchments and the households residing along Ginfile stream is two ways of correlation effects, the stream affect the household. Households also affect the stream. The house and the river side are common wall, the stream water pass near to the houses wall. Due to this the residents and householders are suffer from the effects of Ginfile stream, the water are enter in to houses, the wall and floor of the houses are cracked through time it is fail, the house smell also changed by underground dam proof and others are caused by the stream but the residents also not protect the stream they dispose all wastes, connect their toilets in to the stream, they are not clean in months by term. A best management practices done by the municipalities are replaces some houses that are highly losses and affected by the flood. But it remains other houses that uses replaced firstly.

Studying the effect of flood hazards on urban households has important role in manage the adverse impact of flood hazards on urban households. Use mitigation measure to control the environmental, ecological, social, health and economic effects of flood, major destruction of property and buildings, upgrade infrastructures and drainages. Bring out to continuous and sustainable measure for the affected population and area ; by substituting the affected houses and rehabilitate the household, control different wastes disposal system, clean the environments, the toilets wastes banned enter in to the stream, plants endemic plant species, aligning structural planning in urban setting with existing catchment management plans warrants sustainable urbanization through provision of enhanced ecological, economic, cultural, aesthetic and recreational values of natural resources and ecosystems to people. Among the important benefits of integrating catchment management plans with growth plans include increased knowledge of future infrastructural as well as resource requirements and constraints, related costs and required investments, timing and responsibilities.

Nowadays, sustainable development is widely perceived as a development pattern that improves the quality of life while protecting and enhancing the natural environment.so constructions of river and river side projection is one of the basic components of sustainable development which integrates the economic, social and environmental needs of a city. So give attention to river and river basins, improper settlements along the river, and the effects of flood hazards on residents along the stream.

5.2. Recommendations

Based on the findings of this study, the following issues are recommended to minimize the vulnerability of households to flood hazards residing along Ginfile stream.

- ✓The Urban Land Administration Offices of Addis Ababa should control the improper settlement along the river side and map of the flooded areas can be created by the software which shows levels of flood hazard and prioritization measures for anti-flood.
- ✓The Urban Land Administration Offices of Addis Ababa shall work on the fact that the river and river side offices must come up with a proposal to upgrade the infrastructure in the flooded area in terms of building of new barrier catchments, re capacitating of the existing catchments, roads and the drainage by implementing plan with timelines to deliver on them to avoid the flood risk and give rapid response.
- ✓Adopting an early warning system by using geographic information systems and remote sensing techniques in monitoring and managing urban land changes and its proper implementation. That has been proven to assist with the procedures to collect and analyze spatial data for hazard and risk assessment. Hence, Urban Land Administration Offices of Addis Ababa and other concerned office and individuals shall take action
- ✓Hospitals, industries and different factories should control the solid and liquid waste (like oil, chemicals, effluents, domestic waste, etc...) disposal systems, and organizing the community with solid waste control and disposal offices and managing hazardous and toilet wastes that are discharged directly in to the river and regulate their wastes all round.
- ✓The flooded areas can be changed in to green areas and parks by encouraging the management of the city parks, green spaces and increase the connectivity to contain non-point source pollution by planting endemic vegetation to make it capable of absorbing the water this can be done together with the environmental cleaning and beautification offices.
- ✓To insure the sustainable urban development the city administration should make policy and aware emergency workers to reduce the impact of a flood on the environmental, social, human health and economic infrastructure, before, during and after flood event activities by undertaking the population at risk
- ✓The government and other concerned bodies should be put compulsory insuring the communities who were relocated and those who are at risk need to be compensated for their losses during floods.

REFERENCES

- ACCCRN (2016). Urban Flooding: national institutes of urban affairs under Asian cities climate change resilience network
- Aklile Nigatu (2014). impact of land use land cover change on soil erosion risk: the case of denki river catchment of ankober woreda, Centers for Environmental Science Addis Ababa University
- Ali, Alijani B and Hosein M (2010), The Effect of the Land Use/Cover Changes on the Floods of The Madarsu Basin of Northeastern Iran. Scientific research on water resource and protection
- Ashagrie A. G., de Laat P. and Uhlenbrook. S (2006).Detecting the Influence of Land Use Changes on Floods in the Meuse River Basin: The Predictive Power of a ninety-year Rainfall-Runoff Relation. Netherlands
- Bariweni P.A., Tawari C.C. and Abowei J.F. (2012).Some Environmental Effects of Flooding in the Niger Delta Region of Nigeria. International Journal of Fisheries and Aquatic Sciences 1(1): 35-46. Bayelsa State, Nigeria
- BikramManandhar (2010).Flood Plain Analysis and Risk Assessment of Lothar Khola. Tribhuvan University Institute of Forestry Pokhara, Nepal
- Central Statistical Agency (CSA) (2010).population project of Ethiopia for all regions at woredaLevel from 2014-2017, Federal Democratic Republic of Ethiopia, August 2013, Addis Ababa
- CFES (2017b). Addis Ababa River and Riversides Developmental Plan Project: River catchments and River sides' Vegetation management, Centers for Environmental Science Addis Ababa University.
- CFES (2017a). Addis Ababa River and Riverside Developmental plan project, Rivers pollution and Sanitation study, Centers for Environmental Science Addis Ababa University
- Creswell J.W (2009). Research Design: Qualitative, Quantitative and mixed methods approaches. Third Edition, SAGE Publications, Pvt. Ltd, India
- Dagnachew L. and Woubet G. (2009). Flood Hazard and Risk Assessment in Fogera Woreda using GIS &Remote Sensing. Addis Ababa University

- Daniel Kssahun, Yonas Tadesse and Sinework Dagnachew (2006). Flood Disaster Impact in Dire Dawa: Some Recommendation for Future Flood Risk. Ethiopian Red Cross Society
- Elliott C. R and Leggett D. J (2002).Reducing the Impacts of Flooding: Extemporary Measures. Construction Industry Research and Information Association. London, Britain
- (ERCS) (2006). Ethiopia floods: International Federation of Red Cross and Red Crescent Societies.
- European Environment Agency (EEA) (2001): Sustainable water use in Europe. Extreme Hydrological events: Floods and Droughts, Copenhagen, Denmark
- Grabs.W.E (2011). Types, Causes and Impacts of Flood Hazards: Integrated Flood Management for Sustainable Development. Associated Programme on Flood Management. Hanoi, Vietnam
- Hodo I. Orok (2011).A GIS-Based Flood Risk Mapping of Kano City, Nigeria. University of East Anglia, Norwich, England
- <http://capitalethiopia.com/2018/05/14/new> (retrieved on 24 July 2018)
- Hurni, Hans (1998). Soil Conservation Research Programme Ethiopia Research Report: Hydrological events: Floods and Droughts, Copenhagen, Denmark
- Jennifer Meyer (2004). Comparative Analysis between Different Flood AssessmentsTechnologies. Louisiana State University
- Joe Morris and Helena Posthumus (2007). Flood Risk Management Policy Issues: vol-1, Rural. FRMRC Research Report UR8. Canfield University
- Khalequzzaman.M.(2006). Flood Control in Bangladesh through Best Management Practices. Georgia Southwestern State University, USA
- MaDGIC, (2014), steps for delineating watersheds in ESRI's ArcGIS Desktop 10.2.2 software: Trent University Library Maps, Data & Government Information Centre: ArcGIS 10.2.2 Software
- Manohar Kumar (2009). Innundation Analysis and Development of Rainfall Runoff Model for Tinau River Basin in Nepal. Lalitpur, Nepal

- Muhammad Zein (2010). A Community Based Approach to Flood Hazard and Vulnerability Assessment in Flood Prone Areas: A Case Study in Kelurahan Sewu Surakarta City, Indonesia
- MulugetaTeferi (2016). Causes of Flooding Hazards and Mitigation Techniques in Adama City: A GIS-Based Risk Analysis and the Way Forward, Ethiopia
- Mutie S.M, Mati B and Gadain H (2006).Evaluating Land Use Change Effects on River Flow Using USGS Geospatial Stream Flow Model in Mara River Basin, Kenya. Center for Remote Sensing of Land Surfaces
- Mutie S.M, MatiB.,Home P., Gadain H. And Gathenya J. (2006). Evaluating Land Use Change Effects on River Flow Using Geospatial Stream Flow Model in Mara River Basin, Kenya
- NHC (2013), Storm surge forecasts: NOAA National Hurricane Center NHC Public Affairs nhc.public.affairs@noaa.gov
- Parvaiz A. Tali (2011). Land use/Land cover Change and its Impact on Flood Occurrence: A Case Study of Upper Jhelum Floodplain. University of Kashmir
- Purnama Budi Santosa (2006). The Role of GIS for Flood Disaster Management. Gadjahmada University, Yogyakarta Qihao Weng (2002).
- Samson Abaya (2008). Floods and Health in Gambella Region, Ethiopia: An Assessment of the Strength and Weakness of the Coping Mechanism. LUMES – Lund University International Master Programm in Environmental Studies and Sustainability Science
- Shiferaw, A (2011). Evaluating the Land Use and Land Cover Dynamics in BorenaWoreda of South Wollo Highlands, Ethiopia. Journal of Sustainable Development in Africa (Volume 13, No.1, 2011). Clarion University of Pennsylvania
- Sinafikish Gezahegn (2013). Causes and Consequences of Flooding in Dire Dawa City, Eastern Ethiopia
- Tan Xuan (2011). Thailand Flood: Effects and Opportunities, Unpublished Document Technologies. Louisiana State University

- Tumaini A .Kimaro (2003).Evaluating Land-Use Change Effects on Flood Peaks Using a Distributed Rainfall-Runoff Model in Yasu River, Japan. Disaster Prevention Research Institute, Kyoto University, Japan
- (USGS) (2018). Department of the Interior: The U.S. Geological Survey's Water Science School.
- Vanessa Lucena. C, Ricardo Ruiz and Nilo de Oliveira Nascimento (2006). Economic Consequences of the Flood: modeling the impacts in an urban space. Belo Horizonte, Brazil.
- Wahren.A, Feger K.H., Schwarzel.K and Munch.A (2009). Land-use effects on flood generation: considering soil hydraulic measurements in modeling. Bannewitz, Germany
- World Meteorological Organizations (WMO) (2007).Applying Environmental Assessment for Flood Management.A Tool for Integrated Flood Management. Associated Programme on Flood Management
- World Meteorological Organizations (WMO) (2009).Integrated Flood Management Concept. Associated Programme on Flood Management
- YonasTadesse (2009).Socio-Economic Impacts of Flooding in Dire Dawa, Ethiopia. International Center for Water Hazard and Risk Management (ICHARM), PWRI, Japan.
- YonasTadesse and GirmaMoges (2010). Flood Triggering Factors and the Efforts to Mitigate Flood Disaster in Dire Dawa, Ethiopia. Dire Dawa University, Ethiopia

APPENDIX

Addis Ababa
University
(Since 1950)



Appendix 1: FGD Guides to ‘Assess the Urban Households’ Vulnerability to Flooding Hazards in Addis Ababa: A Case Study from Ginfle Stream’ to woreda level and Addis Ababa Fire and Emergency Prevention and Rescue Authority (AAEPRA).

Dear respondent,

The main objective of this FGD Guide is to collect primary data to undertake an assessment on ‘Urban Households’ Vulnerability to Flooding Hazards in Addis Ababa: A Case Study from Ginfle Stream’. Your responses to the questions are valuable and will be held in utmost confidentiality to be used only for the analysis of this research. You will not be identified by name in any case. If you accept to participate in this research, you will be doing so voluntarily and there will not be any monetary returns. You are also free to refuse to respond to any questions you do not feel comfortable answering or to withdraw from the research all together. This interview will take about an hour of your time to respond to the questions.

1. Do you feel that you are vulnerable to flooding hazards?
2. If ‘yes’ or ‘No’, describe how
3. If ‘yes’ for Question No 1, why you are living in this area? Why not you move to safer areas?
4. What do you think is the cause for flooding hazards in this area? Please mention the major causes?
5. What specific example do you have for the flooding disasters in this area? Please describe deaths? Resource damages? Landslide? Others
6. Which month is very severe in flooding in this area?
7. Is there any measures taken so far?
8. If ‘yes’ describe what has been done by the government? By the community? By NGOs?

9. Please explain the flood vulnerability status of the households residing along Ginfle river in Addis Ababa
10. Do you think that the flooding hazard is increasing over years in this area?
11. If 'yes' or 'No', describe how
12. If 'yes' for Question No 10, what do you think are the major reasons?
13. How do you evaluate the perception of the households on flooding hazards
14. What are the flood coping strategies of the households residing along Ginfle river in Addis Ababa
15. What do you suggest for the protection of flooding hazards in this area? Please describe the responsibilities of the government? By the community? By NGOs?

Thank you very much for your time & professional support

Addis Ababa
University
(Since 1950)



Appendix 2: KII Guide to Addis Ababa Rivers and Riversides Development Project Office (AARARSDP) and sub city office.

Dear respondent,

The main objective of this KII Guide is to collect primary data to undertake an assessment on ‘**Urban Households’ Vulnerability to Flooding Hazards in Addis Ababa: A Case Study from Ginfile Stream**’. Your responses to the questions are valuable and will be held in utmost confidentiality to be used only for the analysis of this research. You will not be identified by name in any case. If you accept to participate in this research, you will be doing so voluntarily and there will not be any monetary returns. You are also free to refuse to respond to any questions you do not feel comfortable answering or to withdraw from the research all together. This interview will take about an hour of your time to respond to the questions.

1. How many rivers and stream are there in Addis Ababa?
2. Do you think that flooding is a problem in Addis Ababa?
3. If ‘yes’ please describe in detail
4. Please mention hotspot areas for flooding in Addis Ababa
5. What do you think are the major causes of urban flooding in Addis Ababa?
6. Is there any place along Ginfile River that is said to be vulnerable for flooding?
7. If ‘yes’ please describe in detail
8. Please describe what Addis Ababa Rivers and Riversides Development Project Office (AARRDPO) is doing to mitigate flooding in Addis Ababa?
9. Please mention areas of intervention by AARRDPO to mitigate flooding hazards in Addis Ababa.
10. What do you recommend to mitigate the flooding hazards in Addis Ababa? Please mention some

Thank you very much for your time & professional support.

Addis Ababa
University

(Since 1950)



Appendix 3: Mean Monthly Temperature (Minimum and Maximum) and Rainfall (1979 - 2014) and Mean Annual temperature (Minimum and Maximum) and Total Rainfall (1985 - 2014)

	Minimum Temperature (°C)	Maximum Temperature (°C)	Precipitation (mm)
	Mean	Mean	Mean
Jan	5.40	22.73	3.00
Feb	6.76	24.04	5.0
Mar	7.65	24.75	5.9
Apr	8.27	24.88	16.9
May	7.86	25.01	17.3
Jun	10.06	24.24	14.4
Jul	10.79	20.13	82.9
Aug	9.75	19.90	236.5
Sep	6.02	21.90	228.4
Oct	3.94	22.21	60.0
Nov	3.81	22.39	4.9
Dec	4.05	22.17	1.5
Total	7.03	22.85	56.4

Addis Ababa
University

(Since 1950)



Appendix 4: Mean Annual temperature (Minimum and Maximum) and Total Rainfall (1985-2014)

	Min Temperature (°C)	Max Temperature (°C)	Precipitation
Year	Mean	Mean	Sum
1985	6.0	21.6	638.4
1986	6.3	21.8	1027.1
1987	7.0	22.3	578.7
1988	6.9	22.0	560.4
1989	6.9	21.7	599.5
1990	7.5	22.2	695.5
1991	7.2	22.3	718.6
1992	7.1	22.0	673.2
1993	7.0	21.8	759.0
1994	6.6	22.4	900.2
1995	7.1	22.8	518.8
1996	7.1	21.5	1062.2
1997	7.5	22.6	629.5
1998	8.3	22.4	1045.1
1999	6.6	22.9	578.0
2000	6.9	23.3	672.3
2001	7.5	23.8	561.9
2002	7.9	24.6	311.6
2003	7.5	23.9	618.9
2004	7.6	23.7	536.3
2005	7.4	23.5	701.6
2006	7.8	23.6	424.8
2007	7.4	23.5	723.5
2008	6.7	23.5	550.1
2009	7.7	23.9	413.0
2010	8.7	22.9	913.2
2011	6.2	24.3	606.9
2012	5.5	24.3	795.0
2013	6.8	23.7	842.7
2014	7.0	23.8	523.2
Total	7.0	22.8	672.6